FLOUR MILLING

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A THEORETICAL AND PRACTICAL HANDBOOK OF FLOUR MANUFACTURE FOR MILLERS, MILLWRIGHTS, FLOUR-MILLING ENGINEERS, AND OTHERS ENGAGED IN THE FLOUR-MILLING INDUSTRY

BY

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PREFACE

It is a singular fact that there is no serious modern work on flour milling in English. This fact was recently stated by Mr. Arthur E. Hawker, secretary of the National Association of British and Irish Millers, in a letter to the Editor of *Milling*. Even the rich American technical literature has no modern works of this kind, and the Americans were compelled four or five years ago to translate the old book of Professor Fr. Kick, the last edition of which was published over twenty years ago (1894).

The want of serious scientific literature on flour milling is noticeable even in the German language, in which dialect during all the time which has elapsed since the appearance of Professor Kick's book not one objective scientific work has been published. As a characteristic feature of the German literature of the last few years (Baumgartner—1902, Baumgartner and Graf—1904, Baumgartner—1907, Pappenheim—1903, Kettenbach—1907), one may point out the absence of descriptions of English and American machinery. I refrain from judging whether this is a result of the Germans not being acquainted with the machinery of English and American manufacture, or whether it is to be ascribed to the peculiar German patriotism in science. Be this as it may, the German authors do not give a broad scientific technical statement to their readers when they omit to mention English and American machinery.

Having been for twenty years engaged in this industry as a theoretical and practical worker, and having studied the technology of milling in Russia, Germany, Austria, Hungary, France, Belgium, England, and the United States, I made up my mind to write a book on this subject, keeping to the most scientific basis. The object I had in view was to produce a practical and theoretical text-book for operative millers and for milling engineers, who have to construct flour mills and to design flour milling machinery.

I thought it necessary to begin my book with an historical outline of the manufacture of flour. I drew up this outline on the basis of the materials which I found in the richest library of the world, that of the British Museum, as well as in the Congressional Library of the United

States, in which I worked on the occasion of my visits to these two countries. I have given an outline of the most important development the milling industry has undergone from the ancient period of the civilised nations of Asia Minor and Egypt till the period when practice determined the correct way of improving the technology of flour milling. The historical outline is important in that it presents the general development of the craft to the mind of the student and forces him to think more logically.

After having spoken of the product which is to be treated, I pass to the study of the construction of the cleaning and grinding machines. The designs of the machines performing a very particular operation in the cleaning and grinding processes are almost infinitely variable. In order to train the student promptly and logically to analyse and estimate the numerous machines, I have classified them according to the principles of their action, having pointed out the most economical principles of operation. Then I have illustrated the fundamental principles from the most characteristic and most popular European and American machines. To explain my idea, I will take for instance the study of the roller mill. I consider this machine from the point of view of feeding the rolls (German, English, and American systems of feeding), disposition of the rolls (horizontal, vertical, or diagonal), driving of the rolls (gear drive in the European makes, belt drive in America), methods of ventilation, etc. Describing the principles of the action and design of certain machines, I make also a critical estimate of them, basing my contentions on practical and scientific considerations.

Such is my method of describing machines, the idea always being to give the student a conception of the most important designs and to force him to think critically.

In the chapter on milling diagrams I give typical diagrams of systems at work in European and American countries, in order that the student may compare all the different schemes of grinding.

In each chapter I give the practically established capacities of the machines and a basis for the calculation of the necessary number and dimensions of them corresponding to a given capacity of a Russian, German, English, or American mill.

No author has as yet paid attention to the problem of the motion of the plansifter and of the movement of the product in the purifier. I thought it therefore necessary to solve this problem, and this makes it possible scientifically to estimate the advantages and disadvantages of the different types of these machines.

In writing my book I have attempted to instruct and prepare the way for learned and scientifically thinking specialists. It is for others to judge as to whether I have succeeded in my achievement.

In writing this book I have largely availed myself of the materials and advice of my professional colleagues working theoretically and practically in England and America for the benefit of the Milling Industry. I consider it therefore my duty most earnestly to thank Mr. W. Jago, the author of the excellent work on *The Technology of Bread Making*, for his kind permission to reproduce some of its tables and photographs of the wheat grain. Further, to Mr. R. A. Sidley, editor of *The Miller*; to Mr. Geo. J. S. Broomhall, editor of *Milling*; Mr. A. R. Tattersall, Mr. Chas. E. Oliver of the *Dixie Miller*, and many others who have rendered me their kind assistance.

In addition, many English and American firms have supplied me with detailed drawings of their machines, which I have reproduced in my book. I am therefore most grateful to Messrs. Thos. Robinson & Son, Rochdale, England; Messrs. E. R. & F. Turner, Ipswich, England; Messrs. Nordyke & Marmon Co., Indianapolis, Ind., U.S.A.; Messrs. The S. Howes Co., Silver Creek, N.Y.; Allis-Chalmers Co., Milwaukee, Wis.; and many others.

Finally, I desire to express my heartiest thanks to Messrs. Geo. Routledge & Sons Ltd., for their kind consent to publish my book in English, and thus to give me a chance to offer it to the judgment of the specialists of England and America, to whom I shall be most obliged for their impartial criticism.

P. KOZMIN.

PUBLISHERS' NOTE

The Publishers desire to add their thanks to Mr. Edward Bradfield, Associate and Technical Editor of *Milling*, for his assistance in revising the proof sheets of this book.

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FLOUR MILLING

CHAPTER I

HISTORICAL OUTLINE OF FLOUR MILLING

I

Flour Milling according to Religious Legends and Classical Literature. Modern Relics of Ancient Forms of Milling

Modern culture of mankind, indissolubly connected with the technics of production, is the last link of a long chain of human endeavour stretching away into the dark space of past millenniums.

The culture of mankind has not developed spasmodically: although history relates of whole peoples vanishing and their culture with them, this is but a seeming disappearance of culture. It is an undoubted fact with us, that a more perfect technical knowledge corresponds with a more perfect culture. Culture never vanished, it simply underwent an evolution. Its old forms were gradually modified and perfected.

When studying the history of the technics of any particular kind of production, we come to the conclusion that the perfecting of the process of production was never brought about by leaps and bounds. On the contrary, it has been a slow process of gradually collecting grains of human knowledge. Out of an inexhaustible source of knowledge, the gains of culture, *i.e.* the weapons of the victorious battle of man for existence and happiness, passed from one people to another; neither racial, social, nor national and territorial partitions of humanity could bar their passage. An empire might vanish, even a people, but the weapons of the struggle for life—in the first place, the implements of production—remained in the hands of others, and the culture did not disappear.

The law of evolution of the technics of production is a curve having no solution of continuity. The study of the development of a production gives us the law of inflection in that curve. Parallel to this curve, *i.e.* in accordance with that law, runs uninterruptedly the line of human culture. That is the reason why historical catastrophes of human culture are impossible, however powerful the wave of barbarians on the cultured people may be.

An intimate acquaintance with technical history is indispensable to every engineer, because history gives us the law of evolution of the implements and processes of production. Only by carefully studying the historical development of the technics of production does the creative power of an engineer receive its true education and evade retrogression.

The most brilliant example of culture and its evolution to date is the technics of procuring and preparing the nutritive substances for food. Since man left the cave epoch behind him, vegetable food has constituted undoubtedly the most substantial part of his nourishment. Even the biblical legend of paradise tells us that man lived on the abundance of the fruits of the earth, and was allowed to use them for food. Traditions about a human paradise on earth reached even the time of Ovid, who depicts the life of primeval man as the golden epoch, when men were content with the food the earth yielded them without constraint. But people multiplied, formed numerous groups, the abundance of the fruits of the earth did not suffice, and the curse of procuring food by the sweat of man's brow began to gain ground. The struggle against that curse is the history of human culture, the history of the technics of production. In the end, a perfect technical knowledge will, of necessity, liberate mankind from this curse.

Since time immemorial, bread has been the most essential element of man's vegetable food. How it happened that man stumbled upon the cereals, why he began to cultivate this unsightly plant, we know not, but, in selecting the cereal plant out of the mass of other fruit, man made no blunder, for the grain of corn contains more nutritive substance than any other fruit; but out of the gloom of ages, traditions slightly varying in import have reached us. Moses says that Cain tilled the soil, that Noah, after the flood, likewise began to cultivate land. Pliny speaks of a tradition which ascribes the origin of agriculture to a deity.[1]

Tradition tells us men were taught to cultivate corn by the goddess of agriculture, Ceres (by Demeter, sister of Zeus, according to the Greeks). "Before this, people fed on acorns." Pliny adds that men learned the grinding of corn to flour also from Ceres.

From this myth we understand that the art of grain grinding, a contemporary of agriculture and proceeding from one and the same deity, has its origin in the same depth of ages as the cultivation of corn.

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[1] Pliny the Elder (A.D. 23–79), *Historia Naturalis*.

A Spartan tradition ascribes the art of making flour to Miles, and says that the chief milling town in Greece of that epoch was Alesia.

According to Hommel,[1] Asia is the native country of the cultivated cereals. He maintains that the Sumerians coming to Egypt from Mesopotamia, eight thousand years ago, had a great influence on the culture of Egypt, having taught the aborigines to procure and work metals and cultivate corn.

About the grinding instruments of the pre-mythological ages the traditions give us no information, but relics of the classical and the Egyptian culture exist, which can give us an idea what the antique Egyptian machine was like.

Excavations and the hieroglyphics of the ancient Egyptians indicate that the primitive milling implements were first wooden, then stone, and later on metal mortars, in which the grain was crushed by blows from pestles. Fig. 1 shows the whole process of flour-making by the Egyptians. This drawing is a reproduction from one of the pictures that decorated the house walls in the town of Thebes, according to Wilkinson's *Account of the Ancient Egyptians.*

FIG. 1.—Grinding in Ancient Egypt.

The mortars here are marked *a*, the pestles with two working ends *b*, the basket of grain or semi-product *d*, the basket of ready flour *c*. The loading (*I*) is done by a man, who pours the grain out of the vessel *g* into the mortar. Two men (*II*) are grinding; one (*III*) is emptying the crushed grain out of the mortar into a sieve; the last man (*IV*) is sifting. The sifting of crudely-crushed grain was known apparently even in these very remote times. The sieve *e*, a kind of rudely-shaped plate, was probably made of papyrus.

On either side of the bas-relief at the top are hieroglyphic inscriptions *h* and *l*, explaining the meaning of the picture. It is supposed that the

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[1] Fr. Hommel, *Prehistorische Indo-Europeer.*

ancient Egyptians roasted or heated the grain until dry, previous to grinding it. That is very possible, as the dryer the grain is, the more easily it is broken by blows from the pestle.

The same type of the primitive mill existed in ancient Greece, and some of the excavated vases bear the drawing of a similar mortar and pestle. Besides that, Pliny gives us a description of apparently similar mills in Greece, saying that "in Etruria, the ears of corn are roasted, and then crushed by means of pestles with sharp saw-like edges below and a cogged wheel in the middle." And yet the primitive milling in Etruria required technical knowledge, for Pliny says (*ibid.*) if the work was done carelessly, the grain was crushed more finely than was necessary and the iron parts of the pestle were soon worn out or broken.

FIG. 2.—Negro Milling at the Present Time in Africa.

But what strikes us most is the fact that after thousands of years living relics of antique Egyptian technics are found. Some of the negro tribes in the valley of the Nile use the mortar and pestle for grain grinding at the present day. The photograph (Fig. 2) shows a striking likeness between the milling of a negro tribe near Khartum[1] and that of ancient Egypt. Here are the same two baskets—one with grain, the other for flour—a stone mortar, and

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[1] Elisée Reclus, *L'Homme et la Terre*, vol. ii.

wooden pounder. There is but a sieve wanting to make the picture identical.

In China, where traditions of great antiquity, concerning gramen, the gift of gods, also exist, wheat was cultivated 2700 years B.C. and the ancient Egyptian type of grinding machine was in use. Until recently, in many parts of China the mortar and pestle were used for clipping and polishing rice, *i.e.* freeing it of the coatings. In several out-of-the-way places in that country, wheat is still crushed to a coarse flour in that mortar. Fig. 3 represents such a mill supplied with a foot drive.[1]

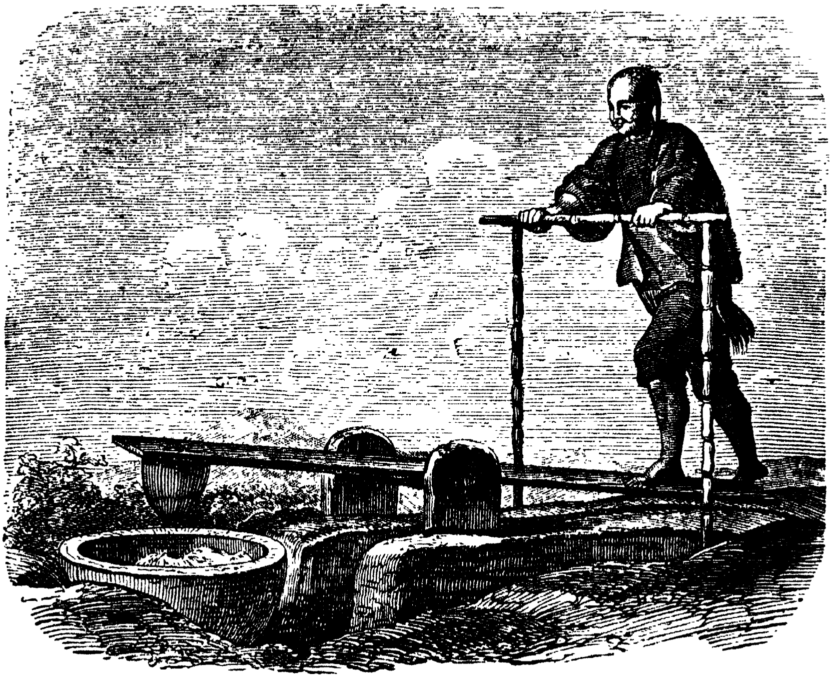

FIG. 3.—A Chinese Mill of the most Ancient Type.

An interesting mill of a similar type, but driven by water, is described by Bridd[2] in the *American Miller.*

This mill (Fig. 4) is used by the Indians, who settled in the state of Kentucky, for maize-grinding. The mortar is hollowed out in a tree stump. A lever, with a stone pestle attached to one end, and a box to the other, is placed on a fork. A jet of water from a stream is conducted along a groove into the box. When the box is filled with water, outweighing the stone, it drops to the lower position, the water runs out

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[1] Staunton, British Ambassador in China. His Report to the Embassy 1797.

[2] *American Miller,* 1907.

of the box, and the pestle falls quickly into the mortar, crushing the grain. The capacity of the mortar is about 28 lbs. of grain; that quantity is ground in eight to ten hours.

The mill, consisting of a mortar and pestle, belongs to the first period of prehistoric technics.

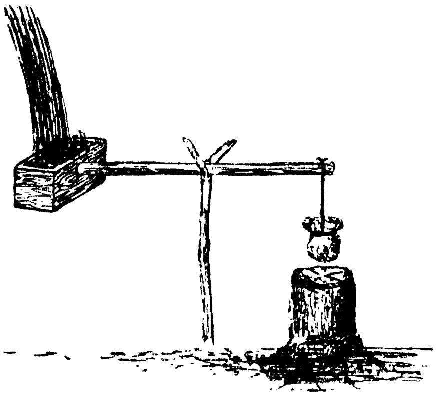

FIG. 4.—Indian Water-mill in Kentucky.

The next stage of its development is a transitory type from the mortar and pestle to two millstones, between which the grain is ground.

The primitive type of such a mill[1] was produced apparently also in Egypt (Fig. 5). The grain was ground on the larger stone by means of the small one.

We find this mill nowadays in the hands of the natives of Africa in the Nile Valley. Fig. 6 represents a negress preparing flour in the same manner Egyptians did some 4000 years ago. Fig. 7 shows the up-to-date milling of the Nubians. The work is performed by children here.

It is curious to note that the same principle of milling has been retained, up to this day, by the Mexican Indians, who are considered to be the descendants of the Aztecs. Fig. 8 reproduces that "mill" used by Mexican Indians of to-day; they grind their corn on it.

These illustrations of primitive grain-crushing show us how slowly ancient man acquired the principles of a more economical system.

FIG. 5.—Ancient Egyptian Milling.

The mill of the first type is very simple—it is based on the *impact principle*. The primeval man had no difficulty in coming upon this principle, knowing, as he did, the destructive power of a blow and the

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[1] Photo of a stone implement found at the excavations in Upper Egypt.

solidity of stone, for he fashioned his axes and arrowheads from that material.

But gradually the human mind became conscious that such work is not efficient. It is evident, besides, that the blows of the pestle, by degrees, wear out the mortar and the pestle itself.

Thus the question of the greatest efficiency of work and of a better constructed machine arises. The impact principle is rejected, and that of *grinding* is adopted.

That principle was adhered to in the mills of the improved type, that might be called "grinding mills," for thousands of years.

When the mills consisting of two grindstones appeared is not known. At any rate, it may be supposed that they made their appearance in Egypt, and 3500 years before our time at the very latest. The Jews, leaving Egypt, doubtless brought much technical knowledge of various productions out with them.

FIG. 6.—Negro Milling to-day in the Nile Valley.

FIG. 7.—Modern Milling: Natives of Nubia.

It was from the Egyptians that they learned to grind their grain to flour on millstones. We find traces of that fact in the fifth book of Moses (xxiv. 6), where it is written, "No man shall take the nether or the upper millstone to pledge." Evidently the grindstone mill was an indispensable utensil of a Hebrew household during their searches for the blessed land, since Moses forbade by law loans on the pledge of a millstone.

In the fourth book of Moses (xi. 8) the heavenly manna is spoken of in the following terms; "And the people went about and gathered it in mills, or beat it in a mortar."

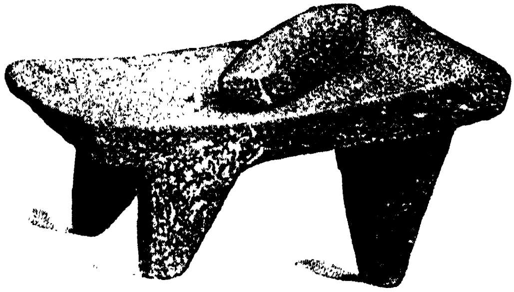

FIG. 8.—A Mill of the Mexican Indians.

The contemporary use of the mortar and grinding mill points to the period of the migration of the Jews, as the beginning of the use of grinding mills, which at the time had not yet succeeded in supplanting the pestle and mortar.

Grinding mills are spoken of more definitely (about 1000 years B.C.) in Homer's Odyssey (song 7, vv. 103, 104), where domestic life at the court of King Alcinous is described: [1]

> "Full fifty handmaids form the household train;
> Some turn the mill, or sift the golden grain."

and then canto 20, vv. 105–111: [2]

> "Beneath a pile that close the dome adjoin'd,
> Twelve female slaves the gift of Ceres grind;
> Task'd for the royal board to bolt the bran
> From the pure flour (the growth and strength of man).
> Discharging to the day the labour due,
> Now early to repose the rest withdrew;
> One maid, unequal to the task assign'd,
> Still turned the toilsome mill with anxious mind."

The grindstones of those mills were very small, a proof of which is to be found in the fact of ancient heroes using them as missiles for throwing at their enemies during battle.

A stone of this description weighs some 45 lbs., and does not exceed 1 foot in diameter. The upper stone, slightly conical, is 4½ inches thick. The nether one is flat and 2½ inches thick. Such stones are disinterred in Abbeville (Picardy). Fig. 9 shows grindstones belonging to an age not

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[1] Pope's translation, p. 12, Odyssey, Book VII, ll. 132, 133.
[2] *Ibid.*, Book XX, ll. 132–139.

distant from that of Homer (found in Syria). The working surfaces of the upper and nether stones are of conic shape. Later on, we shall find proof that this mill was the predecessor of that of the Romans.

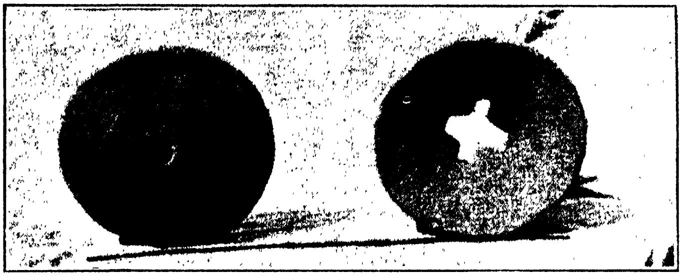

FIG. 9.—Millstones of the Age of Homer.

We ventured the opinion that the double stone mill was invented in ancient Egypt, and then brought into Greece. Indeed, the kind of mill described by Homer is still used in Morocco.

FIG. 10.—Milling by the Natives of Morocco.

These mills are also in use in the Orient and in China. A celebrated traveller and explorer of the Orient, Journefause, says he saw a similar mill on the isle of Nicaria. Giving a description of it, he tells us that the grain was poured into an aperture in the upper stone and fell in between the two stones. The upper stone (2 feet in diameter) was made to rotate by means of a stick fixed into its edge.

Similar millstones are mentioned by Clark, who saw them in Nazareth; they were worked by two women. One of them was turning the upper stone, taking the handle with her right hand half way round, and passing the handle to the second woman, who after performing the same motion, returned it to the first from the other side, &c. With their left hands they poured the grain into the hole in the upper stone.

The Chinese rice-mills are of the same construction according to Staunton, though designed not for the grinding of grain, but for freeing it of its outer cover. He describes it in the following manner: "The rice is placed in between two flat cylindric stones, which are so far apart that with the rotation of the upper stone the grain is but freed of its covering, and not ground."

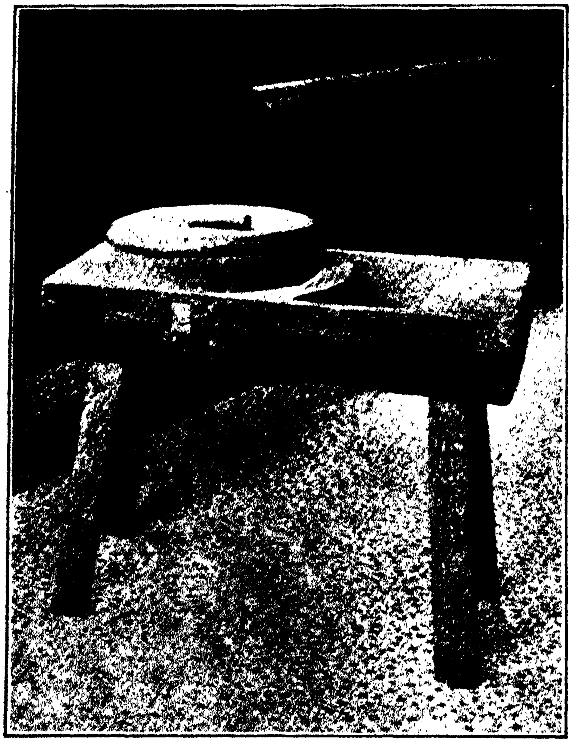

Fig. 11.—A Hand-Millstone Set of the Caucasian "Dukhobors."

The type of hand-mill alluded to by Moses and Homer is still preserved among the natives of Morocco. Fig. 10 is a photograph of such a mill, made in 1908.

But not only the semi-savage aborigines of Africa use these mills; Fig. 11 shows us an almost identical hand-mill, with a few improvements, that the "Dukhobors" from the Caucasus used, before migrating to America.

The improvements in this mill, when compared to the Morocco one, consist in the fixing of the stones to a block hollowed out in the shape of a trough. The hole *a*, bored in the side of the trough, serves for discharging the flour.

This type of hand-mill brings us to the end of the first period of milling technics of the antique, mainly slave-owning culture. The consumption of bread not being high, there was no need for large production of it, and therefore the milling was successfully performed by slaves and women.

The work being very difficult, criminals were condemned to do it for punishment.

As to the woman, it was one of the items of her ordinary household work.[1]

To this day, in Mecca, a place is shown where Fatima, daughter of Mohammed, worked a hand-mill.

II

Types of Mills Driven by Animal Power

The new mill, where mainly animal power and only partly human power is utilised, appears with the passing of flour milling from the family, which only satisfied its private needs, into the hands of the producer, working for the market.

The principle of grinding the grain between two millstones remains in the new mill, but it is larger, and has undergone some modification in its construction tending to reduce the expenditure of power. This mill was invented at a later period, yet we find no traces of it among the relics of antique Egyptian, Roman, and Greek cultures. Only the latest excavations of Pompeii have given us pictures of the improved mill of the time of Roman dominion, as well as nearly perfectly preserved millstones. In all probability this type of mill was invented by the Romans at least 150 to 200 years B.C.

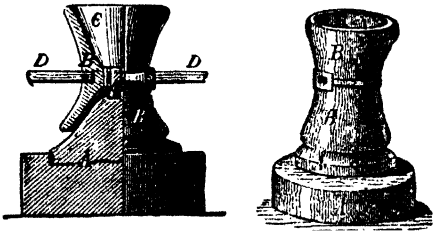

Fig. 12 —Mill of the Period of the Kings of Rome.

Fig. 12 represents the outer view of the mill in question, and the same in section.

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[1] It is a curious fact that in Little Russia, millet is still ground with a "makogon" in a "makitra" (pestle and mortar) to flour, for preparing "borshch" (a kind of soup), because millet meal is not produced on our mills.

The foundation of the Roman mill consists of a cylindrical pillow of stone. *A* is about 5 feet in diameter and 1 foot thick. To this foundation is rigidly fixed a conic stone (the nether stone—"meta") with the top truncated about 2 feet in height. The cone is provided with an iron journal at the top. The revolving upper stone ("catillus") *B* has two bell-shaped hollows, thus resembling a sand-glass.

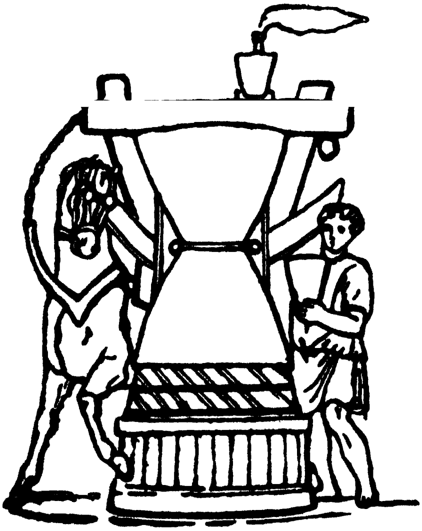

FIG. 13.—Roman Mill turned by a Horse.

In the place where the tops of the bells are joined an iron cross beam is fixed, like a dove-tail in shape at the ends.

In the middle of this beam is a round hole, into which the journal is inserted, so that in between the inner sides of the lower bell and the outer surface of the cone there is just the space needed for grinding the grain which is put there. The grain is poured into the hollow *C* of the upper bell *B*, acting the part of hopper, from whence it falls into the space between the grinding surfaces. The upper stone is revolved by means of levers *D*, which are inserted into the two or four rectangular cavities made in it.

FIG. 14.—Roman Mill driven by Slaves and Asses.

The product is discharged into the ring-shaped groove below, made on the surface of the foundation.

We have detailed information concerning the nature of stones used in milling from Pliny. Judging by his descriptions, it was known that not every stone can be used for milling purposes. The grindstones of the Pompeian mills were shaped of lava from Vesuvius. Coarse and fine sieves, made of horse-hair and linen, were used for separating the flour from the bran and whole grains that passed unground. There were usually

FIG. 15.—Pompeian Mills.

FIG. 16.—A Chinese Mill.

several kinds of flour known on the market. He mentions even the number of flour grades and refuse obtained from one medimnum holding 108 laurels, viz. :

Flour of finest quality (pollen)	17 laurels.
Flour of medium quality (similago) . . .	50 ,,
Flour of semolina, 1st quality (farini tritici) . .	30⅓ ,,
Flour of semolina, 2nd quality (secundarii panis) .	2½ ,,
Flour of semolina, 3rd quality (cibarii panis) .	2½ ,,
Bran (furfur)	3 ,,
Various refuse	2⅓ ,,
Total	108 laurels.

It was mentioned above that working the mill was the occupation of women, chiefly female slaves. Men were employed in that work later—serfs and criminals, sometimes forced to wear wooden discs round their necks, to prevent any possibility of reaching their mouth with the hand and eating the flour.

Fig. 17.—A Hindoo Mill.

After it was discovered that larger and heavier stones work with greater efficiency, animal power was put to use, especially that of horses and asses.

For that purpose a fencing of beams with shafts for the harnessing of horses was arranged round the runner, as shown in Fig. 13, which represents part of a bas-relief in the Vatican. Blinkers were placed on the eyes of the animals, probably to prevent giddiness.

The mill driven by an ass is reproduced in a book on *Herculaneum and Pompeii*, by Rou-Barre (vol. 2, tab. 83). This drawing was made from a picture at the entrance to the Pompeian Pantheon. Besides the mill there are the mill-demons shown in the picture.[1] The mill is in the middle of the picture, and seven spirits are seen round about it, some working, others resting from their work over a glass of wine. One of the spirits is about to harness an ass and to start his work. Fig. 14 shows a similar mill at work. Fig. 15 is a photograph of four such mills after their disinterment, in perspective. Those mills were found close to a bakery, and probably formed a complete bread factory.

Mills with a lever-drive evidently kept their place a long time in milling. They are to be met with in the classic world as well as in the far Orient. A Chinese mill, worked with the aid of a horizontal lever by a man, is represented in Fig. 16.

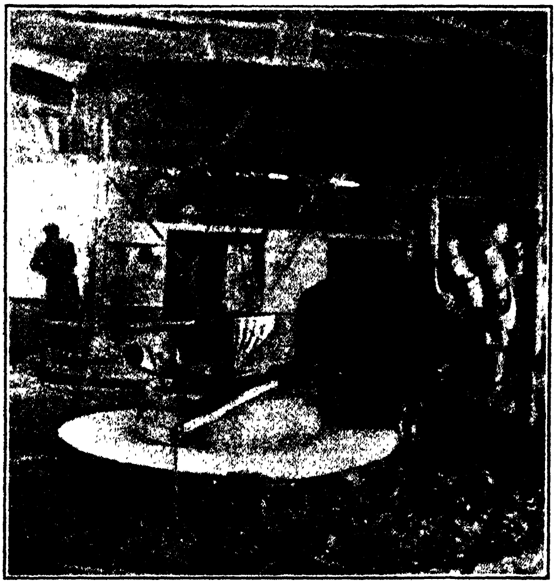

Fig. 18.—A Chinese Mill worked by Buffaloes.

Fig. 17 is a picture of a Hindoo mill driven by oxen. Though it is furnished with a lever-drive, the primitive mortar and pestle system has been retained here. The crushing of grain, however, is based on the principle of grinding. This mill was described by the traveller Sonerat in his book, *Reise nach Ostindien und China.*

Animal power is still used in modern China for driving mills. Fig. 18 shows a mill driven by buffaloes. Yet we must note that modern Chinese mills, where buffaloes are employed as motive power, have received considerable improvements, in comparison with those of the Romans.

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[1] A belief that an unholy power lives in the mill exists also among the Slavs.

III

THE UTILISATION OF WATER POWER FOR MILLS

As the construction of a mill grew heavier, in response to the need of greater output, men were forced to apply a greater driving power, which should be more efficacious than the muscles of a slave, woman, or animal. Naturally, they turned to water and air first of all, and utilised the power of these moving elements.

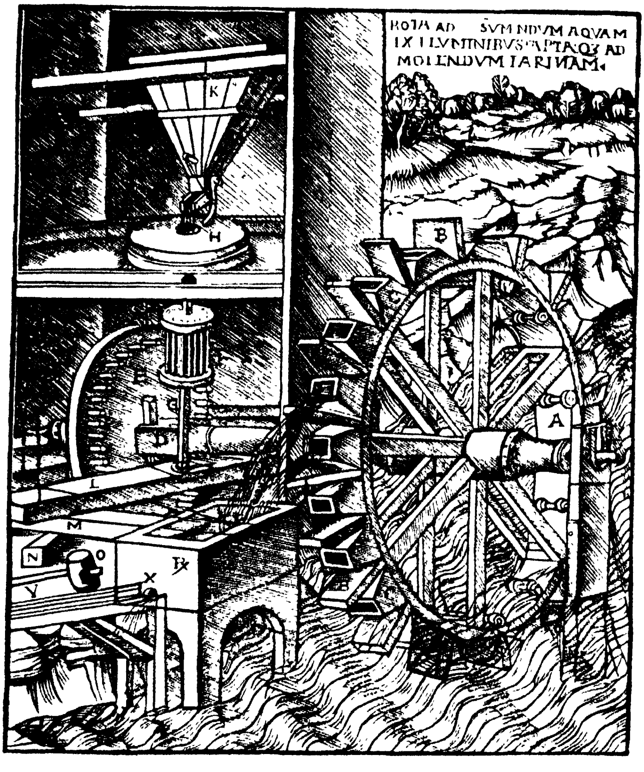

FIG. 19.—A Water-mill as described by Vitruvius.

The first veracious information concerning mills driven by means of under-shot water-wheels, and a minute explanation of their construction, we find in Vitruvius.[1]

It is to be regretted that Vitruvius in his immense work about the art of building did not furnish it with drawings; all illustrations given in some of the later editions of his work, are only attempts to depict what he described.

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[1] Vitruvius, a Roman architect, wrote *De Architecturâ* about 16–13 years B.C.

Such is the drawing in Fig. 19, taken from an edition of Vitruvius' work, published in 1521 in Camo, in Old Italian.

Here *A* represents a wooden water-wheel. On its rim are radially-fixed paddles *B*, receiving the pressure of moving water, and boxes or ladles *C*, which serve to bring up the water used for special purposes.[1] The shaft of the water-wheel is turned with the long end inwards. On the square part of the shaft *D* is fixed a comb-wheel *E* engaged with a mangle gear. The cogs of the collar comb-wheel enter into the mangle wheel *F*, set on *G*, the spindle of the millstone, which rests with its lower end on a beam *L*, the upper end passing through a fixed (not shown in the drawing) lower grindstone, and is hermetically fastened to the runner *H*, into the opening of which the product to be ground is poured. The latter is fed from a pyramidal hopper *K*, where the grain is kept. The lower opening of the hopper is furnished with an adjustable vibrating shoe.

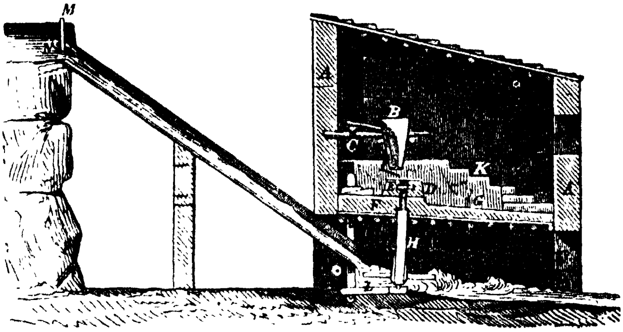

FIG. 20.—Arabian Water-mill.

The water lifted by the wheel *A* pours out of the boxes *C* into a tank *R*, whence through an opening *X* it passes into the spout *Y*, and may be used for irrigation. Possibly a fullery was attached to the mill, which may explain the presence of a hammer *O* in the drawing, though it may have been used for hammering a stopper into the outlet *X*.

We may suppose the use of horizontal water-wheels or turbines on mills to be nearly as old as the use of vertical water-wheels. Simple turbines are found in mountainous regions in almost all lands where the population is slightly touched by civilisation, however low their mechanics may stand.

Fig. 20 proves this surmise to be correct. It is a drawing of an Arabian water-mill, made at Rollet's by a captain of the French artillery soon after the taking of Constantinople by the French. *A* denotes the wall of the mill-building, *B* the hopper for pouring the grain in, *C* a cross bar communicating a vibratory motion to the hopper, *D* a revolving grindstone (making 112 revolutions in the present case), *E* the spindle of the grindstone, *F* masonry serving as nether stone at the same time,

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[1] Probably for irrigation.

G a cavity, where the ground product (flour semolina) is collected, *H* a shaft on which a turbine *I* is mounted, *K* a ladder, *L* a lever for the runner *D*, *M* a gate in front of the spout *N*. It is also mentioned that the turbine is 1·6 metres in diameter, and is furnished with thirty paddles.

With the aid of a spout, through a small opening in the dam, the water is directed on to one half of that wheel, so that it falls into the concave side of the paddles bringing the wheel, the shaft *H*, and grinder *D* into motion.

As to horizontal water-wheels in the mills, M. Rühlmann quotes an extract from the French encyclopædia.

In the 14th vol. of the *Dictionnaire Technologique*, p. 207, it is stated that horizontal water-wheels in the so-called bazacle mills in Tumra were built in the twelfth century (1190).

Then, in the issue of *Neues Hannoversches Magasin* on October' 4, 1802, p. 1277, is the following description of a Bashkir mill that was evidently a contemporary of the vessel mills of Belisarius:

"The Bashkirs have mills of a peculiar construction, apparently an invention of the people. With the view of economising labour, they choose the smallest rivulets for their mills, make a hedge of twigs which is filled with earth, and dam the stream with it (or an ordinary dyke of brushwood). On the dyke is built a hut on piles. In that hut grindstones are placed on a scaffolding standing in the middle with railings running round its edge. The grinders are not of stone, but of a hard tree stump or block of wood, and are shaped in the form of plates, studded in an orderless way with flat iron nails, so laid that their prominent parts run lengthways from the centre to the periphery. The nether wooden grinder is rigidly attached to the scaffolding, while the upper one may be raised and revolves conjointly with the vertical shaft that runs through the opening in the nether grinder and rests with the point of an iron crutch in a cavity made in the centre of the upper grinder. The vertical shaft is usually made of one block of wood, so that its lower part ends in a round thick knob, into which a good number of flat wings or paddles, slightly concave on one side, may be hammered in a manner resembling the spokes in a wheel, and forming the water-wheel proper. A bolt is hammered into the thick end of the shaft below, by means of which the vertical shaft rests in the rivulet on a beam and revolves in it, as in a bearing.

"The grain to be ground into semolina or coarse flour is poured into a hopper built of planks. Under the opening of that hopper, a short horizontal spout is placed, leading to the opening in the middle of the upper grinding disk. The corn-bin with grain is hung to the cross-beam of the mill, free to be shifted. A handle, tied to the corn-bin, which touches the upper grinder with one end, imparts a vibrating motion to it."

We presume, however, that the author errs in ascribing the invention of this mill, with a horizontal water-wheel, to the Bashkirs. From the oldest times and up to this day, such a mill is a common object in the Caucasus. Possibly the author has mistaken the natives of Caucasus for Bashkirs.

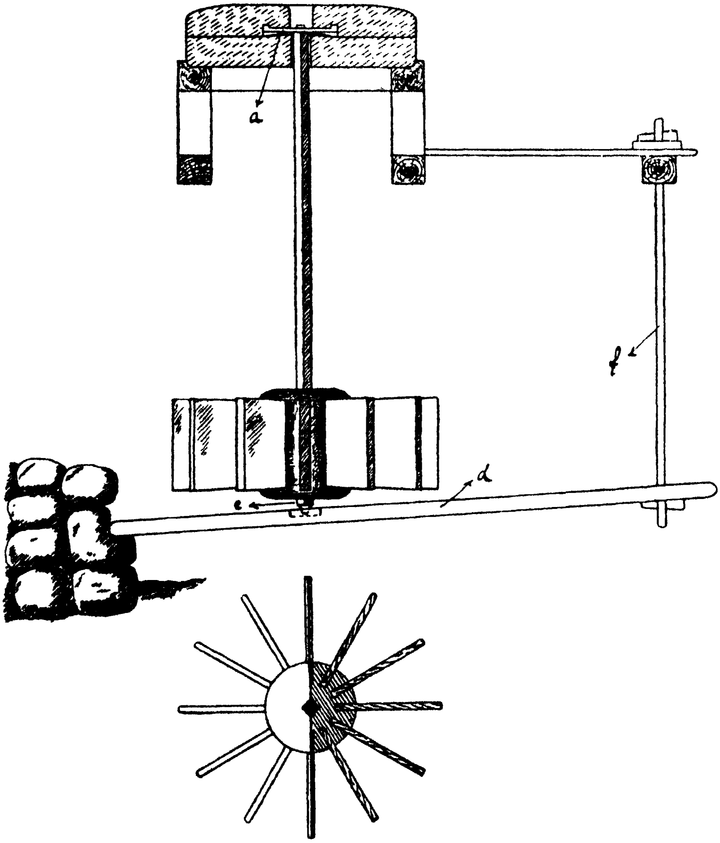

Fig. 21.

The mountaineers, and even the people of the plains of the northern Caucasus, chiefly use maize flour, of which an unleavened bread is prepared, "Chureck." Wheat is also ground, but is used only with an admixture of maize flour, as the use of pure wheat flour is a luxury among the natives. The whole amount of maize and wheat is ground for local consumption in the water-mills depicted in 1802 by the *Neues Hannoverches Magasin.*

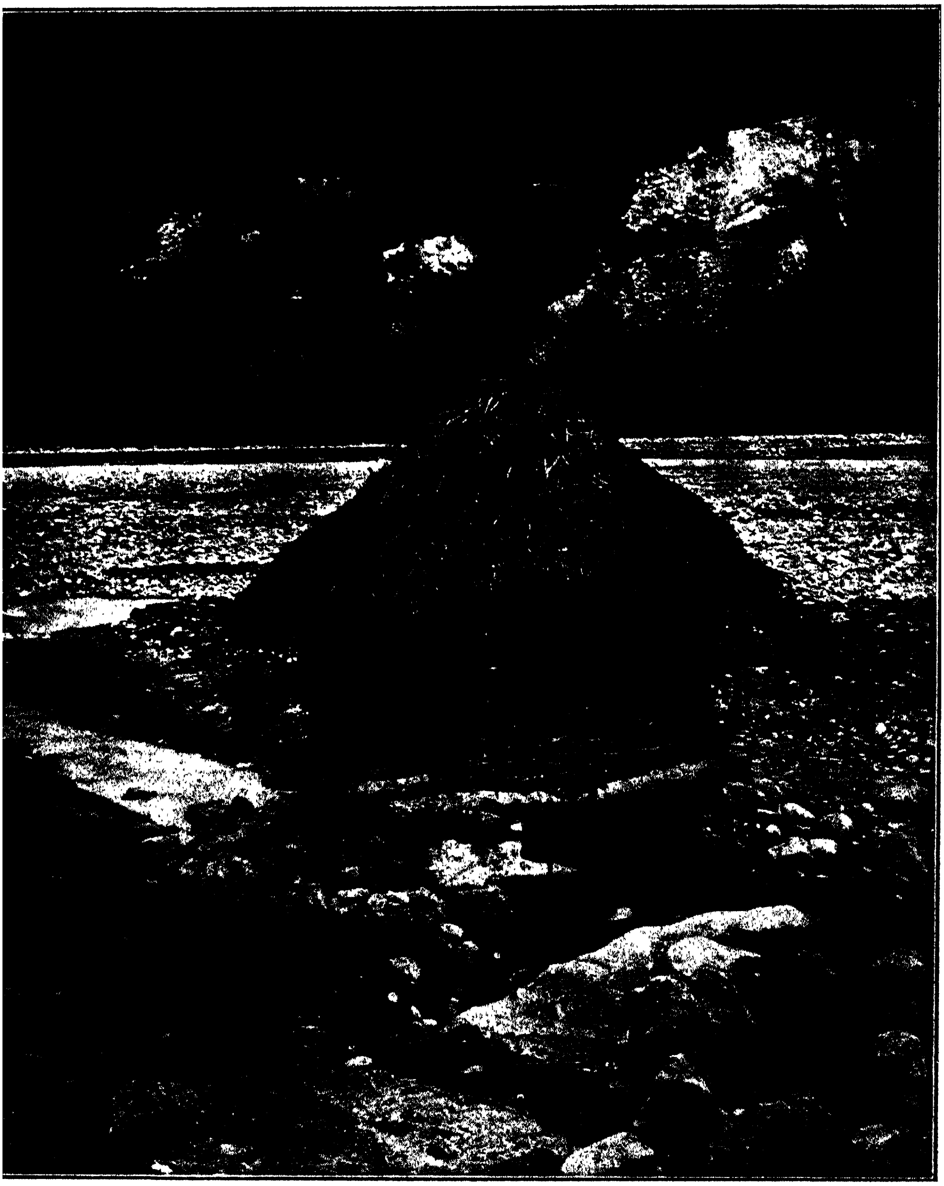

FIG. 22.—A Caucasian Mill with one Set of Grinders.

Fig. 21 is a sketch of this mill. The shaft of a horizontal water-wheel rests with one end *e* on a step-bearing in the shaft *d*, which may rise and fall with the aid of a stem *f* and a wedge in its upper end. To the upper end of the shaft is fixed a runner by means of a driving iron *a*. On the lower end of the shaft is set a wooden hub furnished with ten to twelve paddles.

The number of revolutions of the water-wheel is from forty to eighty per minute, the fall of the water being 3⅓ to 7 feet. The diameter of the grinders is 1½ to 3½ feet, the thickness 3⅓ to 7 inches.

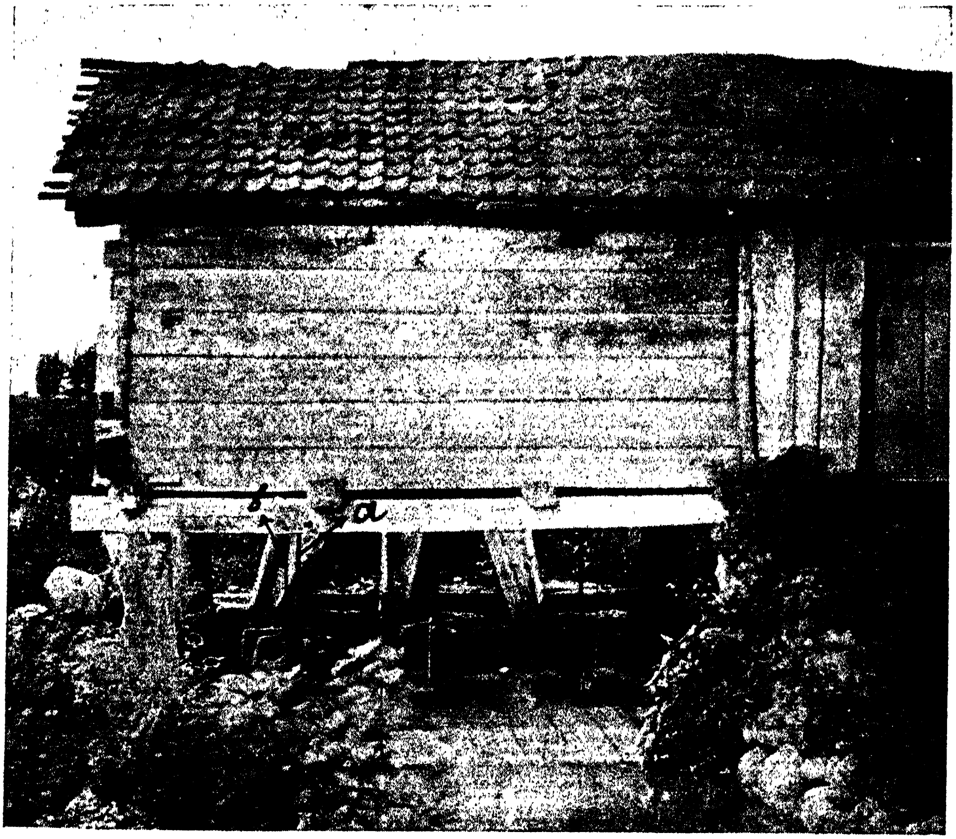

FIG. 23.—A Caucasian Mill with three Sets of Grinders.

These mills are usually furnished with one burr, and are built on mountain brooks. Their capacity varies from 1 to 8 or 10 poods[1] per day.

Fig. 22 is a photograph of such a mill, with a single set of grinders. It is of brushwood wicker-work, with a thatched roof. Fig. 23 shows a mill with three sets of grinders, and lastly, Fig. 24 gives us a view of nine such mills, situated along a mountain torrent, clinging to the mountain side like swallow nests.

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[1] 1 pood = 36 lbs.

In these mills the work is usually performed by women. This type of water-wheel became known in France and Germany only in the fifteenth century. Therefore, the supposition that these mills were brought to Europe by the crusaders at the end of the thirteenth century is quite just.

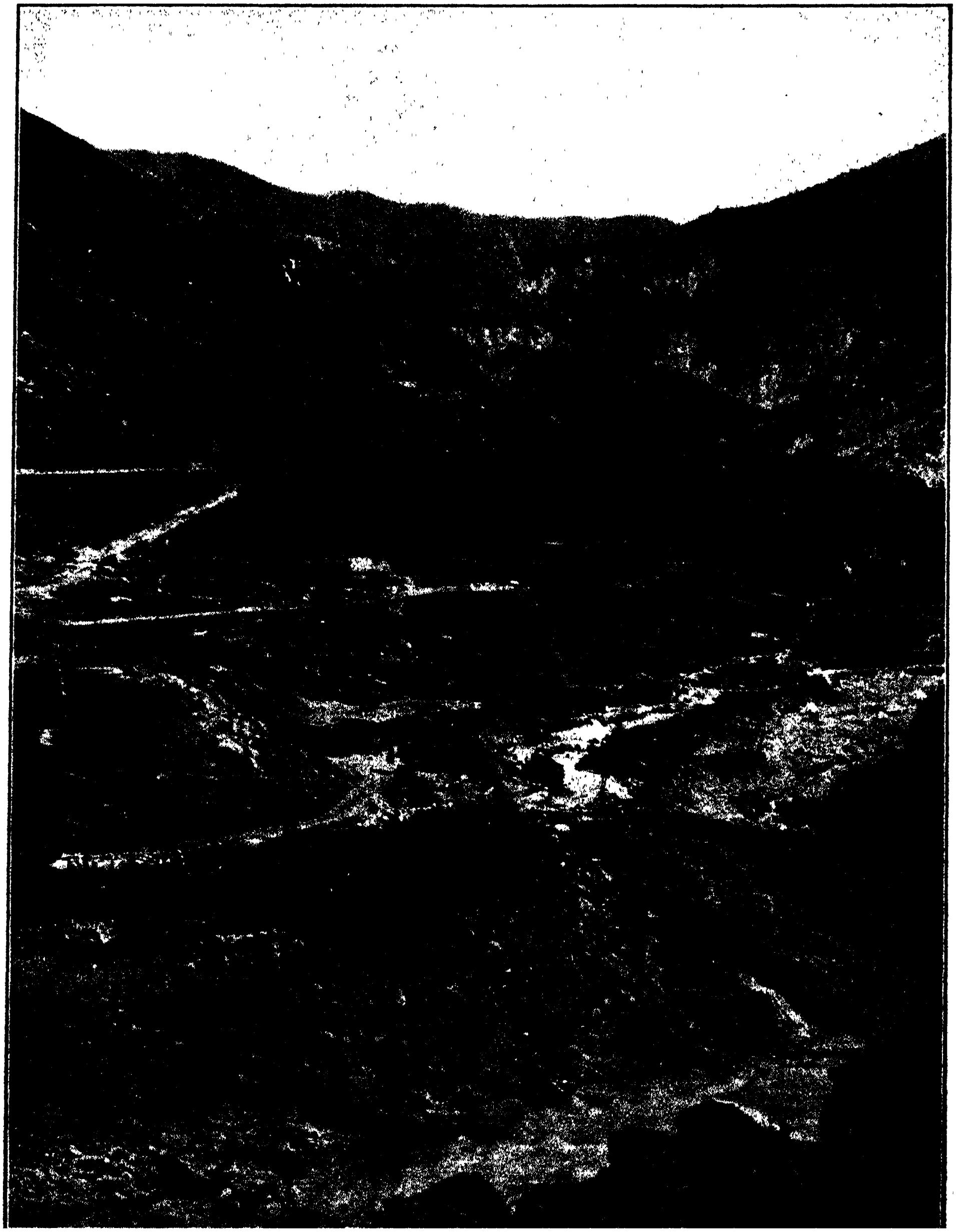

FIG. 24.—A Row of Mills along a Mountain River.

IV

THE AMERICAN AUTOMATIC MILL

A strong impetus was given to the development of milling technics in Europe by the Americans. The idea of an automatic mill, as of many other improvements in machines connected with the principle of automatism, belongs to them.

It is astonishing, but a fact nevertheless, that the discovery of the French quarry "La Ferté-sous-Jouarre," producing the famous French stones, was made by the Americans. That stone was used in America for making grinders a long time before it became known to the French millers.

The Americans threw away the sifting bag of the old European mill, and substituted for it cylindrical and polygonal reel-separators, which are also American inventions. For the transportation of the product the Americans adapted elevators and conveyors. For the cooling of flour special apparatus called hopperboys were planned. The flaxen tissue in sifting bags was supplanted first by wool, then by wire, and lastly by silken tissue.

Thus everything tending to progress in the technics of the furnishing of mills in the end of the eighteenth and first quarter of the nineteenth centuries belongs to the initiative of the Americans. For nearly forty years, up to the thirties of last century, the teacher of the Europeans was the celebrated American engineer, Oliver Evans, whose book has passed into thirteen editions,[1] and was translated into French and German.

In the review of European mill building the great influence of America on Europe in that respect will be pointed out. At present, we shall give a description of a typical American automatic mill, the design of which was completed by Evans as early as 1783.

Fig. 25 illustrates the whole process of milling in a longitudinal section of Evans' mill (Evans' automatic mill).

The mill is situated on a river. The reception of the grain is effected either by means of an elevator from a vessel, or from carts brought up to the mill. We shall first examine the reception from carts.

The grain is poured out of sacks down spout 1 on to a scale 2. After being weighed it is let down into the grain bin 3 (black pit), and thence through spout *t* conducted to the elevator 4–5, which supplies the large bin 6. Part of the floor below 6 is also occupied by bins, ending in a

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[1] Oliver Evans, *The Young Millwright and Miller's Guide*, the thirteenth and last edition published in Philadelphia, 1850.

pyramidal bin 7, on the next floor but one below. Out of bin 7 the grain passes through the hopper 8 into the burr, the purpose of which is to rub off the outer husk, remove the germ and dirt. Consequently this grinder is the same as the German Spitzgang. The grain, comparatively cleaned of husk, germ, and dirt, is aspirated in passing out of the grinder, the clean grain falling again into bin 3 (no dirty grain is mixed with it, as it was all passed into bin 6), the heavy refuse into bin 9 lying below, while the air and light refuse are blown out through an opening in the bin 9*a*. In proportion to the freeing of the grain of its husk, it is taken by the same elevator 4–5, this time into bins 10 and 11. From these bins it is conveyed into the reel-separator 12, where the small grain and chaff are sifted away. The throughs of that separator are fanned, therefore the good grain falls into bin 14, the light kernels and chaff are blown by the ventilator into bin 32, and still lighter refuse into bin 33.

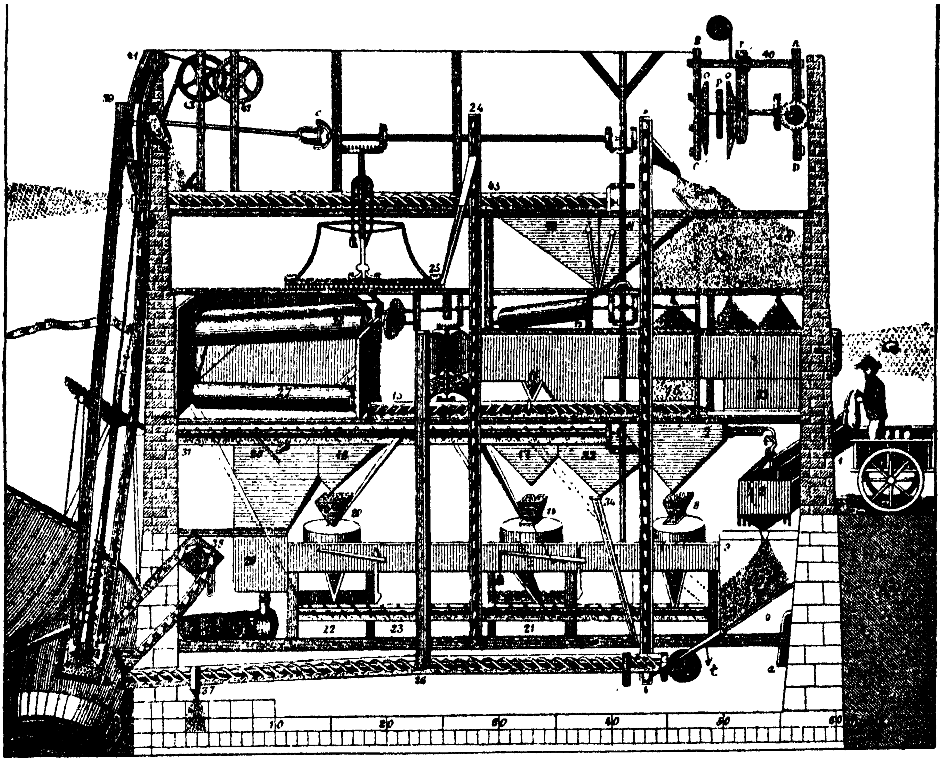

FIG. 25.

Out of bin 14 the cleaned grain passes into conveyor 15–16 with paddles right and left, which discharges the grain into conveyor boxes 17, 7, 18, which feed the grinders 8, 19, 20.

After the grinding the product is conducted into the common conveyor 21–22 and then into elevator 23–24, which passes it into the hopperboy 25, a kind of flour mixer designed by the Americans for the purpose of cooling the product. On leaving the hopperboy, the flour flows first on to two cylindrical reel-separators 26, where the throughs are conveyed into bins 28 and 29 with a chamber for flour, and the refuse left on them is once more sifted on the controlling separator 27. The refuse from separator 27 is taken by conveyor 31 either to bin 32 to the light kernels and chaff, and then reground on grinder 8, or ground apart.

Thus we have a complete automaton, with grain-cleaning and repeated grinding of the product, if needed.

The principle of sorting the product according to quality was known to Americans long before the Europeans learned of it, and effected with much greater success. It is necessary to describe the sorting cylinder 12, where the coarse impurities as well as chaff or small grains are sorted away (Fig. 26).

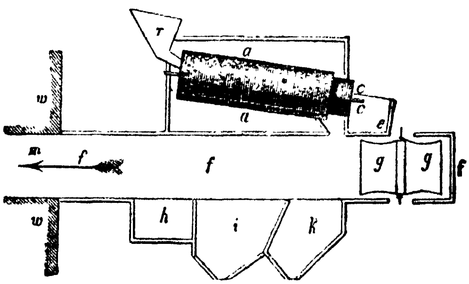

FIG. 26.

This cylindrical reel-separator is an invention of Evans (called "Rolling Screen and Fan"), and works in the following manner: out of the conveyor box *r* the grain flows into the inner cylinder *b* concentric to cylinder *a*. The meshes in the cloth of cylinder *a* are smaller than the grain, those of cylinder *b* larger. The two sieves are joined to each other. The refuse of sieve *b*, large admixtures, passes into box *e*, the throughs into sieve *a*. The refuse of sieve *a*, the good grain, flows into bin *k*, and the throughs, fine dust, &c., fall through a crevice in the air-pipe. The grain and throughs are subjected to the effect of a current of air blown by fan *g* along *f*. The dust is carried out and the heavy refuse falls into bins *i* and *h*.

The diameters of these cylinders are 2, 5, and 3 feet; the number of revolutions 15 to 18 per minute.

When the mill is supplied with grain from a barge or vessel, the reception is accomplished by an elevator, 39, which ascends and descends with the aid of chain sheaves 42–43. The elevator pours the grain into the conveyor 45, which carries it into bins 10 and 11, the conveyor being exhausted the while. The dusty air is discharged out of the conveyor 45 on its left side, and out of the grain-cleaning chamber of the mill through the outlet Q.

V

THE INFLUENCE OF AMERICAN TECHNICS IN EUROPE

In the civilised countries of Western Europe for many centuries the system of a single milling passage reigned, and is still adhered to, in peasant windmills. In those mills both grain and husks were ground in millstones, and the flour was sifted through hand-sieves of horsehair preparatory to baking. Some 250 years ago the sifting bag was adapted to the mill and performed the work of a sifting apparatus.

Over 150 years have elapsed since the French technics introduced a new style of milling—the repeating type (*mouture économique*), which is beginning slowly to spread in Europe.

Up to the end of the eighteenth century the milling technics of Europe remained the same with scarcely any alterations, there being no motive cause for progress, either in social organisation or in the trade-corporation industry. Flour mills were working almost exclusively to supply local needs, and seldom for neighbouring districts.

The last quarter of the eighteenth century witnessed the beginning of the gigantic breaking up of the economic structure of feudal Europe, caused by three powerful historical factors, which brought about a new era of progress. Those factors were: the perfecting of Watt's steam-engine, the struggle for liberty in America, and the French Revolution. Technical progress and the victory of the middle-class over the feudal system in Europe rendered possible the organisation of industry on new principles of production, those of capital.

The first country benefited by the principle of capitalism in the flour-milling sphere was America, as the production of flour in the United States required a great number of mills. The want of hands and the high wages forced the Americans to have recourse to a rational technical organisation of production.

To that end, in the beginning of the nineteenth century hundreds of automatic mills, similar to the one described, were built in America, chiefly in the state of Pennsylvania and along the river Mississippi.

The influence of American milling technics became noticeable first in the English milling industry, partly by reason of their economic relations, which were closer between these two countries than between the others, partly owing to their common tongue. Yet that influence commenced only after 1781, as is proved by the fact that the most reliable English work of the time (*Rees' Cyclopædia*) in its chapter on flour milling[1] gives a detailed description of English mills, in which no mill of American type is mentioned. It also speaks of a celebrated English engineer, Smitton, who built in 1781, in Deptford, a mill for the needs of the fleet, called by him "The Steam Mill," according to his own system that he had worked out as early as 1754. The motor adapted by Smitton was Newcomen's steam pump, which pumped water into tanks, placed at a sufficient height.

The water, flowing from these tanks on to the water-wheels, worked the mill.

At the end of 1782, Watt had so far perfected his steam-engine, that it was possible to adapt it for immediate use in working a factory. In 1785 was built the first steam-mill in London close to Blackfriars' Bridge, which was called Albion Mills. It was built and arranged by the engineer John Rennie, and the Watt's steam-engine was purveyed by the works of Boulton & Watt, in Soho. The mill only began operating in 1786, having ten millstones for wheat grinding.

The capacity of the steam-engine was 50 h.p., 1 h.p. grinding 63 lbs. of wheat per hour, and burning about 3½ cwt. of coal per hour! But even that great expenditure of fuel was considered to be very profitable, and, judging by the results of milling, Rennie's mill was recognised to be exemplary.

During the end of the eighteenth century, mill-building in England made rapid progress. Besides the brothers Rennie (George and John), in that department, the names of Modsley, Etken, and Steel in London, Fenton, Murrey, and Woods in Leeds, and Fairbairn and Lille in Manchester are renowned.

George and John Rennie built a mill, the largest in the world[2] at the time, in Plymouth, for the victualling of the fleet, containing twenty-four millstone sets. This was probably the first fireproof mill, as the building was constructed of iron and stone. The millstone sets were divided into four groups, each group of six being driven by one large cogged wheel.

VI

MILLS IN FRANCE

Flour milling in France of the eighteenth century was far superior to that in other European countries. In a book by Malouins, published in 1767, we find the description of a mill where the product was twice

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[1] *Rees' Cyclopædia*, vol. xxiii., 1781.

[2] *Ibid.*

sifted by means of reel-separators. Fig. 27 is a rather primitive, but sufficiently characteristic drawing of the inner arrangement of the mill.

The millstone set *GK* rests on a timber hursting *M*. The feed-hopper *B* is filled with grain by a workman. The float *D* in the feed is a sufficiently heavy plank attached by a string *C* to the bell *E*. When the grain is spent and the hopper is empty, the falling plank *D* pulls the string, and rings the bell as a signal.

A large wooden box *L* and two separators *K–K* are placed under the hursting. The ground product flows into the upper separator or dresser. The refuse from that separator passes on into the lower one.

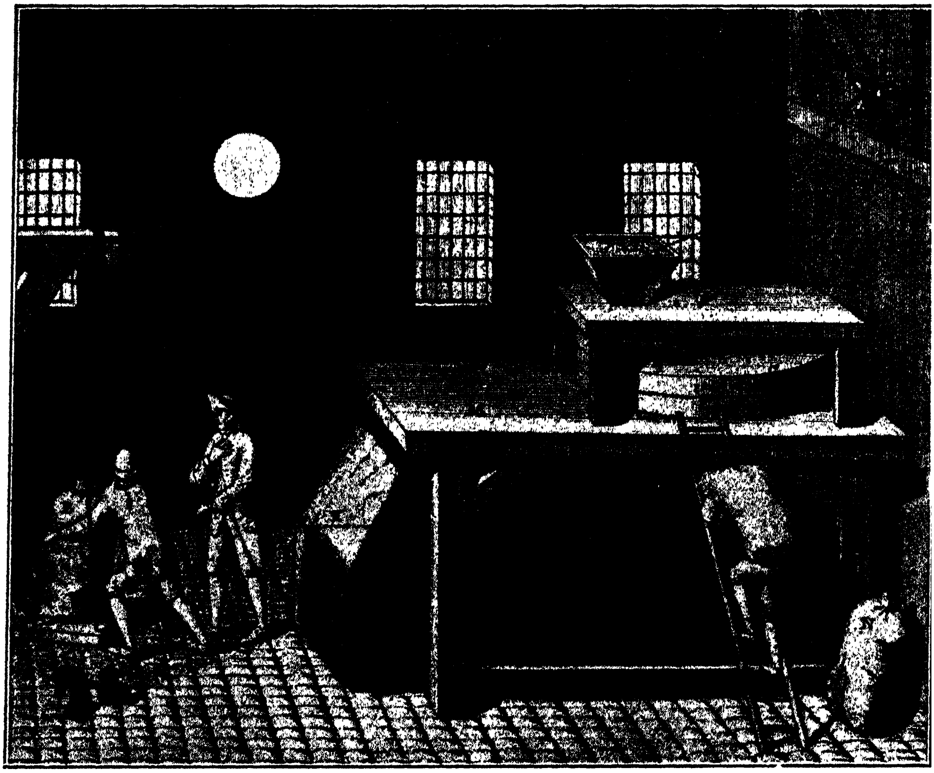

FIG. 27.

The throughs of the separators yielded flour which was collected in the box *L*.

To prevent the flour from escaping into the building, the box and separators were hooded with a curtain which formed a kind of dust chamber. The tissue in the separators was woollen.

In proportion to the flour collected in the box the curtain was lifted and the flour removed with shovels.

The influence of American milling technics began to penetrate into France much later than into England. In the celebrated *Methodical Encyclopædia* of Diderot and D'Alambert (1788), a mill of the end of the eighteenth century is described greatly resembling the type of mills constructed in the beginning of that century, depicted by Belidor in a work called *Architecture Hydrolique*, as early as 1737.

Such stagnancy in milling technics and industrial life generally has its explanation in the stormy period of the French Revolution and in the wars of the succeeding Empire. Only after the continental wars had ended did the industry of France revive, and flour milling adopt the Anglo-American type of mills. These new types of mills in France were built by English firms. In 1818 the English engineer, Modesley, was building a mill of four millstone sets in St. Quentin. In 1825 Atkins and Steel built a mill in St. Denis, near Paris, for Bensit, who acquired a name in the French milling literature later.

But the vivacious and creative mind of the French was not satisfied in the further development of mill-building with imitating the English and Americans. French engineers have introduced many original inventions, chiefly in the sphere of transportation, cleaning of grain, and dressing the product. The building of their mills excelled in beauty of architecture, and the departments in proportionality of sizes. One of the greatest inventions of the French of that time is the cleaner and separator, the most indispensable machine of the grain-cleaning department. Doubtless the development of milling technics pushed the question of perfecting the water-wheel, adapted then almost exclusively in mills, to the front, and it was Fourneyrond who produced the first turbine. This was of no less importance to the development of milling in France than was Watt's steam-engine in England.

VII

PROGRESS OF TECHNICS IN GERMANY

The old German mill which was in use up to the fifties of the nineteenth century[1] is illustrated in Fig. 28. Such mills (section in Fig. 28 *A*) were driven by a water-wheel with the aid of a mangle gearing *m–l*. The mangle gear *l* is set on a spindle resting on the step-bearing *K* lying on a beam *p* which may be raised and lowered, regulating the distance between the grinding surfaces. The adjustable grinder *B* is connected with the spindle by a driving iron *i*. Fig. 28 *B* gives the side view.

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[1] Prechtl, *Technologische Encyclopädie*, vol. x. Stutthard, 1840.

From the millstone the flour flows into a woollen sifting bag *K*, to which a vibratory motion is communicated by a fork *v*, performing returning oscillations from shaft v_1. The fine flour, sifted through the bag *K*, passes into the box *L*. The bran, semolina, and coarse meal (overtails) fall on sieve *M*, where the bolting is repeated. In this manner, two kinds of flour were obtainable, and semolina, which was then reground. Sometimes the sifting bag was replaced by sieves of different density, to obtain a greater number of kinds of flour. *C* is a solid driving iron, *D* a ratchet wheel for the vibratory motion of the shoe set into the opening of the runner (see *A*); Fig. *E*, a mechanism communicating the vibratory motion to the fork *v* which shakes the sifting bag. The mechanism shown in Fig. *F*, and the working of which is obvious, was frequently adapted for the same purpose. In the first and second case the revolving cross-head *w* acting upon a wooden spring v_2 effects a vibration of the rollers on which the spring is set. Fig. *G* is a sieve *M* for sifting the overtails from the sifting bag; Fig. *H* is a wooden spring counterbalancing the vibrations of the sieve *M*. The tightening of the spring is regulated either by transposing the taper-pin *i*, or tightening the string *s*. On Figs. *K* and *N* we find the shaft and screw apparatus for raising the vertical journal *p* when the distance between the grinding surfaces is to be regulated.

The new mill made its appearance in Germany later than in England and France. The feudal system, the corporate organisation of the trades, and the conservatism in technics maintained by them were the chief causes of this tardiness.

The feudal law had created the so-called "compulsory grinding" in the mills belonging to the landowner, thus putting the monopoly of production into the hands of the lord of the manor, and precluding any possible competition. Yet the necessity of competing in the market and fighting against the imported French and English flour forced the Germans to adopt the American type of mill, as more efficient and producing better flour.

Having grasped the advantages of the American mill, the German engineers and industrial promoters commenced studying that type with the carefulness and minuteness characteristic of the nation.

The first German flour mills of the Anglo-American type were built and began operating in Prussia. As early as in 1825, such a mill was arranged in Magdeburg by F. Murrey of Leeds; in Guben, under the supervision of an enterprising leaseholder, Korti.

In Berlin there sprang into existence a steam-mill of Schuhmann

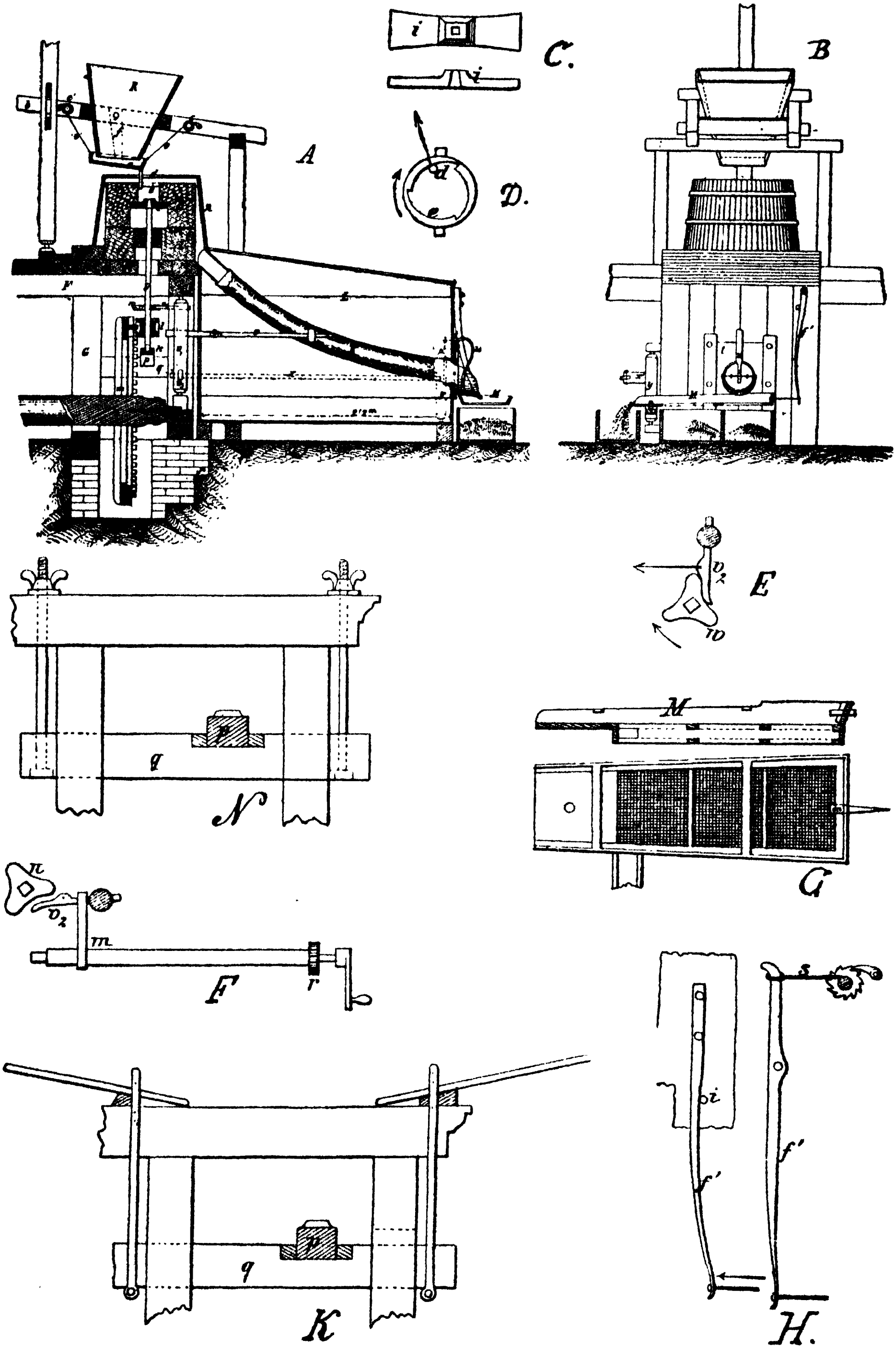

FIG. 28.

and Kratzeke arranged by an engine-builder Freund after the fashion of English mills; and on the upper Oder a steam-mill of the American type, similar to that in Guben, was working.

The Prussian trade committee furthered these beginnings in every way, by publishing, for instance, in 1825 detailed drawings and descriptions of the best English and American mills, and sending in 1827 two pupils of the Imperial Trade Institute (Hantzel and Wulf), who were studying mill building, to America and England, to acquire practical knowledge in everything pertaining to the question. Hantzel and Wulf's report was published by order of the Prussian Government of 1832, and these two builders erected with great success several large mills and very skilfully performed the milling operations.

In the western provinces of Prussia the Ober-President von Winke became renowned, having built about 1830 the first standard mill of the American type on the river Leine.

In the south of Germany the first to introduce mills of American construction was the Royal Government of Würtemberg. The first mill of that type was erected on the site of an old mill belonging to the treasury in Berg, by Stutthart.

The building of that mill was begun in the summer 1830, and ended in 1831. It commenced operating on the 1st September 1831. Here three water-wheels set into motion ten millstones, three aspirators and three separators with silk cloth, one sieve, two product elevators, one sorting dresser, and several sifting machines. In a short time the flour from this mill commanded so extensive a market that by 1832 an enlargement of the mill was thought of. But the greatest good the mill wrought, was the example it set, for soon in different parts of the kingdom mills of the Berg type sprang up. Such mills were erected in Althausen, Zeflingen, Urach, Reutlingen, Tübingen, Esslingen, and Heilbronn.

Some time before the mill in Berg was built, the attention of the Royal Government of Bavaria was attracted to the question, and it published on 27th February 1828 the following announcement:

"A remuneration of 3000 guldens will be allotted to the man, who in two years' time shall have built and commenced working a flour-grinding mill of at least three stones, constructed after the manner of those successfully operating for several years, in England and North America."

The sole claimant of that prize, a mechanic, Spät of Nürnberg, announced in 1831 that a mill of the type mentioned, containing four millstones and driven by an overshot water-wheel, had been erected by him, and was working. Spät was awarded the prize in 1832, notice being taken of the fact that "the mill is indeed of the Anglo-American type, but somewhat modified."

This improved mill of Spät's enjoyed no great success as an example to be imitated, and in 1837 a miller, Bachmann, was sent by royal order for the Bavarian Millers' Union to Würtemberg to study the American mills of that country.

A far larger field was gained by the Anglo-American mills in the following years (1833–35) in Prussia, where the Royal Sea Trading Society took a prominent part in their diffusion.

From 1822 that Society, acting on behalf of the merchants of Dantzig, distributed the grain purchased by it among the local mills and sent the fine flour partly to England, partly to Transatlantic ports. Thereby the traders soon arrived at the conclusion that German flour milling was too far behind that of foreign countries, particularly of North America, to enable them to compete successfully on the outland markets.

In consequence, the Society purchased a milling plant situated on the Oder in Tiergarten, in the neighbourhood of Ohlan (in Silesia), and entrusted its reconstruction in the American fashion to an experienced technical miller named Hantzel. In 1834 eight stones of the rebuilt mill were installed and started, two more flaking mills being added to the number later on.

This mill was the standard for mills built in after years, and produced flour of a higher quality for home use, as well as for export.

At the same time private industry did not remain inactive. Particular attention must be called to the effort of a merchant, Witt by name, who greatly assisted the development of the flour-milling industry in Dantzig. In a mill with twenty pairs of stones, rented by him in Dantzig, he had twelve reconstructed, on the American system, and added new ones to them, so that in a short time he had no less than thirty-one millstone sets of perfected construction in operation.

The second of the above-mentioned engineers who had been sent to America, Wulf, had an open field here for developing his activity on a large scale in the capacity of director of the technical side of the business.

Büscher of Neustadt-Eberswalde next deserves mention. He was a government engineer, and with his five-stones mills of the American type strove to enable the owners of small mills, without any marked alterations to the plants, to produce flour which only slightly differed in quality from the product of the most perfect mills of the day.

In 1835, Krückmann, the owner of a mill in Berlin, adapted his three-stones mill for hard grain, and shortly afterwards a councillor of commerce, Grunau in Elbing, reconstructed his mill in the improved style.

Before that, on the Rhine, opposite to the town Neuwied, on an estate, "Zur Nette," belonging to Karl Winz, a mill on the American system was erected and worked. This mill contained four sets of stones driven by two water-wheels.

VIII

FURTHER DEVELOPMENT OF MILL-BUILDING IN EUROPE

In 1823, after unsuccessful attempts by Helfenberg in Rohrschach (Switzerland, cant. St. Gallen), Ballinger in Vienna, and von Kollio in Paris, a certain von Müller of Lucerne began building, first in Warsaw, then in Triest, and lastly in Frauenfeldt in Switzerland, mills which operated by means of iron rolls instead of millstones. These rolls did not fulfil the hopes placed in them, and it was only in 1834 that a Zurich engineer, Sulzberger, eliminated the defects of the roller mill and attained real success. The joint stock company established by Müller in Frauenfeldt began to build roller mills with an unusual energy, and not only successfully erected Müller's mill in Warsaw, Triest, and Frauenfeldt, but took pains to build such mills in other localities too.[*] These mills were driven by steam-engines. With a steam-engine and a sufficient quantity of fuel and water for feeding the boilers, it was possible to set up a reliable motor anywhere.

In 1836 there were several steam-mills in Prussia; Berlin alone was in possession of three of the number. In Austria-Hungary the first steam-mill began working on the 26th September 1836 in Odenburg (in Hungary in the neighbourhood of the lake Neusiedler). About that time a similar mill came into existence in the Grand Duchy of Baden in Mannheim; a little later, in the Grand Duchy of Hessen, two large steam-mills began operating, one owned by Schneider & Co. in Oppenheim, close to the banks of the Rhine, the second in the vicinity of Weissenau by Mainz.

In Hanover a leaseholder, Fiedler, had mill-plants of the American type in Klickmühle (capital of Hanover) in 1832, and the first steam-mill in Rehden was started by Hartmann in 1836.

All these enterprises enjoyed great success, as, thanks to them, wheat gained near markets, and local consumers received flour of a higher

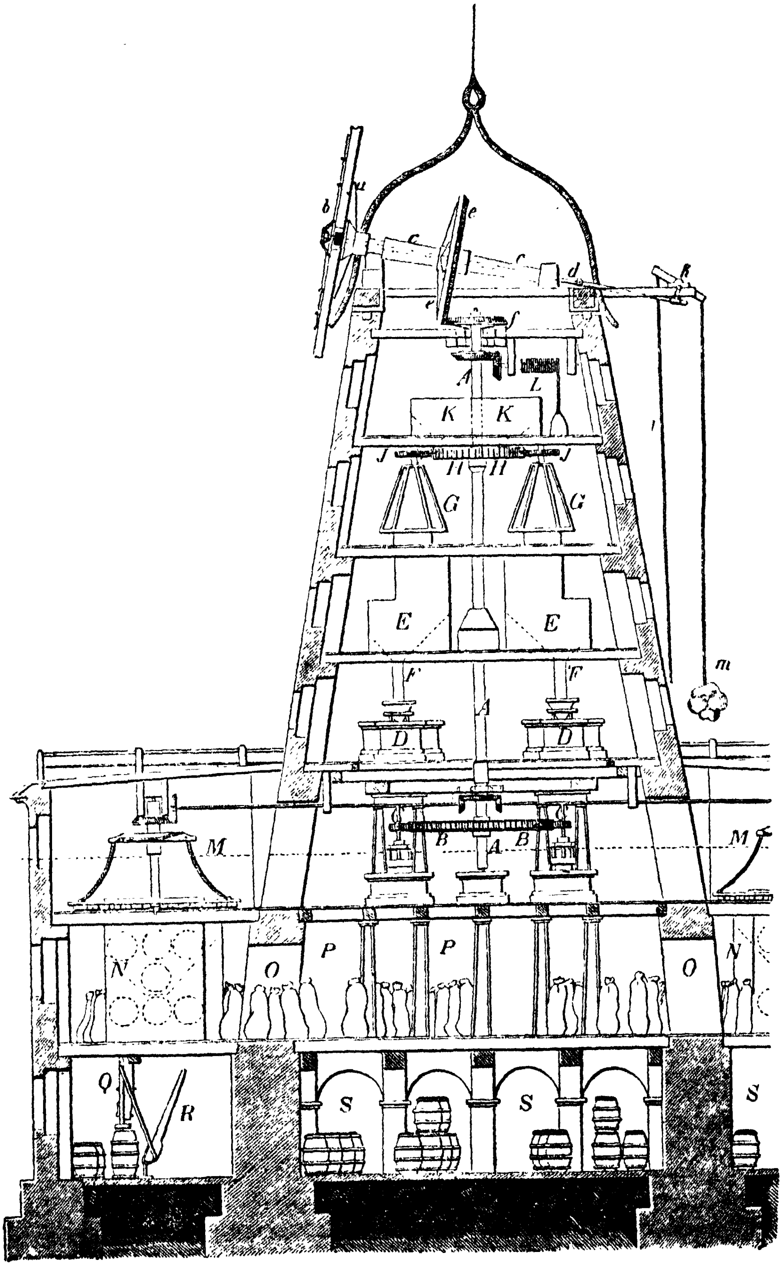

Fig 29.

quality. The Hanover steam-mill in Rehden, which ran some two years only, proved to be the sole exception. The main causes of its failure were the restrictions it was placed under by the restrictive and archaic regulations imposed by the trade corporation; besides which its being situated among large water-mills, and the excessive consumption of coal by the boilers, were factors which influenced its fate.

The first wind-propelled mill of the American type in Germany is the mill by Breslau, constructed by Hofmann, a then well-known factory warrant officer, about 1836. Fig. 29 shows a vertical section of the mill with its full equipment.

On the top floor, under the roof, is a hollow main shaft of cast iron *cc*, with spider *a* and wings *b*, which may be brought into any position (to assume a working taper of the surface of the wings) by the aid of straight and angle shafts, moved by shaft *d* and rope *e* with a shaft *k* and counterbalance *m*. The motion of the wind propeller is transmitted by means of cogged wheels *e* and *f* to the vertical main shaft *A* of the whole plant.

The seventh floor (some 20 ft. in diameter) contains supply bins *KK* for grain and an appliance for elevating it.

The sixth floor is designed for grain-cleaning apparatus, of which only the so-called smutters (machines for freeing the grain of its husk) *GG*, driven by gears *H* and *J*, are shown here. From this floor the grain passes into bins *EE* on the fifth floor. In all probability, other cleaning machines were stationed on the third floor, as the smutters would not be sufficient for that purpose.

On the fourth floor we find the stones *DD*, set symmetrically in a circle, the radius of which is self-defined, owing to a large cogged wheel *B*, which couples with the gears of the spindles of all four millstones.

On the third floor are stationed the cogged wheels driving the millstones and gears, and two mill-drives *MM* for collecting the grain and cooling the product.

We may add that of the four pairs of millstones (5 ft. in diameter), two pairs were from a French factory (La Ferté), the other two being from the Rhine (of volcanic basalt in the environs of Andernach). These stones made from 100 to 110 revolutions per minute, the wind propeller making 10 to 12 in the meantime.

On the second floor are the sifting bolters *NN*. The middle part of that section, supported by strong wooden pillars, serves for storage.

In the ground floor is the hand-press *QR* for packing the flour purposed for export into barrels *S*.

IX

THE STRUGGLE BETWEEN THE ROLLER AND STONE MILLS

The first steam roller mill of the Sulzberger (Frauenfeldt) type appeared at the end of 1837 in Mainz; it was followed by similar mills in Stettin, Munich, and, at the end of 1837, in Leipzig.

Steam roller mills made their appearance in Austrian dominions, Buda-Pest, and Milan, probably at the same time.

The costs of arranging such a mill, with a capacity up to 300 centners[1] of wheat per day, amounted to 156,500 guldens, with a floating capital of 93,500 gulds.

These Sulzberger roller mills were adapted solely for factory production of flour, suitable chiefly for export, as the product did not become heated in grinding, while it was possible to grind only perfectly dry grain.

The roller-ground flour first gained great popularity from its good outward appearance and high quality. It was even maintained that this flour contained more nutritive matter than flour ground on stones.

In Prechtl's *Technological Encyclopædia* were given the results of the analysis of flour from a Milan flour mill made by a professor of chemistry, Ottavio Ferrario.

	Roller-ground flour	Stone-ground flour
Gluten	0·152	0·131
Starch	0·706	0·680
Sugar	0·052	0·048
Gum	0·031	0·027
Water	0·054	0·095
Silicic acid	0·005	0·015
Alum	...	0·003
Lime	...	0·001
	1·000	1·000

But gradually the opinion as regards roller mills began to change, to which assistance was lent by the circumstance of a quick discovery that on the roller mills of the day a perfectly pure product was not to be obtained, and special stone sets had to be built for that purpose.

The owners of roller mills soon began to complain of heavy expenses incurred by the repair and oiling of the rollers, and particularly of the

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[1] Centner = hundredweight.

excessive expenditure of power and the necessity of employing many hands. Thus, for instance, the Ludwig mill in Munich produced 13,000 Bavarian bushels of flour per year on thirty-six roller mills, whereas the thirteen stones that were substituted in their place later, gave 26,000 bushels of flour, while the number of hands was reduced from twenty-eight to nine.

In Saxony the mills of the Anglo-American type were first adopted at the end of 1838 in two localities: in Neumühle by Dresden, and in Kloster-Mühle in Chemnitz. Both these mills were worked by water-wheels driving millstone sets.

In the following year (1839), in Austria, a splendid mill was started in the town of Fiume (Croatia). This mill was situated within a half-hour's journey from the sea. It contained eighteen sets of French stones, 4½ to 5¼ ft. in diameter, driven by three overshot water-wheels with a total capacity of 95 h.p. Its capacity was to be 198,000 centners of flour from the best kinds of wheat—Banatka, Russian, and Rumanian.

In 1840 the plan of construction of a steam-driven mill, previously rejected, was worked out anew, and after a short time one of the best Austrian mills, the licensed steam mill in Vienna, was erected.

The renowned firm of Coquerille, in Séraing, near Liège, supplied the mill with machinery, arranged it, supervised the erection of it, and took the whole responsibility upon itself.

In 1842, when the mill began working, it was equipped with sixteen sets for wheat grinding, and two for that of corn. In course of time, it was enlarged to twenty-two sets driven by three Wolf's steam-engines, of the joint capacity of 200 h.p. When arranging the mill, it was designed merely for the Anglo-American low grinding which was not adapted for producing the so-called "Imperial Flour" (Kaiser mehl), which goes to the baking of rolls, very popular in Vienna.

Therefore it soon had to be reconstructed for semolina grinding, on the French system or "Mouture économique," to be discussed later in the section treating of grists.

In this manner the stone mill won the battle almost everywhere. Between the forties and to the sixties, the roller mill struggled in vain against the millstone set, improved by a system of exhausts and dust collection.

However, at the end of the sixties, the factories of Escher, Wyss & Co., near Vienna, and F. Wegmann in Zurich, brought out the perfected roller mills, which began successfully to supplant the stone set in the industrial flour mills.

CHAPTER II

GENERAL IDEAS OF THE RAW MATERIALS FOR FLOUR PRODUCTION

I

The Berries of the Cereals

The berries of the cereals are the pre-eminent raw materials of the milling industry. In order to understand the working of the various grain-cleaning and grain-grinding machines and to study the nutritive qualities of the products of the grain, it is necessary to be acquainted with the structure and the chemical composition of the berries of the different cereals.

On first examination we see that the berry of the cereals has an oval form. If viewed through a magnifying glass some hairs, either forming a sort of beard (wheat, rye) or covering the whole body of the grain (oats), are perceived at one end of it, and the germ or the embryo at the other. On examining a slightly magnified section through the berry we can see that it consists of a starchy nucleus, surrounded by several coats or skins; if we magnify the section 150 times we can discern six such coats which may be detached more or less easily from the berry. Flour or groats are made of the nucleus, and the skins yield bran, a by-product of flour manufacture.

Each of the skins consists of several separate layers that cannot be easily detached one from another. We shall investigate them more closely when examining the wheat berry, and will now proceed to consider them briefly.

The first three skins of the cereal berry (see Fig. 30) are called outer envelopes or envelopes of the fruit, the two second are the envelopes of the seed proper, the last one is (inaccurately) called the gluten envelope.

The first envelope *A* (Epidermis, Epicarpium) consists of thick-walled cells filled with air, and disposed along the longitudinal axis of the berry. Its outer surface is either smooth or shrivelled, its colour varies according to the species of the cereal. It is often pierced through by hairs, acting as air-conducting channels while the grain is ripening.

The second envelope *B* (Mesocarpium, Sarocarpium) consists of colourless, or sometimes yellowish, loosely built cells. It is very thin and possesses no well-outlined characteristics.

The third envelope *C* (Endocarpium) is composed of cells disposed at right angles to the axis of the berry. While this latter is still unripe the envelope is of a greenish colour, when quite ripe it becomes colourless.

These three envelopes may be comparatively easily taken off the seed.

The fourth envelope *D* (*Testa Episperm*) has oblong cells, much smaller in size than those of the outer envelopes.

Fig. 30.

The fourth envelope *D* and the fifth *E* (Embryonic membrane) are called envelopes of the berry proper. Theyare both very thin, adjoin closely to each other, and it is most difficult to detach them one from another.

The sixth envelope *F* (Perisperm) is a layer of aleurone, and is also called the gluten envelope. Its volume constitutes one third of the total volume of all the envelopes. Its cells have very stout walls; they are very hygroscopic, and being put in water soon become swollen. It was formerly supposed that they contained gluten (an endosperm-nitrogenous substance), and the envelope was therefore called the gluten envelope. And though the careful analyses made by Shenk and Brucke have shown that these cells do not contain any gluten at all, the term is still in use.

The gluten envelope comes into a close touch with the endosperm and the envelopes of the seed proper. It is therefore possible to take off the three inner envelopes of the berry without breaking this latter.

The nucleus *G* (Endosperm) that yields flour when broken, consists of comparatively small cells with thin, colourless walls. The cells of the endosperm are filled with granules of starch and very small granules of gluten (cleber). The nearer to the centre of nucleus the smaller is the proportion of gluten in the cells. The largest quantity of it is contained by the cells that adjoin the sixth envelope of the berry.

A section through the nucleus is either flour-white, or has the appearance of a glassy, somewhat yellowish substance. The colour of the nucleus darkens gradually from the centre towards the outer cells.

The germ *H* of the berry is firmly attached to the nucleus. Its cells are tiny and very compact, and contain much nitrogen, mineral salts, and fats. While the plant is developing the germ is fed on the starch and the cleber of the nucleus. This accounts for the so-called germination of the raw grain kept in a warm place.

The envelopes are not, as we are going to see, of a nutritive nature, and must therefore be removed before the endosperm is finally reduced to flour. Their total weight constitutes from 17·6 per cent. to 30 per cent. of the weight of the berry.

Let us now examine in detail the wheat berry.

II

PHYSICAL STRUCTURE OF THE WHEAT GRAIN

The functions of the grain are those of reproduction, hence its structure. The grain consists of three distinct parts: the germ, the endosperm, and the bran. The germ is the seed properly speaking, for it develops ultimately into the plant. The endosperm consists of a starchy substance; it constitutes the main body of the grain, and is destined to supply food to the germ in the early period of its growth. The bran consists of several separate coverings, which enclose both germ and endosperm, and are destined to protect the grain.

The study of the physical structure of the grain requires the use of the microscope.

Fig. 31 represents a section through the crease of the grain, shown in elevation by shading on the left-hand side of the sketch. The figure has been obtained by tracing from typical slides, and reproduces fairly well the relative dimensions of the germ and the endosperm. The bran is seen to enclose both. With the aid of a microscope one can see the so-called aleurone cells or the square cells of the bran lining the interior. The name "gluten" cells, though commonly used, is not accurate, for these cells contain no gluten.

Fig. 32 shows a cross section through the germ of a Kubanka wheat grain. Here we see the pigment-containing cells going all round the grain and forming in the crease a thick spot of colour. The aleurone cells of the bran do not continue round the germ. The next figure (33) represents the same section, but examined with a higher power objective.

It shows more clearly the outer skins of the bran and allows us to see quite distinctly the square aleurone or cerealin cells. At the bottom of the crease they become more numerous and form a double line. The bifurcation of the crease is perfectly distinct. The rather large dark yellow spot of pigment cells is plainly seen in the middle of the fork. The starch granules are also seen.

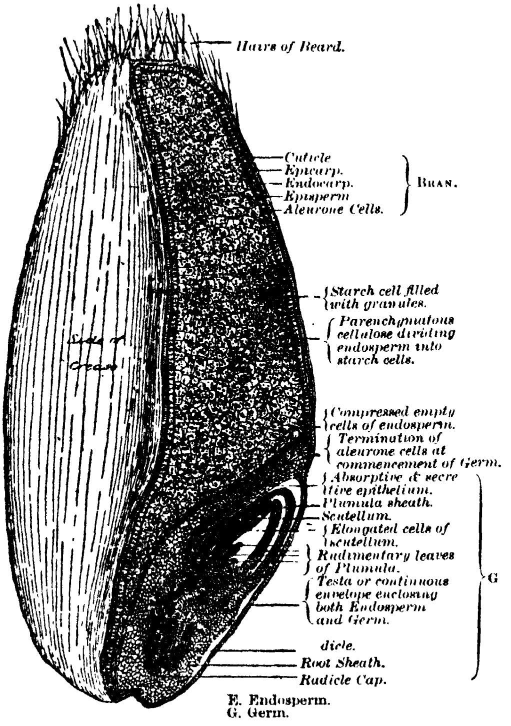

FIG. 31.—Longitudinal Section through a Grain of Wheat, magnified about 10 Diameters.

In order to examine the bran and the endosperm we must select a very thin section. The bran consists of the outer envelopes of the grain and those of the seed proper. Fig. 34 shows them all on a longitudinal section.

a is the outer "epidermis" or cuticle. It constitutes, according to Mege Mouries, 0·5 per cent. by weight of the whole grain, and consists of thick-walled, longitudinally disposed cells. It is often pierced through by hairs acting as air-conducting channels while the grain is ripening.

b is the "epicarp." This amounts to about 1 per cent. of the grain; it is very thin and possesses no well-defined characteristics.

c is the "endocarp" and the last of the outer series of the grain envelopes. Its cells are disposed at right angles to the axis of the grain, and appear to be almost round on the longitudinal section. Its weight constitutes 1·5 per cent. of that of the grain.

d is the "testa," the first of the two envelopes of the seed proper. It is also called "episperm." It consists of oblong cells much smaller in size than those of the outer envelopes and contains most of the colouring matter of the grain.

e is the "embryonic membrane" and the second envelope of the seed proper. It is very thin and closely adjoins the testa. Together they constitute 2 per cent. of the grain.

f is the layer of "aleurone" cells. These cells appear to be almost square in outline and have very stout walls. They absorb moisture easily, and being put in water, soon become swollen. As already mentioned, they only enclose the endosperm and do not envelop the germ.

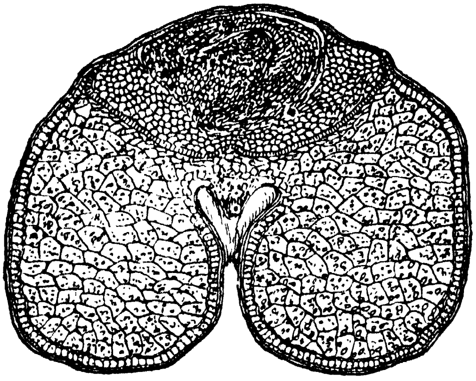

FIG. 32.—Transverse Section of Grain of Wheat, magnified 13 Diameters.

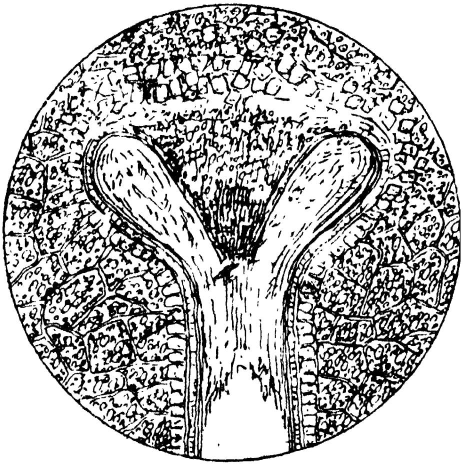

FIG. 33.—View of Crease in Grain of Wheat, as shown in a Transverse Section.

g is the layer of parenchymatous cellulose, which divides the endosperm into comparatively large cells. These latter are filled with granules of starch and very small granules of gluten. Towards the centre of the endosperm the proportion of gluten becomes smaller.

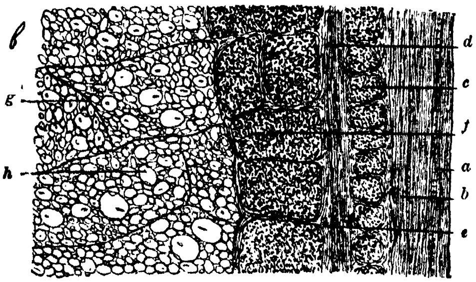

FIG. 34.—Longitudinal Section through Bran and Portion of Endosperm of Grain of Wheat, magnified 440 Diameters.

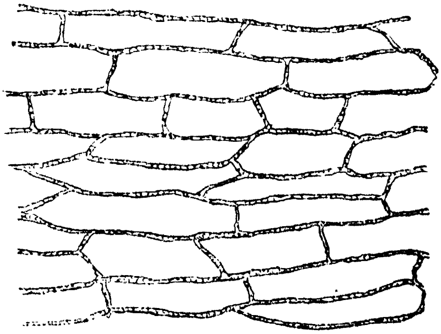

FIG. 35.—Outer Layer of the Bran of Wheat, magnified 250 Diameters.

h is the "hilum" of an individual starch granule.

The envelopes must be also examined on the flat. They can be detached easily enough off the body of the grain in three layers, (1) epidermis and epicarp, (2) endocarp and episperm, and (3) the inner skin which contains the cerealin cells. Fig. 35 shows the structure of the outer layer. Its cells are arranged longitudinally in the direction of the grain and are four to six times larger in length than in breadth. Fig. 36 represents the hairs of the beard at the end of the grain. We can see on the section itself how they are attached to the skin; the mount also shows canals extending about half the length of the hair. Fig. 37 shows the structure of the second layer. We see that it consists of two layers, one over the other, which are not both in focus at the same time. The upper layer consists of a series of long cells often termed "girdle" cells, and arranged transversely to the longitudinal section of the grain, as shown on Fig. 34 (marked *c*). On this they seem to be almost round. Underneath the girdle cells are the pigment-containing cells.

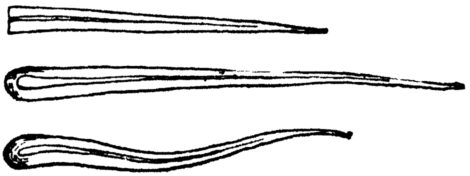

FIG. 36.—Beard of Grain of Wheat.

Fig. 38 shows the aleurone or cerealin cells of the bran to be of an irregular outline, though when viewed on section, either longitudinal or transverse, they appear to be square or rectangular, and are therefore often termed cubical.

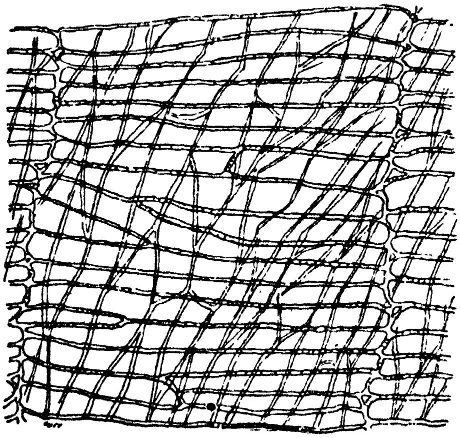

FIG. 37.—Middle Layer of the Bran of Wheat, magnified 250 Diameters.

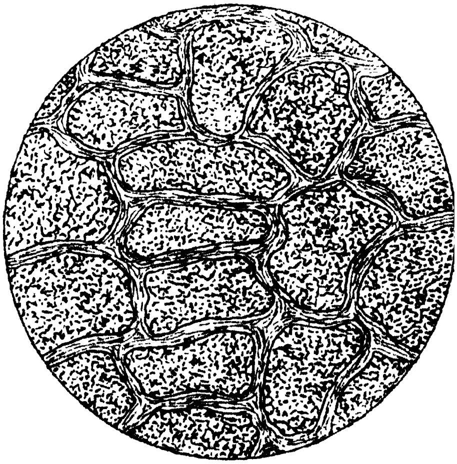

FIG. 38.—Inner or Aleurone Layer of the Bran of Wheat, magnified 440 Diameters.

Let us now compare the longitudinal section through the bran of wheat, as shown on Fig. 34, with its transversal section shown on Fig. 39.

Though the latter section was not so good as the longitudinal, the drawing shows clearly enough the general structure of the bran. The cells of the middle skin appear to be of considerable length when we see them on the flat. When we look on them lengthwise, we must, of course, notice the ends of the cells of the outer skin. The aleurone cells appear more irregular in outline on the transversal section than on the longitudinal. The study of these drawings must, of course, be followed by an examination of the actual slides under the microscope.

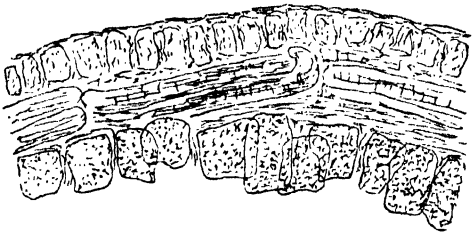

Fig. 39.—Transverse Section through Bran of Wheat, magnified 250 Diameters.

The bran of the wheat berry is chiefly composed of cellulose or woody fibre and of soluble albuminous matter. When treated with hot dilute solutions of acid and alkali it yields cellulose in a fairly pure state. The following is the way to obtain cellulose for the purpose of microscopic study: pieces of the different layers of bran are put in separate test-tubes and subjected for an hour to the action of dilute sulphuric acid. Then this latter is poured off and substituted by caustic soda solution, in which the pieces of bran are digested for another hour. Then solutions of 1 part respectively of acid and alkali and 20 parts of water are used, and the resulting cellulose can be mounted on glass slides.

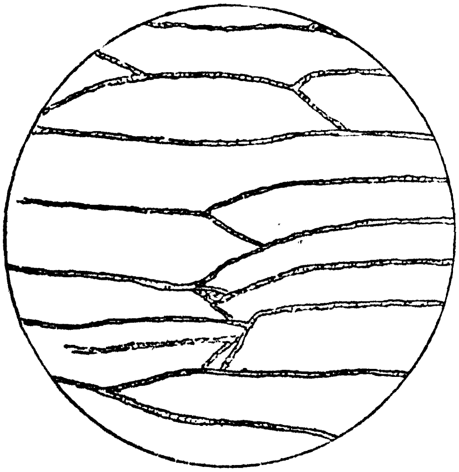

Fig. 40.—Cellulose of Outer Skin of Bran, magnified 250 Diameters.

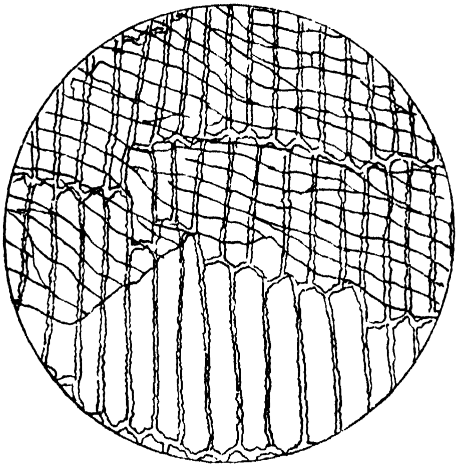

Fig. 41.—Cellulose of Middle Skin of Bran, magnified 250 Diameters.

Figs. 40, 41, 42, and 43 show respectively the cellulose of the outer, middle, and aleurone layers of bran as viewed under the microscope. The structure of the first and second pieces of cellulose does not differ much from the structure of the original layer of skin. The first appears to be almost transparent, and in the second the underlying pigment cells are partly stripped off. The aleurone layer changes considerably in appearance, when treated with alkali, for it contains a large quantity of protein matter. Fig. 42 shows a piece of this layer, in which the greatest part of protein has been removed by the action of the caustic soda. Fig. 43 shows another specimen, in which there remains almost no protein at all.

The outer layer of wheat bran is thus largely composed of cellulose, and cannot, therefore, be used for human food. The middle layer contains less cellulose, but a larger quantity of colouring matter. The inner contains but a very small proportion of cellulose and large quantities of protein. This latter is injurious to the flour, for it exerts a strong action on broken starch granules. None of the three must be therefore admitted as a part component of the flour.

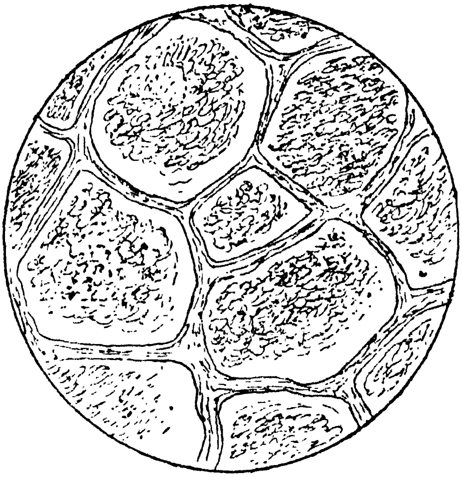

FIG. 42.—Cellulose of Aleurone Layer of Bran, with Portion of Protein remaining, magnified 440 Diameters.

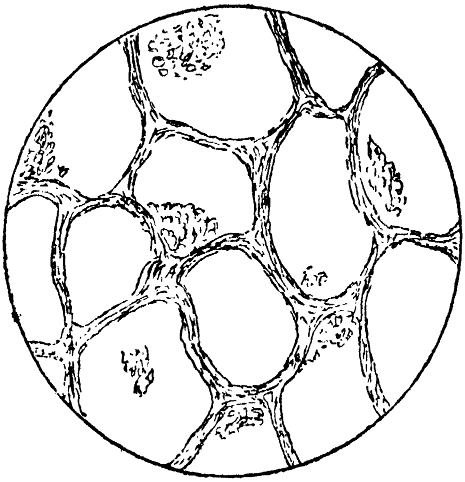

FIG. 43.—Cellulose of Aleurone Layer of Bran, with only the slightest Trace of Protein still remaining in some of the Cells, magnified 440 Diameters.

If separated from the bran and subjected to acid and alkali treatment, the endosperm yields traces of cellulose. It is most instructive to subject to the same treatment several different varieties of flour.

This will allow the student to examine (1) whether the flour contains a large proportion of particles of bran, and (2) whether the latter remains intact, or portions of it have been detached from one of the surfaces and ground into flour.

III

CHEMICAL COMPOSITION OF WHEAT

The grains of the cereals consist, as shown by analysis, chiefly of the following substances: fat, starch, cellulose, dextrin, sucrose, probably also other kinds of sugar; soluble protein bodies; albumin, globulin, and proteose; insoluble protein bodies; glutenin and gliadin, which together constitute gluten; mineral matters, principally potassium phosphate, and finally water.

Bell has tabulated as follows the average composition of the different cereals:

TABLE I

CONSTITUENTS.	Wheat.		Long-eared Barley.	English Oats.	Maize.	Rye.	Carolina Rice without Husk.
	Winter.	Spring.					
Fat . . .	1·48	1·56	1·03	5·14	3·58	1·43	0·19
Starch . . .	63–71	65–86	63–51	49–78	64–66	61–87	77–66
Cellulose . .	3·03	2·93	7·28	15·53	1·86	3·23	Traces.
Sugar (as cane) .	2·57	2·24	1–34	2–36	1–94	4·30	0·38
Albumin, &c., insoluble in alcohol .	10·70	7·19	8·18	10·62	9·67	9·78	7·94
Other nitrogenous matter soluble in alcohol . .	4·83	4·40	3·28	4·05	4·60	5·09	1·40
Mineral matter .	1·60	1·74	2·32	2·66	1·35	1·85	0·28
Moisture . .	12·08	14·08	13·06	11·86	12·34	12·45	12·15
Total . .	100·00	100·00	100·00	100·00	100·00	100·00	100·00

Another comparative table of the composition of cereals was drawn up later by Clifford Richardson. In this the moisture figures are considerably lower than in Bell's analyses, a fact that is due probably to the greater dryness of the American climate.

TABLE II

AVERAGES OF DETAILED ANALYSES OF CEREALS

NUMBER OF ANALYSES.	Wheat 27	Barley 14	Oats 18	Maize 21	Rye 17
Fat	2·30	2·67	7·87	5·54	1·83
Starch	67·88	62·09	56·91	66·91	61·87
Cellulose	1·90	3·81	1·29	1·41	1·47
Sugar, &c.	3·50	7·02	6·07	2·18	7·57
Dextrin and soluble starch . .	2·30	3·55	3·47	2·18	4·75
Proteins insoluble in 80 per cent. alcohol	7·45	7·86	13·43	4·96	9·07
Proteins soluble in 80 per cent, alcohol	3·58	3·66	1·82	5·84	2·53
Mineral matter	1·84	2·87	2·22	1·54	2·06
Moisture	9·25	6·47	6·92	9·34	8·85
Total	100·00	100·00	100·00	100·00	100·00
Ratio of proteins to carbohydrates .	6–9	6–5	4–8	7–6	6–5

Still later Hutchinson represented the general composition of the cereals in the following table:

TABLE III

CONSTITUENTS.	Wheat.	Barley.	Oats, Rolled.	Maize.	Rye.	Rice, no Husk.	Millet.	Buck-wheat.
Fat	1·7	1·9	8·1	5·4	2·3	2·0	3·9	2·2
Carbohydrates . .	71·2	69·5	68·6	68·9	72·3	76·8	68·3	61·3
Cellulose . . .	2·2	3·8	1·3	2·0	2·1	1·0	2·9	11·1
Proteins . . .	11·0	10·1	13·0	9·7	10·2	7·2	10·4	10·2
Mineral matter .	1·9	2·4	2·1	1·5	2·1	1·0	2·2	2·2
Water . . .	12·0	12·3	6·9	12·5	11·0	12·0	12·3	13·0

Analyses of Wheats from Different Countries.—The tables on pp. 50–54 are the results of a series of analyses made by W. Jago. The first eighteen were made in 1884 on specimens of English wheat of the 1883 and 1884 harvests, and still represent fairly well the general composition and character of English wheats.

Nos. 1–18 are samples of 1883 wheats, except where otherwise mentioned. The figures of moisture, of soluble extracts and proteins are rather high, while those of gluten are lower than in foreign wheats. The Revitts yielded exceedingly small traces of gluten, so small that it was practically impossible to recover them from the bran.

Nos. 19–27 are all 1883 samples of wheats used by the millers of the south of England. Nos. 19 and 20 are samples of the same variety, but grown in different localities. No. 21 is a sample damaged during growth. Nos. 28–38 are fine quality samples of the south and western counties, all of the harvest of 1884.

If compared to those of 1883 the figures of moisture, soluble extract, and soluble proteins are rather low. The average of the glutens is also lower. In the 1883 series No. 18, a Scotch west-country specimen, yielded the lowest percentage of gluten, 5·00, and the highest of moisture, 16·18. Similarly, No. 38 of the 1884 series, grown in a damp climate, South Devon, yields 5·00 per cent. of gluten and 16·20 per cent. of moisture.

Since 1884 several new varieties of wheat have been introduced in England. Among these, two varieties, "Tiverson's" and "Webb's Stand-up," are largely cultivated now. French wheats and the Hard Fife are also grown to some extent.

The foreign wheats present, of course, a greater number of varieties than the English. A comparison between the moistures and the glutens of wheats and the flours produced from them is most instructive. Russian wheats yield generally a higher percentage of gluten than the American. The Indian are, as a rule, rather poor, both in gluten and in moisture. They appear to be almost sandy. When worked up with water, and only after long "conditioning," they acquire the characteristic ductility of wheaten flours. The Persian wheats contain more gluten than the Indian, especially the clean Persian, No. 68.

No. 78 comes from Winona, U.S.A., and serves to make flours Nos. 8 and 9. The upper set of gluten estimations was obtained after the dough had stood for two hours. The wheat itself and the flours produced from it absorb water extremely slowly. No. 80 comes from Manitoba. The comparatively high percentage of moisture, soluble extract, and proteins are characteristic of the cold climate.

The sources of British supply have greatly changed since the time when these analyses were made. London gets now almost none of the United States spring wheats. The Duluth wheats have been largely substituted by the Manitoba. Durum wheat is imported from the United States in considerable quantities. The winter Americans are known as Red Winter and Hard Winter. The Russian wheats known as Saxonka and Kubanka have also almost disappeared from the London market, being substituted by several other varieties (Ghirka, Asima, and others).

TABLE IV

English and Scotch Wheats

No.	Name and Description.	Weight per Bushel.	Mois-ture.	Soluble Extract.	Soluble Pro-teins.	Crude Gluten.				Remarks.
						Wet.	Dry.	Ratio of Wet and Dry.	Height of Aleuro-meter.	
1	Fine Rough Chaff . . .	64·5	14·50	6·46	1·45	19·1	6·64	2·9	26	......
2	Very fine Old Rough Chaff, 1882	65·0	13·16	6·66	1·37	17·5	6·00	2·9	...	Gluten and moisture both low; was a weak wheat when harvested.
3	Fine Red Lammas . . .	64·5	14·0	7·26	1·69	23·9	7·26	3·12	30	Above average of gluten.
4	Old Red Lammas and Nursery (mixed)	63·5	14·62	6·33	1·42	21·25	7·7	2·76	37	Percentage of gluten raised by addition of Nursery.
5	Mixture used for "Seconds" Flour, consisting of 1 Saxonska, 1 Kubanka, 1 New Zealand, 1½ White English, 1¼ Red English . .	62·5	13·60	6·73	1·64	24·5	8·7	2·8	28	Consists of half foreign.
6	Fine Herts, White . . .	63·5	14·82	6·75	1·16	14·5	5·19	2·8	...	Weakest in gluten of English wheats; moisture highest.
7	Fine White, Oakshott's Pedigree	63·75	13·72	7·60	1·57	18·25	5·93	3·0	25·5	High extract; a sweet, weak wheat
8	Fine English, White Victoria .	64·0	14·0	8·06	1·66	23·0	7·73	3·0	35	Extract highest of series: sweet and moderately strong.
9	Nursery, Sussex	...	15·56	5·4	1·67	23·37	8·12	2·86	39	High in gluten and very sound.
10	Fluff, Sussex	...	16·04	5·53	1·30	22·42	7·86	2·86	25·5	Moisture high, but extract low.
11	Golden Drop, Sussex . .	...	15·18	5·60	1·65	18·42	6·64	2·77	...	......
12	Pricked Ear, Sussex . .	...	14·91	5·06	1·30	18·55	6·38	2·9	31·5	......
13	Essex Revitt, 1883, fine average quality	59·47	15·54	6·72	1·40	Trace	...	...	...	There was only the slightest amount of gluten in these wheats; No. 14 contained, if anything, the more.
14	Essex Revitt, harvested damp	58·08	15·68	6·70	0·82	Trace	...	...	...	

15	Webb's Challenge, Berks . .	62·06	15·66	6·93	1·01	19·8	6·41	3·0	31	These wheats contain very nearly the same amount of gluten. No. 16 contains less moisture and more extract.
16	Webb's Challenge, Oxfordshire	63·17	14·50	7·3	1·69	18·37	6·25	2·9	...	
17	Rough Chaff, Didcot . .	62·79	15·10	6·12	1·69	27·6	8·21	3·3	35	Highest gluten of series.
18	Scotch West Country . .	59·47	16·18	6·93	1·42	14·75	5·00	2·94	28	Moisture highest and gluten lowest of series.
19	Fine Kent Red . .	64·18	13·03	6·80	1·88	23·5	8·46	2·8	...	Grown on good heavy land in Suffolk, 1883; fairly farmed; delivered by farmer at 66 lbs. per bushel.
20	Essex Rough Chaff, White .	63·26	14·07	5·50	1·69	26·0	8·90	2·9	...	Grown on good, heavy land in Essex, 1883; fairly farmed; delivered by farmer at 66·5 lb. per bushel.
21	Red Chaff.	...	13·20	6·51	2·17	19·5	5·03	2·8	...	Grown in Devon, about two miles from sea; considered by sender to have probably been injured during the blooming period.
22	English Red	...	14·81	5·48	1·40	20·7	7·61	2·7	...	Grown in the neighbourhood of Boroughbridge.
23	Rough Chaff	65·0	13·70	5·74	1·43	23·2	7·24	3·2	...	Grown at Hampstead.
24	Reff Square Head . . .	64·0	13·18	5·54	1·45	16·62	5·75	2·9	...	......
25	Red Lammas	64·0	13·52	5·38	0·90	25·25	8·09	3·1	...	......
26	Wheat from the Vale of Taunton	...	13·35	6·44	1·21	18·00	6·62	2·7	...	Wheat of splendid quality, but in opinion of miller who forwarded it not very strong.
27	Scotch E. Lothian . . .	60·3	13·93	6·68	1·76	18·42	6·86	2·7	...	......
28	Rough Chaff, grown at Newbury	...	14·18	5·44	1·28	18·10	6·33	2·8	...	......
29	Red Lammas	65·2	13·22	5·00	1·40	19·00	6·69	2·8	...	......
30	Herts, White	...	13·12	6·12	1·16	21·20	7·62	2·8	...	......
31	Nursery, grown at Lickhampstead	...	13·40	5·60	1·08	20·50	7·07	2·9	...	......
32	Rough Chaff, grown at Compton, Berks	...	12·60	5·12	2·84	15·50	5·54	2·6	...	......
33	Trump, grown at Newbury .	...	13·00	4·52	1·12	18·50	6·25	2·9	...	......
34	White	62·98	12·30	5·36	1·80	23·70	8·61	2·7	...	......
35	Red	61·30	10·40	5·96	1·40	17·50	6·06	2·9	...	......
36	Red Chaff from Sidbury, Devon	62·0	15·54	4·00	1·32	17·20	6·21	2·9	...	......
37	Red Nursery	64·0	16·22	3·98	1·06	14·80	5·53	2·8	...	......
38	Square Head, from S. Coast, Devon	64·0	16·20	3·57	0·91	14·50	5·00	2·9	...	......

N.B.—The moisture percentages given in the above table are taken from Jago's well-known work, but it should be observed they are practically all *low* compared with the results obtained from the regular tests made in modern British mills.

TABLE V

Foreign Wheats

No	Name and Description.	Weight per Bushel.	Moisture.	Soluble Extract.	Soluble Proteins.	Crude Gluten.				Remarks.
						Wet.	Dry.	Ratio of Wet and Dry.	Height of Aleurometer.	
39	Hard Minnesota . . .	63·7	13·32	6·80	1·22	25·87	9·29	2·78	41	An interesting wheat: gluten and moisture both somewhat high.
40	Wheat Mixture, from 3 English, 3 Californian, 1 Red American, 1 No. 1 Calcutta .	64·1	12·60	6·22	2·83	20·5	6·91	2·96	42·5	......
41	No. 1 Minnesota, Hard Spring .	61·4	13·46	6·80	1·1	25·92	9·03	2·8	51	......
42	No. 2 Minnesota, Hard Spring .	59·7	13·82	6·97	2·03	23·75	8·54	2·78	35	More water and less gluten than No. 41 ; soluble proteins very high.
43	Red Fife, Manitoba . . .	63·9	12·36	7·12	1·01	24·75	8·88	2·8	39	Forwarded by editor of *The Miller*.
44	Walla Walla, Oregon . .	60·0	11·1	5·78	1·5	11·7	4·2	2·8	...	Instances of low moisture and low gluten occurring together.
45	Walla Walla, Oregon, 1883 harvest	58·7	11·14	6·33	0·67	17·55	5·79	3·0	29	
46	Californian, 1883 harvest . .	60·0	10·1	7·65	0·87	24·12	7·97	3·0	45	Low moisture ; does not, however, coincide with high gluten.
47	No. 1 Winter American . .	61·3	13·27	6·00	1·57	17·00	5·69	2·98	...	Run considerably lower in gluten than Nos. 39, 41, and 42.
48	No. 2 Winter American . .	60·1	13·18	6·46	1·79	20·87	7·00	2·97	30	
49	No. 2 Chicago Spring . .	59·9	12·05	6·60	1·88	23·92	8·41	2·84	36	Intermediate between the weak and strong American wheats.
50	Saxonska	60·76	12·04	7·06	1·45	28·0	10·0	2·8	50	Strong dry wheats, the former forwarded from Scotland, the latter from south of England.
51	Saxonska, 1883 harvest . .	59·56	11·84	6·46	1·45	27·25	9·36	2·9	37	
52	Kubanka, 1883 harvest . .	61·59	12·15	7·3	1·06	30·33	10·8	2·8	51	High gluten.
53	Jaganisg Ghirka . . .	60·2	11·6	7·84	1·57	29·5	10·69	2·8	39	Gluten very high.
54	Red Dantzig	58·18	14·7	7·2	1·96	26·25	8·92	2·94	45	A weak, damp wheat.

55	New White Indian	60·58	12·28	6·33	1·3	19·25	6·83	2·82	28·5	Gluten very low, water average.
56	New Australian	61·13	10·9	7·18	1·35	23·42	7·87	3·0	39·5	Water and gluten both low.
57	New Zealand "Growy"	59·3	13·12	7·74	1·5	16·92	5·68	2·98	26	Gluten low ; soluble extract high.
58	Hard Calcutta	57·99	10·50	7·26	1·80	16·5	6·82	2·4	...	......
59	No. 1 Calcutta	60·95	10·62	7·84	1·57	8·5	3·16	2·7	...	Very low in gluten.
60	No. 2 Calcutta	60·03	10·76	8·34	1·45	13·0	5·05	2·6	...	Gluten low.
61	No. 1 Bombay	63·90	10·32	5·74	1·64	19·0	7·10	2·7	...	Very like No. 64, but contains more moisture.
62	Soft Red Bombay	64·55	10·69	5·27	1·25	21·5	7·51	2·9	...	Highest gluten of the Indian wheats.
63	Hard White Kurrachee (Karachi)	58·18	9·63	5·78	1·21	14·7	5·74	2·7	...	Moisture very low, gluten also low, showing that dry wheats are not always the strongest.
64	Red Kurrachee	61·04	10·01	5·58	1·09	19·0	7·16	2·6	...	Is very similar in character to No. 62.
65	White Jubblepore	64·27	10·35	5·23	1·42	18·0	6·55	2·7	...	......
66	Low Persian	58·64	10·12	6·05	1·26	22·5	8·70	2·6	...	The Persian wheats run distinctly higher in gluten than the Indian wheats.
67	Hard Persian	61·13	10·46	5·91	1·28	26·0	9·50	2·7	...	Gluten and moisture both higher than No. 66.
68	Clean Persian	61·41	10·97	5·54	1·16	30·0	10·63	2·8	...	Gluten and moisture still higher. The gluten is equal to that in some of the strongest Russian wheats.
69	Australian	62·70	10·26	6·00	1·26	26·5	9·60	2·7	...	......
70	"	...	11·74	5·80	1·52	29·0	9·48	3·0	...	......
71	Kubanka	...	13·18	6·34	1·35	28·7	10·01	2·8	...	......
72	Milwaukee	...	11·62	5·44	1·21	21·7	8·69	2·5	...	......
73	Red Königsburg	61·50	11·72	6·00	1·40	27·20	9·61	2·8	...	......
74	Spring American	60·76	12·50	6·32	1·52	20·80	7·85	2·8	...	......
75	Algerian	...	10·96	6·06	1·12	26·20	9·62	2·7	...	The upper of the two sets of gluten estimates given was made immediately on doughing the meal : the lower after the dough had stood for an hour.
						29·20	10·44	2·9	...	
76	Persian	60·21	11·22	5·60	1·32	16·00	6·20	2·4	...	
						22·70	8·30	2·7	...	
77	No. 1 Club Calcutta	...	11·42	...	...	16·80	5·90	2·8	...	
						21·80	7·65	2·8	...	
78	No. 2 Club Calcutta	...	11·43	...	...	16·30	6·20	2·7	...	
						21·20	7·15	2·9	...	
79	No. 1 American Hard Fyfe Wheat	65·00	11·17	4·85	1·40	32·00	11·40	2·8	...	......
						24·00	9·86	2·5	...	......
80	No. 1 Hard Wheat, Canadian	65·10	12·31	6·16	2·00	28·00	10·22	2·7	...	......
81	Persian Wheat	...	11·26	6·60	0·80	26·05	9·00	2·9	...	......

TABLE VI

AVERAGE COMPOSITION OF AMERICAN WHEATS

No of Analyses.	District where Grown.	Weight of 100 grains.	Water.	Ash.	Oil.	Carbo-hydrates.	Cellulose.	Proteins.	Nitrogen.	Heaviest 100 grains.	Lightest 100 grains.	Highest Proteins.	Lowest Proteins.
		Grams.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Grams.	Grams.	Per cent.	Per cent.
260	United States and Canada . .	3·638	10·27	1·84	2 16	71·98	1·80	11·95	1·31	5·924	1·830	17·15	8·15
108	Atlantic and Gulf States . .	3·464	10·42	1·75	2·17	72·61	1·72	11·33	1·81	5·079	1·830	15·58	9·45
47	The Middle West	3·607	10·51	1·76	2·01	71·67	1·90	12·15	1·94	4·902	2·138	16·63	10·15
97	West of the Mississippi . . .	3·806	10·04	1·99	2 22	71·12	1·87	12·76	2·04	5·924	2·561	17·15	10·15
8	The Pacific Coast	5·044	9·74	1·84	2·08	76·18	1·56	8·60	1·37	(5·745)	(7·253)	9·47	8·05
6	Canada	3·325	9·74	1·56	2·29	73·8	1·67	10·87	1·74	3·686	2·964	14·70	9·45
32	Pennsylvania	3·373	10·72	1·67	2·05	72·47	1·73	11·38	1·82	4·658	2·035	15·58	9·45
9	Maryland	3·597	10·52	1·75	2·09	72·25	1·74	11·65	1·86	5·079	3·075	14·53	9·80
11	Virginia	3·343	10·34	1·70	2·21	71·85	1·71	12·71	1·95	4·208	1·830	14·00	10·15
7	Georgia	3·597	10·00	1·96	2·30	72·24	1·72	11·78	1·89	4·627	2·834	14·00	9·45
22	North Carolina	3·776	10·03	1·59	2·25	73·94	1·76	10·43	1·67	4·628	2·780	12·43	8·93
17	Alabama	3·314	10·94	2·03	2·21	71·84	1·62	11·36	1·79	4·627	2·011	13·65	9·80
	Michigan (Kedzie)	...	11·28	1·73	...	74·97	...	12·02	1·92	...	...	13·78	9·13
22	Michigan	3·969	10·71	1·64	2·06	72·12	1·80	11·67	1·87	4·902	3·402	15·23	10·50
8	Kentucky	3·434	10·83	1·75	1·87	70·37	2·03	13·15	2·10	3·666	3·146	14·53	11·90
14	Tennessee	3·150	10·19	1·89	2·00	71·33	2·02	12·51	2·00	3·990	2·138	16·63	10·15
12	Missouri	3·502	9·80	1·92	2·19	72·36	2·17	11·56	1·86	3·867	3·098	14·00	10·50
9	Minnesota	3·354	10·60	1·71	2·03	70·96	2·04	12·66	2·03	3·828	3·116	17·15	10·85
10	Kansas	3·204	11·80	1·64	1·98	71·35	2·08	11·15	1·78	3·424	2 881	12·25	13·50
19	Texas	2·847	10·03	1·81	2·11	70·85	2·06	13·14	2·10	3·937	2·561	15·23	10·68
45	Colorado	4·682	9·57	2·21	2·38	70·91	1·62	13·31	2·13	5·924	3·851	15·94	11·19
8	Oregon	5·044	9·74	1·84	80162	76·18	1·56	8·60	1·37	5·745	4·253	9·47	8·05

Composition and Weight of Wheats according to Professor Fleurent.—Professor Fleurent has analysed certain hard wheats, Russian, Algerian, and Canadian (the last contained 25 to 30 per cent. of soft wheat), and tabulated the results as follows:

TABLE VII

	Russian Wheat.	Algerian Wheat.	Canadian Goose Wheat.
Average weight of grain in grams	0·030	0·048	0·037
Constitution, per cent.:			
Endosperm	84·95	84·99	84·94
Embryo	2·00	1·50	2·05
Husk	13·05	13·51	13·01
Composition of the Entire Wheat.			
Water	11·42	11·34	11·36
Nitrogenous matter:			
Gluten	14·76	11·00	10·88
Soluble (diastases, &c.)	2·25	1·82	1·67
Ligneous, of husk	1·82	1·90	1·91
Starch	50·15	55·05	54·55
Fatty matters	1·18	1·93	2·70
Soluble carbohydrates:			
Sugars	2·17	2·68	2·18
Galastose	0·65	0·46	0·75
Of husk	1·76	2·19	1·90
Cellulose	9·73	9·40	9·21
Mineral matters	1·56	1·42	1·35
Undetermined and loss	2·48	0·81	1·54
Total	100·00	100·00	100·00

The gluten contained by the Russian wheat consisted of gliadin, 46·45 per cent., glutenin 37·89 per cent., and congluten 15·66 per cent. Fleurent considers the congluten to be the cause of the want of elasticity of the flour obtained from hard wheats.

Composition and Properties of Durum Wheat and Flour.—Durum wheat, *Tricitum durum*, is cultivated in considerable quantities near the Mediterranean and in Southern Russia, and is chiefly grown for the manufacture of macaroni. It has been also introduced recently in America, where bread flours are manufactured from it. Its grains are hard, ambertiated, and almost twice as large as those of ordinary Russian wheats Norton, of the South Dakota Agricultural Experiment Station, has

CHAPTER III

PREPARATION OF GRAIN FOR GRINDING

I

IMPURITIES AND THE PRINCIPLES OF CLEANING

As we have already seen in the general review of the grain, the impurity of the stock is due to the character of the production. An admixture of seed of other plants is unavoidable even when the culture of the cereals is most careful. The separation of the seeds of foreign plants from the grain, although performed on the larger farms, is not satisfactory, the grain being usually prepared for sowing and not for sale. The grain of the large rationally worked farms is comparatively clean; that of the Russian peasantry and small farms, on the other hand, sometimes contains up to 6 per cent. of impurities.

In addition to the seeds of foreign plants, the grains of bad quality of the corn itself belong to the impurities. Those are mainly the so-called "shrivelled" kernels, unripe at the time of harvesting and dried to light meagre grains, or those appertaining to harvests caught by drought and admixed to the normal grain. Kernels of corn stricken by some disease, *e.g.* smut, are also of this group.

Assuming the corn to be ground at the mill is wheat, the kernels of other cereals, such as rye, barley, oats, &c., are to be added to the number of foreign matters.

Besides being impure through admixtures of vegetable origin, the grain acquires impurities of organic and mineral substances, and particles of metals. The method of production, storage, and transportation of corn make the admixture of particles of straw, empty cobs, stones, dust and dirt that cover the grains, small stones, and lumps of earth inevitable. And then during the threshing and cleaning of grain on the farm more or less often nails, woodscrews, nuts, and other metal parts of machinery fall into it.

All impurities may be classified in three groups:

(1) Poisonous admixtures that may bring about an empoisonment

not to mention the deterioration of the qualities of flour (its colour and baking qualities): ergot, cockle, smut, &c., pertain to this class.

(2) Impurities reducing the quality of flour. Here we find the seeds of non-poisonous plants, dust, and dirt.

(3) Impurities that may do some damage to the machinery, *e.g.* rapid wearing out of sieves, breakage of parts of the machinery, &c. Stones and pieces of metal form this group.

Now, if the mill is to yield a wholesome product of good quality, and the milling machinery is to be set in normal working condition, the grain should be freed of all this foreign matter.

The impurities we have been examining usually differ from the sound product by one, or several tokens conjointly, of the following categories: (1) size, (2) specific gravity, (3) shape, (4) natural peculiarity of the admixture. The machine, designed for the extraction of foreign bodies out of the grain, is constructed in accordance with the particular manner in which the impurities differ from the main product. Thus four types of machinery, each taking advantage of the peculiar differences of the admixtures, have been evolved. But often the separation of the grain, and the extraneous bodies differing from it in size and specific gravity, is combined in one machine.

II

EXTRACTION OF PIECES OF METAL FROM THE STOCK

Magnetic Separators.—Before feeding the grain into a machine all pieces of metal, that might damage the working parts of the machine, must be extracted. These pieces being exclusively of iron or steel, their extraction is based on the property of the magnet to attract and detain both metals.

A magnetic apparatus adapted for that purpose is shown in its simplest form in Fig. 44. It consists of two cast-iron frames *C*, between which a cast-iron box *D* is placed. The frames and the box are bolted together. In the box is set a row of magnets, their poles *a* and *b* coming out on the surface of the cast-iron or timber tapering plank *E*. The poles *a* and *b* are disconnected by an insolated interlayer. On the plank *E* is placed a cast-iron or timber feed-hopper *A* with a gate *B*, by the lifting and dropping of which the flow of grain may be regulated. The grain is poured in as shown by the arrow *S* and, falling through the lower crevice between the gate *B* and the magnet table *E* (arrow *S*), leaves the iron and steel pieces on the magnet line. From time to time these admixtures are removed by hand.

This is the most simple apparatus, though sometimes a still plainer appliance is used. Horseshoe magnets of the common kind are inserted into corresponding spouts down which the grain passes. Usually a wooden stopper, with three to four magnets set into it, is fitted into a hole in the spout (Fig. 45). At intervals the stopper is taken out, and the metal particles attracted by the magnets removed.

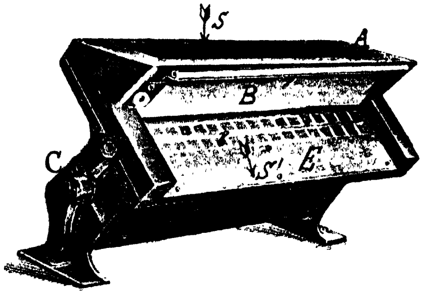

FIG. 44.

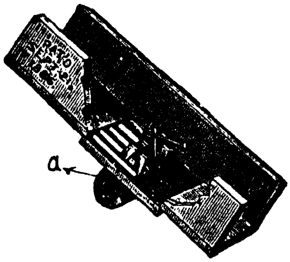

FIG. 45.

The removal of the particles detained by the magnet offers some inconvenience, demanding constant attention from a workman occupied on other machines. Therefore another type of magnetic apparatus, removing the iron particles automatically, is in use. Such an apparatus, from Howes' factory in America, is represented in Fig. 46. The whole apparatus is of timber. The arrangement of the magnet is the same as in the simple apparatus. But here cast-iron scrapers *r* set on an endless belt (other factories make a chain-gearing) pass over the magnet surface. These scrapers catch up the iron particles stuck to the magnets and throw them into the bucket *E*. The belt is driven by a pulley *t*, the axle of which, passing through the feed-hopper, communicates the rotation to the belt pulley *n* with the aid of a bevel gearing *k*. By means of gears *S*–*S*, on the left-hand side of the apparatus, a feed roll in the hopper is brought into play. The taper of the hopper gate is regulated by screw nuts *b*–*b*, thus altering the

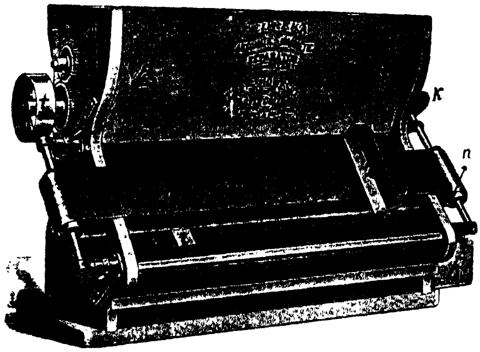

FIG. 46.

feed opening between the roll and the gate. The belt *R* is tightened and loosened by screw-nuts *g*–*g*.

The number of revolutions the belt of such an apparatus performs per minute is between 15 and 25, its capacity 9 to 16·5 tons per hour, according to the size of the apparatus. One of the defects of this apparatus is that the scrapers carry some grain away and interrupt its even flow.

Besides the magnetic apparatus just examined, there are other apparatus with a revolving working magnet, and with an electro magnet, but those of the latter kind are rather complicated in construction, and are seldom used in mills, since the simple apparatus works satisfactorily.

The capacity of the simple magnet apparatus varies between 3·5 cwt. and 4·5 tons, depending on its size. A magnetic separator with revolving magnets is shown in Fig. 47.

The magnets are enclosed in the cylinder *A* with a worm-wheel *E* which couples with the worm *D* fixed on the axle of the belt-pulleys (loose and fast) *T*. The flat surface of the cylinder containing the magnet *B* coincides with the surface of the spout, where a hole corresponding in size with the area of the working surface of the magnet is cut. The product flowing along the spout, the iron particles stick to the magnets, which are then scraped off with bar *F* and fall out through the channel *a*. A link mechanism *C* serves for setting the magnet.

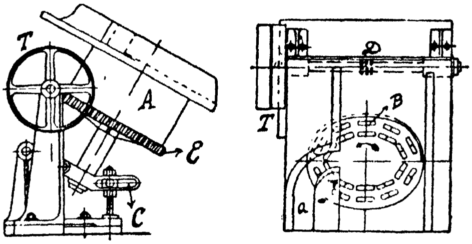

FIG. 47.

III

SEPARATION OF LARGE AND SMALL IMPURITIES

1. *Separation according to Size*

Sifting.—Previously to the further cleaning of grain, a product has to be obtained of an approximately equal size, *i.e.* a product of which all the measurements would be correspondingly equal. The working surfaces serving to that purpose are the sieves.

As shown in Fig. 48, there are sieves either of woven iron, steel, copper or bronze wire, or of a perforated sheet of metal.

When a mass of corn passes over such a sifting surface, the separate grains will fall through the sieve when the meshes are slightly larger than the grains. The larger matter rolls off the sieve. In this manner the throughs supply the grain, while the overtails consist of the larger impurities.

The removal of the smaller impurities is attained by rocking the grain on a sieve of which the meshes are smaller than the smallest grains. In this case the grain tails over, and the small matter dresses through.

Before passing on to the construction of the machines separating the impure matter from the grain by sifting, the sizes of the meshes and the numeration of cloths have to be explained.

The sizes of the square meshes in wire sieves are defined by the number of cloth which, in its turn, is defined according to the number of wire threads to the linear inch. If the number of the sieve is 6, the number of threads is 6, forming 36 meshes to a square inch. No. 40 corresponds to 40 threads and 1600 meshes, &c. It is to be noted, however, that the reckoning is made in English inches, 25 mm. (in England and in America), Viennese inches, 26 mm. (in Austria, Hungary, and Germany), and French inches, 27 mm. (in France). This must be kept in view, when selecting fine sieves, No. 42 and upwards, from various factories.

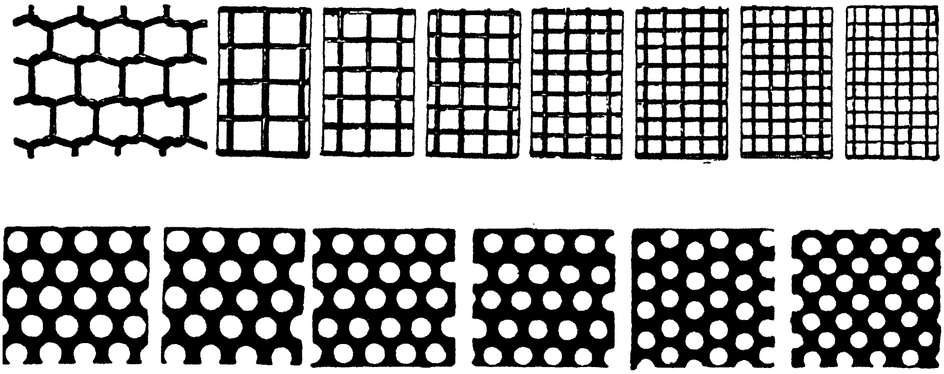

FIG. 48.

Besides that, the thickness of wire plays a prominent part in the definition of the size of the cloth-meshes. Generally speaking, the diameter of the wire varies between 2½ and 0·1 mm. Within the bounds of Nos. 1 and 8 the diameter of the wire does not vary (in No. 8 it is 0·5 to 0·65 mm.); outside of that limit it may differ. For this reason the density of the cloth is greater or smaller, which is reflected in the number of the cloth, though the meshes be of the same size. For instance, No. 16, a cloth of greater density, corresponds to the finer No. 20, the meshes of the two cloths being equal, but those of No. 20

exceeding No. 16 in their number. The density of the cloth is usually defined by the weight of a square yard or metre.

Nos. 1 to 8 are applied for sorting away the matter larger than the grain, of which Nos. 1, 2, and 3 are used in front of the primary storage bins, which receive the grain to be fed into the mill. These sieves detain large stones, chips of wood, strings, &c. on their surface. Nos. 4 to 8 are set in sifting machines where the sieves separate the smaller matter as screenings, the grain falling through. The rest of the numbers of wire cloths above 8 keep tail over the grain, and let the fine impurities through.

As to the quantity of numbers of cloths for cleaning the grain. in Germany and Austria-Hungary forty are in use, beginning with the 4th, and ending with the 75th. These numbers are arranged in the following way: from 4th to 26th a successive increase by one number; 28th to 46th, by two; 50th to 70th, by four; and the last is No. 75. The Russian factories produce generally with the difference of one the Nos. 1 to 8, of two Nos. 10 to 28, and of four Nos. 32 to 60.

In Russia, besides the numeration to the inch, there exists a numeration to the vershok, and according to the number of threads. It is adopted here and there on the Volga and in the central region. It is advisable, however, to keep to the inch numeration, more especially as the vershok numeration is quoted only by the peasant hand workers in the government of Nijni-Novgorod.

Speaking of perforated sheet-iron sieves, the fact is to be pointed out that their numeration is exactly the reverse of that adopted in woven-wire clothing. No. 1 is the sieve with the finest meshes, ½ mm. in diameter, and No. 24 has the largest, 25 mm. in diameter. There are twenty-four numbers, No. 1 containing the greatest quantity of meshes, 1600 to 2025 to a square inch. The shape of the meshes is mostly round, though rectangular ones are also made.

(i.) *The Construction of Sifting Machines*

During the sifting process the product must be made to travel over the bolting surface. This is done by means of moving sieves, which compel the grain to travel in the direction defined by the kind of motion peculiar to the sifting surface. On examining the various constructions of the machines, we may divide them into two groups in respect of the kind of motion of the sieves: (1) machines with vibratory motion, and (2) with rotary motion.

The sieve in the old German mill (Fig. 28, *G*) may be regarded as the most primitively constructed machine of the first type that can be used for grain cleaning. Sieves of that kind are set at a slight angle to the horizontal plane. When the sieve frame moves in a longitudinal-reciprocal direction, the grain is displaced by force of inertia, the movement of the sieve being straight, parallel to the axis of oscillation. When the sieve moves crossways, the grain travels in a zigzag line.

A comparison of the two methods of moving the product over the sieve persuades us that the second is preferable, as travelling in a zigzag way the stock remains on the working surface a longer while, and the separation is more perfect.

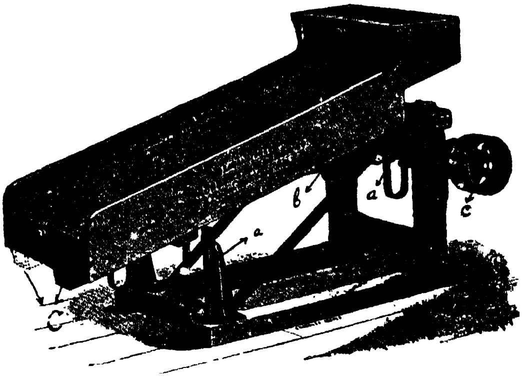

Fig. 49.

"*Eclipse*" *Bolter of Nordyke & Marmon Co.*—The "Eclipse" bolter of the American factory of Nordyke & Marmon Co. (Fig. 49) presents a simple and original construction of a sieve with longitudinal oscillations. A wooden box *D* has at its upper end a receiving hopper *A*. Two sieve trays *B* are fixed in the box. The frame is set on four U-shaped springs *a* and is oscillated by a connecting rod *b*, communicating with the crank rod of the driving shaft. *C* are the spouts delivering the product and small impurities. The overtails of the upper sieve is the large refuse. The number of revolutions is 450 per minute, the capacity of the machine 6 to 18 cwt. per hour.

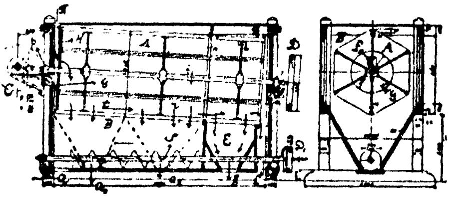

Fig. 50.

Reel-separators.—Machines extracting foreign matter by bolting, but with their working surfaces revolving, are called reel-separators. It has already been mentioned that they are an American invention, and the simplest form of that machine was examined on p. 25, Fig. 26. The fundamental principle of its construction is the same to-day. Besides the use of the round reel-separator, practical flour milling has introduced hexagonal reels into the industry, by reason of their simple construction and cheapness.

A reel-separator of the most simple kind (Fig. 50) is generally a timber hexagon shell *A*, 1250 to 3500 mm. long, its diagonal measurements 350 to 1000 mm., covered with bolting cloth and placed in a timber chamber *B*, its axis inclined at an angle of 0·08 to 0·1 to the horizon. The reel-shaft is mounted on bearings *p*, outside the chamber. The grain flows to the reel-separators through a spout *N*, and on this side the separator is sheltered by a lid *H* revolving with the reel-separators conjointly. A round cover *G*, with an aperture *F*, for the passage of grain, is fixed to the interior wall of the chamber and is stationary. Between *H* and *G* there is a small clearance, besides an opening with a clearance in G for the reel shaft. The right end of the reel-separators remains open. In the sides of the chamber there are apertures for inspection, closed with solid timber gates or frames clothed with linen. The reel-separator is operated by a bevel gearing *C*, and the worm conveyor *S* by a belt (sometimes geared) drive on belt-pulleys D D_1. The head of the reel-separator (the inlet of the product) is generally clothed with one, two, or three numbers for sifting the small matter, the tail part (outlet of the product) with cloths with larger meshes for the discharge of the grain. The work is performed in the following manner: the grain is fed through *N* into the rotating reel-separator, which being inclined, it travels in a zigzag line towards *t*. The small impurities, passing to the lower part of chamber *B*, are discharged by the worm *S* through the opening *a*. The grain flows into the conveyor box *E*, and runs out into *b*, while the large impurities fall out as refuse through the opening *c*.

A plainer reel has no conveyor, and the lower part of the chamber is divided into hoppers (outlined in dots) delivering the small impurities through openings a and a_2.

Figs. 51 (longitudinal section) and 52 (cross section) represent a reel-separator constructed of metal (cast-iron frame and iron hoppers) by Thomas Robinson & Son, Rochdale, England. No conveyor is adopted here; the dust, sand, &c., small impurities falling automatically out of the first conical hopper, the grain out of the second, while the large refuse passes out the same way as in the preceding reel-separator.

The simplest kind of a round reel-separator with a timber frame and boxes is shown in Fig. 53. The reel is clothed with three cloths of various numbers. Two sections, *A–A*, for small refuse, sand and dust, are clothed with No. 14; two other sections, *B–B*, for larger matter and very small grain, have Nos. 10 to 12; the last two sections, *C–C*, for the passage of grain, Nos. 5 to 6. The large impurities tail over. The product moves in the direction indicated by the arrow. The hopper *D* receives the small impurities, *E* the medium, and *F* the pure grain. The doors are removable from the side walls of the reel-chamber; one of them, *G*, is shown in the drawing. The cylindrical reel-separator generally consists of two semi-cylinders, so as to afford the possibility of their clothing.

Sometimes the clothing used for reel-separators is of perforated sheet-iron with round or rectangular holes. The reel-separator in Fig. 54 is furnished with three sieves, of which *A* has rectangular and round holes, *B* only round, and *C* only rectangular. The product is fed as indicated by arrow *S*. In section *A* the throughs are small impurities, and long but thin seeds (of oats, rye, shrivelled grains in wheat cleaning); section *B*

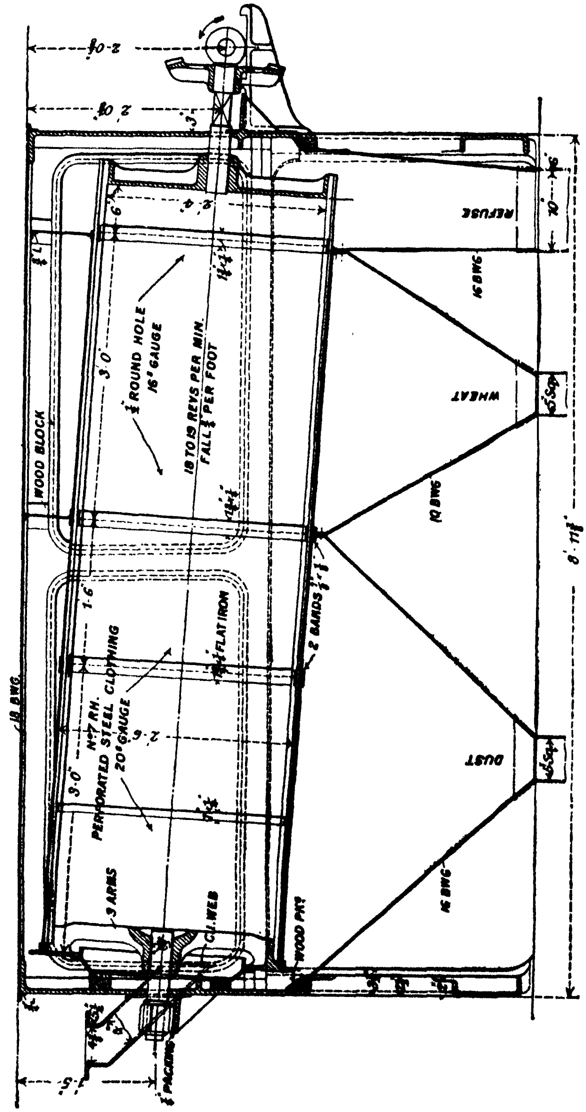

FIG. 51.

gives only the small refuse as throughs, and the clean grain is sifted through in section *C*. The larger refuse constitutes the overtails. In this way, in the first part of this reel-separator, impurities differing in size as well as in shape (oats, wild oats, rye) are separated away. Another type of machine, however, for sorting the grain according to shape remains to be noted. Therefore the use of reel-separators supplied with these covers is expedient only where a simplification of the grain-cleaning process is unavoidable from considerations of economy, and the grain-cleaning department is deprived of machinery sorting the grain according to shape.

However, an outline may be given of the modern type of reel-separators, which are mainly used on mills for separating the large and small grain, though also capable of sorting the seeds of other plants away from the chief bulk of product to be milled. Fig. 55 represents a cylindrical grader reel from the factory formerly known as "Bros. Seck," in Dresden. The product is fed into the receiving spout, and falls into the reel, covered with a bolting cloth with rectangular meshes. (The sieve next to cloth *A* is removed.) The meshes of the sieve *A* may be the same throughout the whole length of the reel. In that case the throughs will be the small grain and the large grain will remain as overtails. If half of the reel-separator is clothed with meshes for rye and oats (when wheat is treated), the second half must carry meshes for small wheat. Then the box containing the conveyor *C* will have two discharge spouts, Z_1 and Z_2.

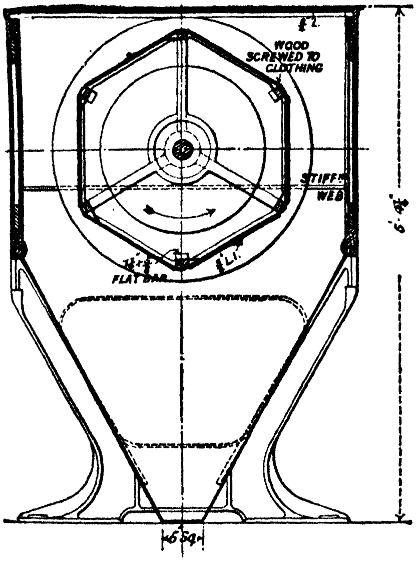

FIG. 52.

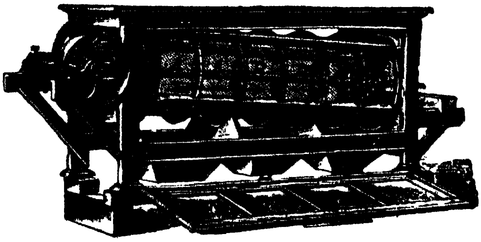

FIG. 53.

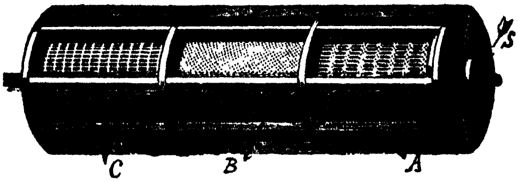

FIG. 54.

The peculiarity of this reel-separator consists in its being furnished with brushes B of iron wire. These brushes revolve and, being pressed against the cover of the reel, clear the meshes of the grains stuck in them. The reel-chamber is of timber, and its parts of metal. T are timber doors (one is off), K and K_1 are lids for the inspection of the worm. The reel-separator is driven by a bevel gearing, and the worm by means of a belt-drive on pulleys b and a.

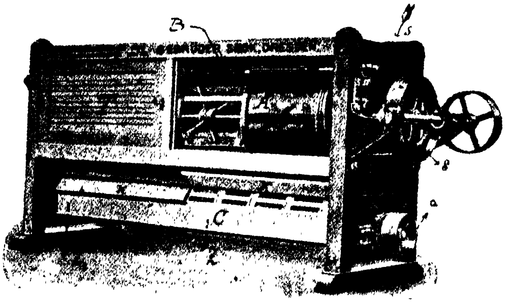

Fig. 55.

Vibro-motor Plansifters. — The small capacity of the reel, and the detrimental effect of the inertia of the mass of machinery with flat bolting trays reciprocating, compelled builders to design a type of machine supplied with flat sieves. The first machine of that style was displayed at the Universal Exhibition in Vienna, 1873, by a miller from Pfalz, Johann Pfoltz.[1] The principle of operation in this machine, which afforded K. Haggenmacher later a basis for the flat-bolter, invented by him in 1888, is the following: a flat sieve s (Fig. 56) is suspended from the ceiling by means of four rods, a, b, c, and d, and is connected with a rotating crank shaft A. The product falling on the tray is bolted, while travelling in a gyratory line. A progressive displacing of the product is attained by an inclination of the tray, which is the method adopted by the firm of G. Luther in their aspirators of latest type, or by means of guiding scrapers as suggested by Haggenmacher in his flat bolter. If a horizontal flat-bolting frame is divided by cross partitions 1, 2, 3, . . . as shown in Fig. 57, the product will travel progressively as indicated by the arrow r, the partitions stopping it half-way and propelling it to run another circle. Were the frame not furnished with

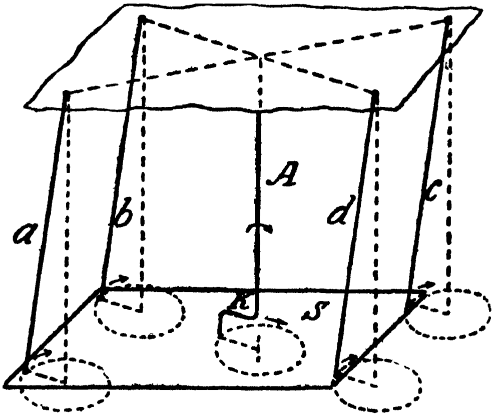

Fig. 56.

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[1] In 1878 another inventor, Pieter van Gelder, patented a flat bolter in England, based on the same principle.

partitions, the product would describe full circles, as shown in *O*, remaining always on one and the same spot.

Flat grain-bolters of the Haggenmacher type are built at the English works of Thos. Robinson (Rochdale). The construction of machinery with flat sieves will be examined later.

The construction of the machinery we have become acquainted with enables us to extract the large and small impurities and sort the grain in respect to its size, which is of great importance to the further cleaning processes, to be considered later. Therefore it follows out of the very idea of cleaning, that the positions and numbers of sieves must be as shown below (English notation).

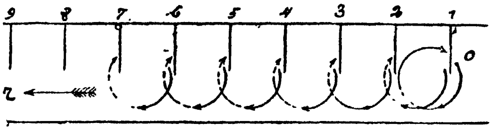
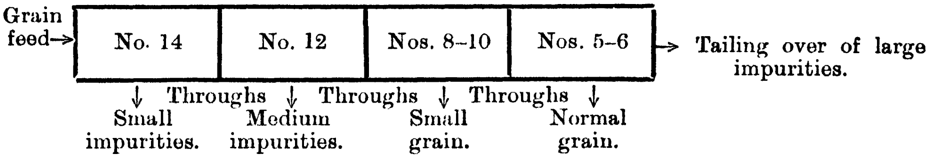
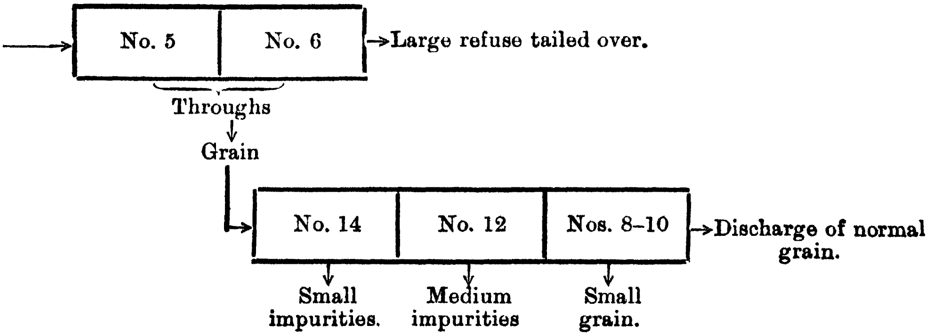


Fig. 57.



In this way, first of all on covers Nos. 14 and 12, small impurities, sand and dust, are sifted through; on cover No. 8 or 10, small grain; on cloth No. 5 or 6, the normal grain, the large impurities being tailed over.

If the grain contains a large amount of impurities (stones particularly), to save the covers Nos. 14, 12 and 8, 10 from the wear and tear, a separate reel-separator may be fitted up for separating the large refuse, and another for cleaning the grain of small impurities and sorting it. Then the scheme of cleaning is:



Both the schemes refer to grain cleaning on reel-separators. The system of cleaning on sieve-separators, and the order of the numbers, will be examined later.

(ii.) *The Quality and the Quantity of the Work of Sieve-Bolters*

Let us now compare the quality and quantity of work of flat sieves and two types of reel-separators. The working quality is defined by the uniformity of the effect resulting from the operations of any particular working organ—the bolting surface, in this case.

Figs. 58, 59, and 60 represent a cross section of reel-separators and part of a hexagon reel-separator. We see in Figs. 59 and 60 that the full working surface of the reel-separators is not utilised in the operations, and Fig. 59 illustrates the fact that not all the sieve actually bolting is capable of doing equal work. Fig. 59 exhibits the small grain *b* and impurities *a* that are to pass through, on the lower part of the hexagon reel or flat sieve, and on the side wall of the reel. In the first position, *a* and *b* will easily pass through the meshes of the sieve, if fitting them; in the second position, they cannot fall through, being wedged in between the facets of the mesh, as the area of the passage here, projected on the horizontal plane, is diminished in proportion to the angle of inclination of the reel. Those impurities must be again thrown on the horizontal plane of the bolter, to attain the position favourable to sifting. It is clear, consequently, that not every part of the working surface produces the same effect, and thus the capacity of the machine is diminished. If we

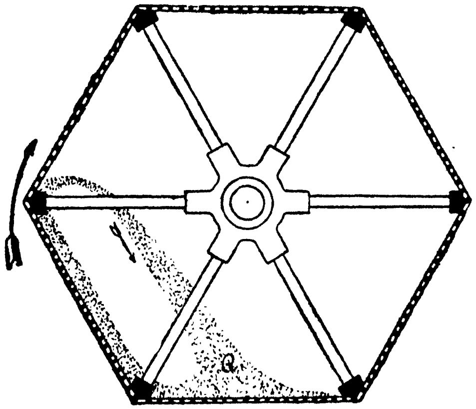


FIG. 58.

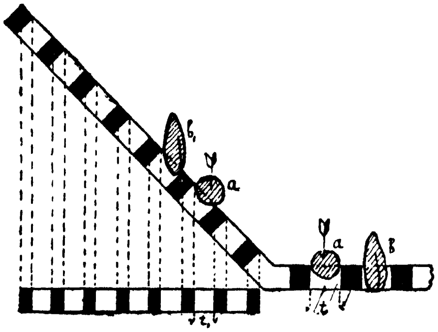


FIG. 59.

have a flat sieve with a fixed incline, the impurities passing through the layer of grain to the meshes will necessarily pass through them.

An examination of the distribution and motion of the product in reels shows firstly that only $\frac{1}{6}$ to $\frac{1}{3}$ of the sifting surface is in actually sifting;[1] secondly, the bulk of product Q (hexagon reel), thrown off the side-walls, when the reel is in rotation, hits the lower wall, and wears it out more rapidly, though effecting a more energetic sifting. If, on the other hand, the bolting is performed on a flat sieve, firstly the whole surface is utilised, and secondly, all the parts of the working surface are subject to the same wear and tear, as the grain travels in a compact mass over the whole sieve.

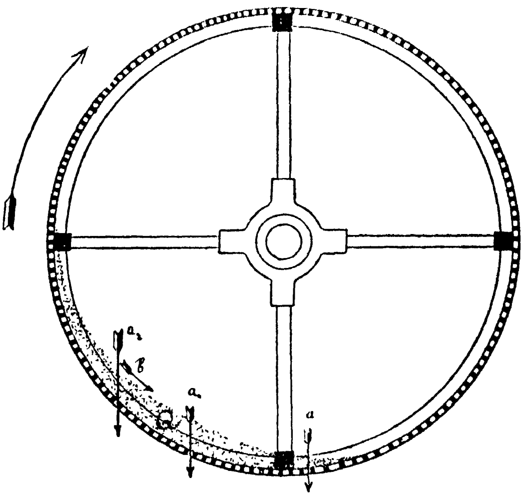


Fig. 60.

These are the reasons why, in regard to their operating qualities, capacity, and wear, flat sieves are to be preferred to other bolters. Besides these advantages, flat sifters are much more compact, and economy of space plays a great part in the choice of machinery. The only advantage of reel-separators is their comparative cheapness and simplicity of construction. No clearly definite capacity of flat sieves and reel-separators per unit of surface may be spoken of, as flour milling technics have as yet no records of accurate tests. That is the cause of contradictions in the data of German authors (Kick, Wiebe, Pappenheim, Kettenbach, &c.), and we shall not quote them. It is to be kept in mind that the capacity of the bolters depends on the amount of impurities mixed with the product, a fact never alluded to by the above-mentioned authors.

Practical experience has shown that the capacity of flat sieves is two to four times as great as that of reel-separators. As to the cylindrical reels their sifting capacity for various sizes is defined by the following

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[1] Some authors accept only $\frac{1}{6}$ of the surface in the hexagon bolter (one facet). However, we cannot agree with that, for bolting is effected by the lower side too in consequence of the impetus acquired by the stock Q when thrown about.

table, giving the average of data from European and American works verified in practice.

The incline of the reel is 80 mm. to 1000 of length.

TABLE X

Nos.	Dimensions of Cylinder.		Number of Revolutions per Minute.	Capacity per Hour in Kilogrammes.
	Diameter.	Length.		
1	350	1250	34	250
2	400	1500	31	450
3	450	1750	28	625
4	500	2000	26	825
5	500	2250	24	1000
6	600	2500	22	1250
7	700	2750	20	1850
8	800	3000	18	2500
9	900	3250	16	3100
10	1000	3500	15	3500

The first three numbers of reels have but three numbers of cloths each. By means of the first sheet, the reels separate the dust, sand, &c. (sieve No. 14). The second bolts the small refuse (No. 12); in the third (Nos. 5 and 6) the grain passes through, the large impurities tailing over. The rest of the numbers of reels, *i.e.* those beginning with 2000 mm. length of cylinder upwards, successfully work with four sheets of cloth. Here the throughs consist of small refuse (Nos. 14 to 12), small grain (Nos. 10 to 8), and normal grain (Nos. 6 and 5), while the large refuse tails over.

(iii.) *Cleaning according to Specific Gravity and Size*

After the impurities have been separated away by bolting, the mass of product, though uniform in size, still often contains foreign matter in the shape of light grains, shells, &c., which have to be extracted. That is done by winnowing the grain. The primitive method of winnowing is the utilisation of the natural power of wind on peasant farms, where the grain is thrown up with shovels, and the wind carries the light matter away. If machinery is used for that purpose an air-current is artificially induced by fans.

The simplest form of machine, called an aspirator, is shown in Fig. 61. The simple separator consists of a chamber *A* with a fan *v*. The lower part of the chamber ends in a hopper closed by a balanced valve *d*. The lid of the chamber carries a valve *e* opening inwards, also counterbalanced. The grain passing down the spout *a* encounters on its way in *b* a current of air aspirated by a fan, which removes the light impurities. The light impurities are carried to the chamber *A*, where those lightest are ejected by the fan, the less light particles falling into the hopper. When a large quantity of refuse has collected in the hopper, the valve *d* is pushed open by its weight, and after discharging it, closes again. The valve *e* automatically admits air into the rarefied space in the chamber. If the fan works too powerfully, then the current of air takes the normal grains away with it.

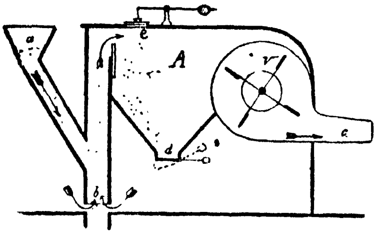

FIG. 61.

With a view to a more effective cleaning A. Fisher suggested the construction of an aspirator with a triple aspiration. Through the feed tube *a* (Fig. 62), in the direction of the arrow *S*, the grain flows on to a spout furnished with three partitions, the height of which may be regulated by the screw *d*. The air-current, passing up (arrows *r*), encounters the stock thrice, and removes the light matter, which is carried through *c* to a chamber similar to the one just described. The heavier extraneous matter falls into the spout *d* by the way of s_1, s_2, and s_3, and is discharged into a sack. The defect of Fisher's aspirator lies in the fact that a mass intermixed to a greater extent with light impurities meets a current of air weakened and dirtied by its preceding work.

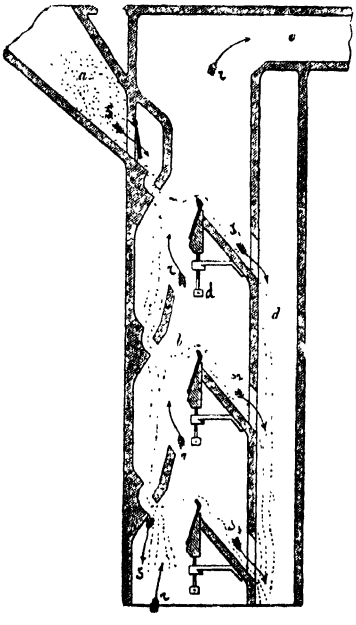

FIG. 62.

The manifold exhaust, based on the principle of Fig. 63, is much more effective. In that machine, the grain discharged into the feeder *A* (arrow *S*) undergoes a quadruple aspiration, with pure air each time. The construction of this machine is very simple. A timber chamber *B*, containing a fan *F*, is baffled by inclined partitions, which form a spout for the grain delivered through *M* after the aspiration. The upper wall of the chamber carries an automatic valve *k*, regulating the rarefication of the air in *B*. The hopper *D* receiving the heavy screenings ends in valves *a*–*b*, which, opening under the pressure of the mass of impurities, discharge them. The lighter refuse falls into box D_1 and is conveyed out by *c* and *d*, while the lightest matter is ejected with the air current by the fan.

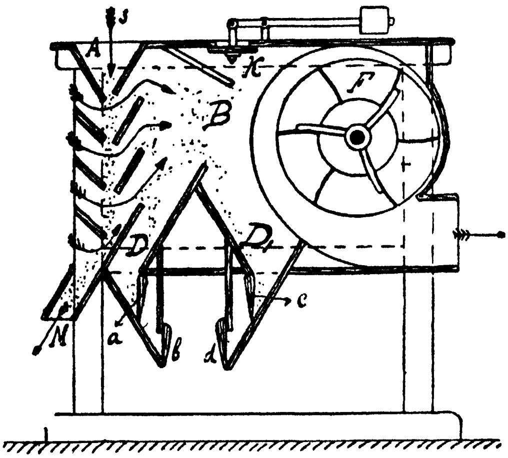

FIG. 63.

Robinson's Aspirator.—For the removal of light extraneous matter, there exists machinery constructed on the principle of utilising centrifugal power. Of the novel types of such machinery Robinson's aspirator must be described (Fig. 64). The grain falls through the feeder and down a spout, running vertically through the exhaust chamber, on to a revolving cast-iron disc. From the disc, it is distributed fan-wise, and then encounters a current of aspirated air, which carries the light matter away, and then conveys it down a spout to its exit. The heavier refuse, encountering a deflecting partition on its way, falls into the box, while the lighter matter passes through the fan either to the dust collector or out of the mill. In this aspirator the feed spout may be raised and dropped by means of a lever-gear and screw for regulating the flow (cross section between the disc and the spout). The disc runs at 190 revolutions per minute. An inspection-glass is fitted in the top of the screenings channel.

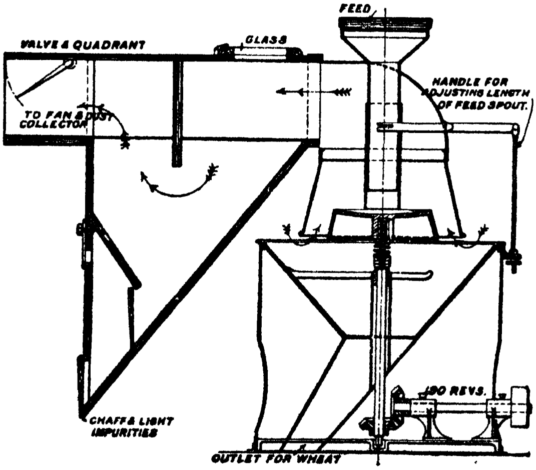

FIG. 64.

The capacity of this aspirator, according to the data of the factory, is from 250 to 83 bushels per hour, corresponding to the size of the machine (Nos. 1, 2, and 3).

Robinson's Cyclo-pneumatic Separator.—Another machine of Robinson's, constructed on the same principle and connected with a cyclone for collecting light impurities, is the cyclo-pneumatic separator.[1] Here (Fig. 65) the disc receiving the grain is enclosed in the cyclone *C*, and the fan is above the cyclone. The fan draws the air out of the cyclone through a passage in the axis, and impels it into the space *B*, by which it is conducted through a side aperture into the cyclone. In this way, the work is performed by the same volume of air which undergoes purification in space *B*. Part of the lighter refuse settles on the sides of the cyclone, owing to centrifugal force, and sliding down the incline, on reaching the worm-conveyor, is taken to the discharge spout. The heavier screenings are delivered to the worm-conveyor out of the chamber *B*. The light and heavy impurities are discharged into one spout in the present case, but a separate passage for either can be afforded by placing another spout along the route of the worm-conveyor before the outlet for the light impurities in the cyclone. The cyclo-pneumatic separator's capacity is 100 to 335 bushels per hour.

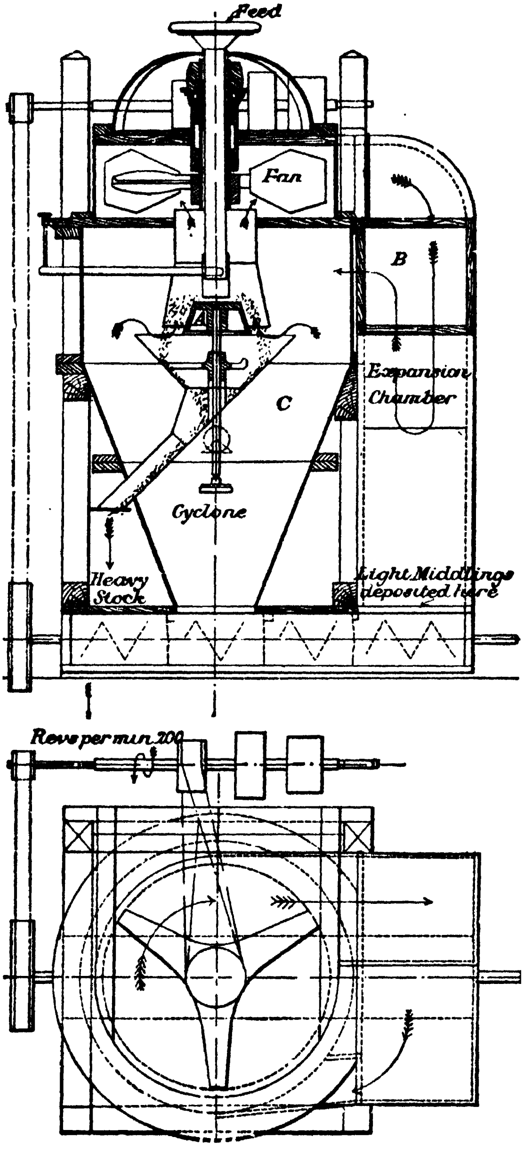

Fig. 65

Hörde's Combined Machine.—For the simultaneous extraction of foreign bodies differing in size and specific gravity, machines operating by sieves and aspiration are constructed. Hörde's separator (Fig. 66) belongs

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[1] A machine of a similar type, Holt's separator, was offered some twenty years ago, but owing to the defects in its construction it did not succeed.

to the simplest class of combined machine. It is a common separator, on the top of which a frame *S* with two bolts is set on four flexible timber stands *t*. The frame is reciprocated by means of two rods *r*, connected with a crank-axle *u*, carrying weights rotating on it, the object of which is to counterbalance vibration of the bolting frame. The grain is fed on to the first sieve, No. 6, which retains the large impurities and delivers them through the side-spouts *a–a*.

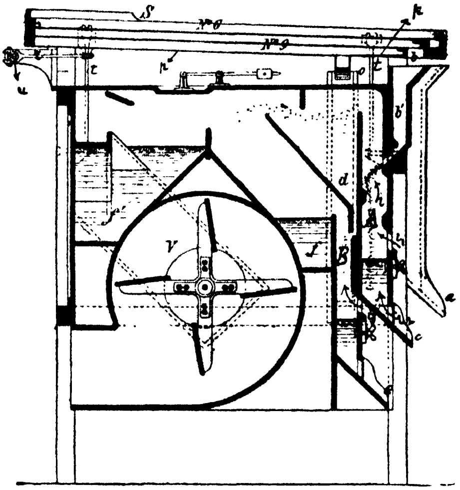

Fig. 66.

On sieve No. 9 the grain is separated from the small matter and flows down the spout *b* to the expansion chamber *A*, where it undergoes a triple aspiration *i*, i_1, and i_2, making its exit, cleaned, through *c*. The throughs from No. 9 pass down sheet-iron bottoms *p–p* to the side-spout *O*. Driven by a stream of air the heavier screenings fall into the hopper *d*, and thence to the expansion chamber *B*, where they are fanned once more in i_3 before leaving the machine through *e*. The lightest impurities are drawn in by the fan along the air-trunk *f*, and ejected with the air, while the medium refuse travels out of the machine down the inclined planes *f*.

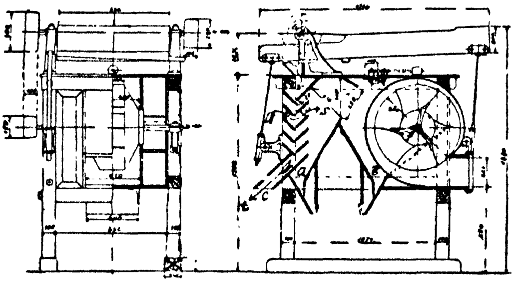

Fig. 67.

The defect of this machine is identical with that of Fisher's separator, *i.e.* the first aspiration *i* is performed with impure air. For this reason the bolting separator of Fig. 67, with a five-fold aspiration, each time with a fresh volume of air *s*, is preferable. The grain is delivered through the spout *c*, the heavy refuse falls into conveyor box *a*, mediums into *b*, and the light matter passes out with the air.

In modern machines of this type the fan generally runs at 500 to 600 revolutions per minute, the crank axle at 250 to 300, their capacity being 40 to 165 bushels, varying with the size of the machine.

T. Robinson's Separator.—In mills of great capacity and in warehouses, where a large quantity of grain has to be cleaned, Robinson's type of machinery is found.[1] The grain flows into the feeder (Fig. 68), and presses open with its weight the valve, which is counterbalanced by weights on shafts. It passes on to the first sieve of perforated steel, No. 20 (meshes 10 mm. in diameter), and in falling on the sieve is subjected to the effect of a strong current of air, which carries away all light extraneous matter. The tails of the first sieve are large impurities, while the grain and the remaining impurities pass to the second bolting tray with two numbers of clothing, 14 and 13. Here the medium impurities are separated away, while the grain falling through is bolted on the third sieve, No. 3, with meshes of $\frac{3}{4}$ mm. On the third sieve the grain is sifted off, and is then exhausted with fresh air in the discharge spout; the throughs here consist of fine impurities. The three trays are enclosed in one common box which is suspended from the frame of the machine on four flat steel rods, and is reciprocated in the same way as the trays of an ordinary separator. The air-draught is induced by two fans running at about 600 revolutions per minute. Light impurities

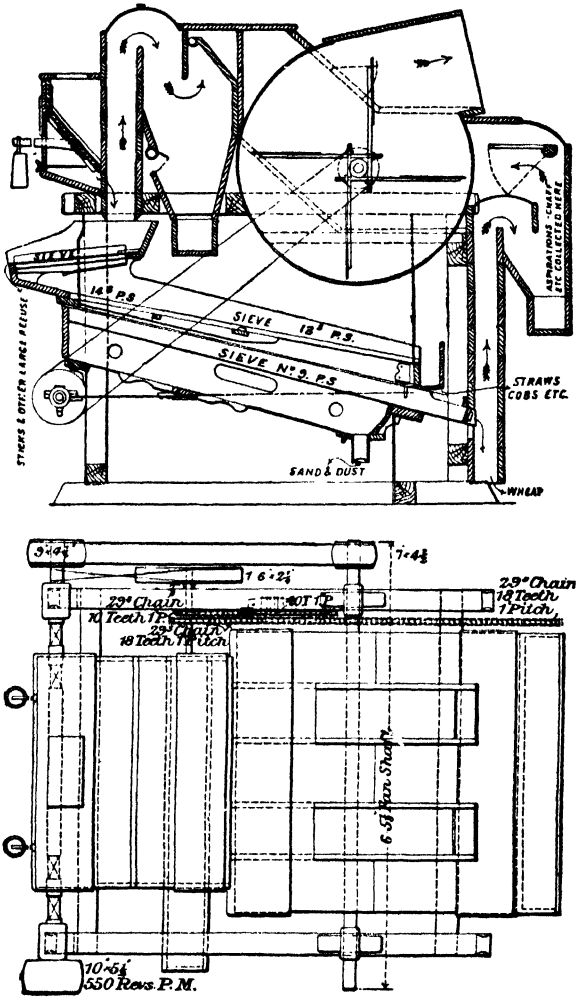

Fig. 68.

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[1] This type has been appropriated from its American constructors, and is being built, with unimportant variations, by all large European works—Seck, Daverio, Luther, Amme Giesecke and Konegen, &c.

are blown through the fan to the dust collector, while the heavy refuse falls into hoppers and slides out down inclined spouts.

The main shaft, which imparts a rocking motion to the sieve, makes about 550 r.p.m.

The capacity of such machines varies between 216 and 2400 cwt. per hour.

Aspirator of form. Seck Bros.—This aspirator is generally used for cleaning the grain to be kept in warehouses, and in mills of a large capacity. Through the feeder *a* (Fig. 69), the grain is delivered on to the first sieve with large meshes, which tails over the coarse, extraneous matter, while the grain falls on the sieve *c* with finer meshes, which remove the smaller impurities, such as corn-cobs, straws, stones, &c., which pass out through a side-spout *d*. The sifted product is then bolted on sieve *e*, which separates the still smaller impurities and flows in a thin, even stream through the discharge spout *f*, where it is exhausted by a current of air, and freed from the dust, chaff, &c.

When entering in the machine, the feed is subjected to the action of exhausts *gg*, which suck out the loose dust, before it is passed to the sieves. Owing to this, the machine, when in operation, produces no dust. The cleanness of the reverse side of the sieves is maintained by automatic brushes *hh* or india-rubber balls which are distributed over the clothing, and the trays moving from side to side, hit the perforated sheets, thus freeing them of dust.

The feed may be regulated, and is performed automatically, viz. the force of the stream varies in accordance with the quantity of the stock fed, in this manner preventing any stoppage, and continuously keeping a certain amount of grain in the hopper. This arrangement lacking, the bolting surface would not be supplied with the stock evenly over its full breadth, thus the aspiration would be inefficient.

The heavy particles of dust lifted by the stream of air collect in two chambers *ii*, whence they are discharged through rocking channels *kk*, arranged on the sieve. The fine dust, at the same time, is driven by the fan to the dust collector.

When mounted, the machine has to be carefully adjusted by means of a spirit-level. By means of weights *L*, adjustable by screws placed at the mouth of the feeder, the force of the stream of stock must be regulated, so as to keep the hopper continually filled to three-fourths of its capacity. The same is to be said of the regulation of the product in *l*, when, on leaving the trays, it flows into the suction drum at the exit. At the feeding and the discharge apertures the air-draught is controlled by means of valves *mm*, arranged in the expansion chamber,

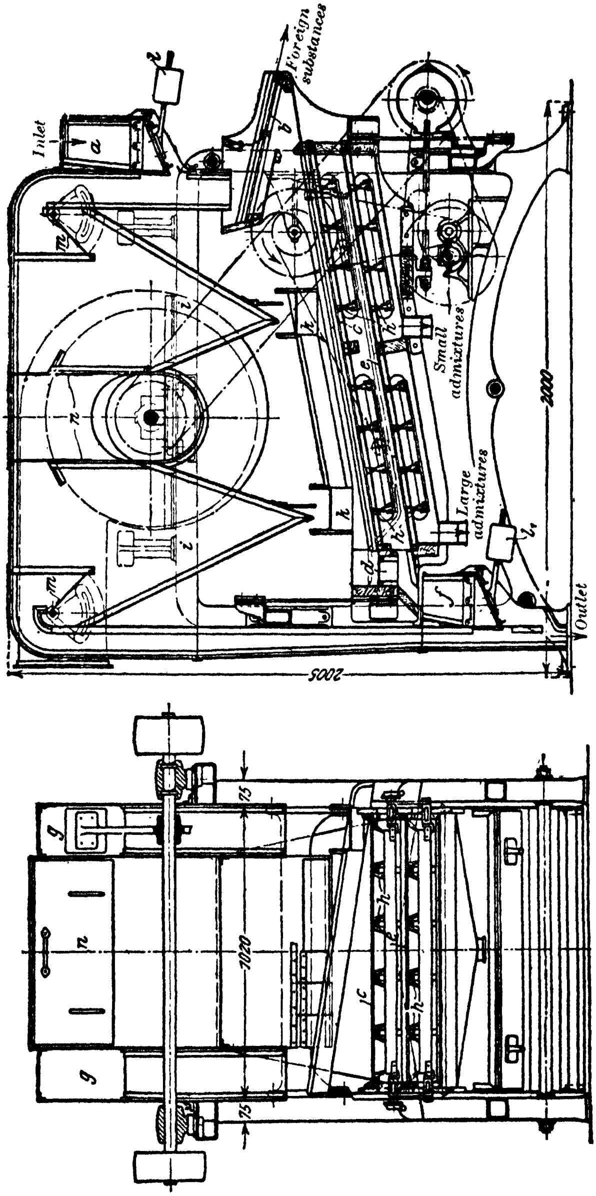


FIG. 69.

which are worked from the outside by levers. The levers are adjusted in their places by means of screws. In addition, a more satisfactory control may be attained by means of two timber distributing slide-valves *nn*, set in the partitions between the refuse collecting chambers and the common expansion chamber of both the exhausts. These slide-valves may be reached through a sheltered aperture in the middle of the upper plank of the aspirator. The slide-valves must never be quite closed.

The aspirator can only be adjusted accurately after a trial operation. The removal of all light impurities from the stock by the air-current is to be aimed at; the good particles of stock, however, should not be carried to the refuse chamber.

The aspirator legs are connected by a spout, which further is connected with the common air-trunk. The trunk opens into the dust chamber, or communicates with some dust-collector. The new bore of the air-trunk may not be smaller than the sum of the bores of both the aspirator legs. Any slight curves of the air-trunk must be made with as large a radius as possible.

The machine is worked from the shaft of the fan making 570 revolutions per minute; by means of belts the motion is transmitted to a crank-shaft which rocks the sieves, and runs at 650 revolutions.

The capacity of such machines varies between 60 and 2000 bushels for warehouses, and 20 to 620 bushels per hour for mills, according to the size of the machine.

The Zigzag Separator.—In this machine (Fig. 70), which does the same work as the preceding one, the trays are arranged in a zigzag line. All five sieves are enclosed in a common box, but its reciprocative motion runs athwart the direction the stock travels. We shall first follow the travel of the stock, and then compare this construction with that of the preceding machine. From the feed-hopper, having opened the counterbalanced slide, and exhausted by an air current, the grain falls on the first sieve (longitudinal section) with round holes (diameter 12 mm.), which shakes the large impurities off and sifts the grain and other matters through. This tray is rocked longitudinally, its axis being perpendicular to the axes of sieves 2, 3, and 4. The throughs of the first sieve falling on the second with meshes $d=5$ mm. leave the large impurities of the second order on its surface, the grain and smaller screenings passing through to a plate, lying parallel to the sieve, and are conveyed to the head of the third tray. The third sieve, having meshes $d=4\frac{1}{2}$ mm., retains extraneous matters of the third order in size, giving as throughs the rest of the stock, which collects on a similar plate under the sieve, which in a like manner conducts the product to the head of the fourth sieve, meshes $d=4$ mm.

Large impurities of the last size are sifted off on the fourth sieve, and the throughs reach the fifth sieve, the axis of which is set perpendicularly to those of the preceding sieves. The meshes of the fifth sieve are $d=2$ mm. It tails the grain over and bolts small refuse, dust, and sand. The grain from the last sieve passes through the exhaust leg to the fan and is freed of the remaining impurities and dust (cross section).

In comparing this machine to the one preceding we notice that the zigzag arrangement of sieves makes it less compact. But its enlargement goes to the account of its height, and has no influence on the area occupied by it. The advantages afforded in return by the zigzag appear in the quality of the bolting, as the distance the grain travels is longer, besides which the product is sifted from the head of the sieve, whereas in the first machine the passing stock falls on different parts of the next sieve, and does not travel the whole length of it.

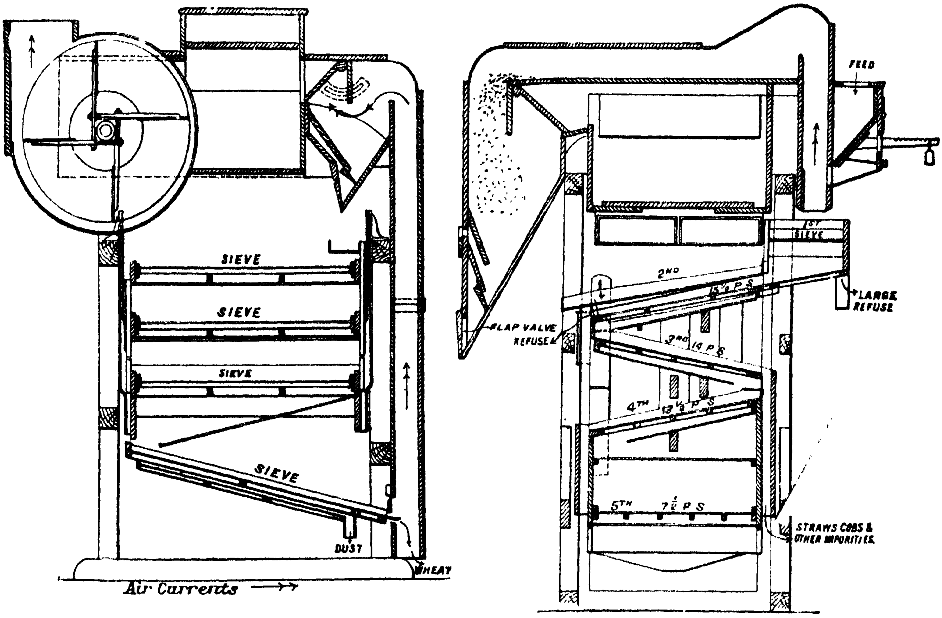


FIG. 70.

The fan of this zigzag of Robinson's makes 600 revolutions, the sieves 520 vibrations per minute, the capacity being 60 to 260 bushels per hour.

Machines with an Inclined Rotating Sieve.—With the view of obviating vibration generated by the reciprocating motion of the working parts, which has a bad effect upon the machine and the building, engineers suggested separators with flat inclined sieves gyrating on the principle already explained. The box C (Fig. 71) contains four sieves, 1, 2, 3, and 4. This box is suspended from the frame on four reed-springs c and connected in with the driving-pin of the fly wheel Q by counterweights. The fly-wheel is set on a shaft rotated by a belt drive. The stock is delivered into the feed hopper A, its flow being controlled by a gate balanced either by a spring, as shown in the drawing, or by a weight. The roll B feeds evenly the sieve 1, an air-current s removing at the same time the light impurities. Sieve 1, inclined to the left, sifts off the large refuse d, dropping the throughs on to sieve 2, which gives the medium impurities r as refuse, and sifts the grain through to sieve 3. The tails of the third sieve are the large grain o, and the throughs are thrown on sieve 4, where the small grain o is retained, and the sand, dust, and other fine particles m pass through. The grain o and o_1 passes down the air-tube v, and once more undergoes the process of separation from the light impurities. The heavier particles of dirt a settle in boxes t, and are taken out through inclined spouts fixed to the bolting box. The number of revolutions of the box is 250, and the capacity is 160 bushels per hour.

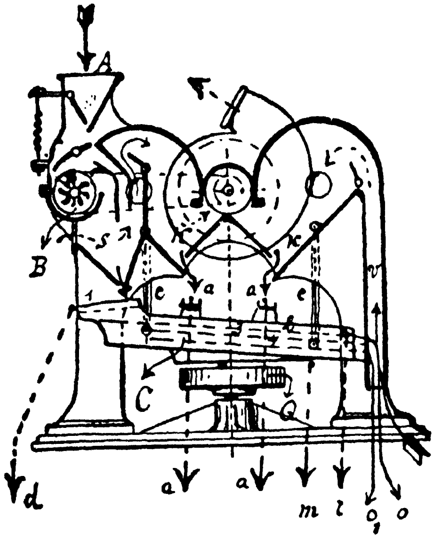


Fig. 71.

Machines of the kind described are built by the firms of G. Luther (aspirator "Triumph") and others.

2. *Separation according to Shape*

In the process of cleansing of the grain of foreign matters by sifting, we have seen that their removal is possible when they greatly differ from the kernels in size. But the sieves will not remove impurities of another shape, yet of a size that agrees with the small dimension of the stock cleaned. To those foreign bodies pertain mostly spherical grains, or particles of grain (broken grain) of the product treated. For instance, the seeds of cockle, or sweet-pea, their diameter coinciding in size with the thickness of a grain of wheat, cannot be separated from it. They cannot, too, be removed when the stock is sorted according to specific gravity, only the light impurities being extracted here. If oats are mixed with wheat, their cross-sections coinciding, they cannot be separated by sifting.

All machinery by means of which impurities, differing from the main stock in shape, are removed, is constructed on principles based on the following properties of these extraneous matters:

(1) Spherical grains roll down an inclined plane or curving surface with a greater speed, and thus developing a greater kinetic energy, leap over obstacles which detain the oblong grains.

(2) Spherical grains roll off a slightly inclined plane, overcoming the friction of rolling, while the oblong grains remain immovable on the surface.

(3) If we have a curved surface or inclined plane with semi-spherical sockets, and stock moving over it, the spherical and broken seeds, will fall into the sockets, and the main stock will roll off.

(i.) *Machines of the First Principle*

The Conic Apparatus.—The apparatus based on the first principle is exceedingly simple (Fig. 72). There are two conic surfaces K_1 and K_2. The diameter of the base of the lower reversed end K_2 is greater than the diameter of the base of cone K_1. The plane of the base of the bottom cone is set higher than the plane of the base of the upper one. The grain flows out of the spout *a* on to the surface of cone K_1. The round grains of cockle, pea, &c., developing a greater rolling velocity, have a larger kinetic energy. Hitting the prominent circular surface cc^1 of the cone K_2 these grains leap over the ring cc^1, while the grains of wheat or rye, in their descent, move slowly, and pass into the cone K_2 and tube *b*.

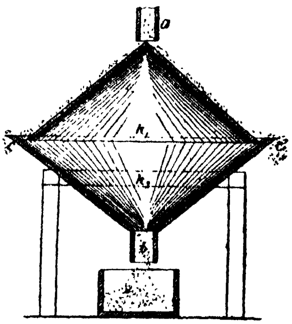


FIG. 72.

The angle of the cones is 35°, the diameters of their bases about three metres. The cones are of polished timber. Though this appliance is bulky, its capacity is great. Open cones would raise dust, therefore they may be encased, which allows the feed to be exhausted.

The Worm Trieur.—The construction of the worm trieur depends on the same principle (Fig. 73). This apparatus consists of helicoidal conic surfaces, of which one, two, or three, *b*, of a smaller diameter, are inscribed in respect of the surface of the large diameter *a*. These surfaces are encased in a box *K*. This *trieur* operates in the following manner: the stock, generally cockle, broken grain, vetch, and undersized grain, passes through the feeder *s* to *b*, a worm of smaller diameter running close to the axle, to which the helicoidal surfaces are fixed. By reason of the action of gravity, the product descends with an according velocity. The round grains (cockle, &c.) develop a greater speed, and roll over the rim *b* into the larger worm, as shown by arrows. At the base there are exits for the sorted product, *c* for non-round grain, and *d* for the round.

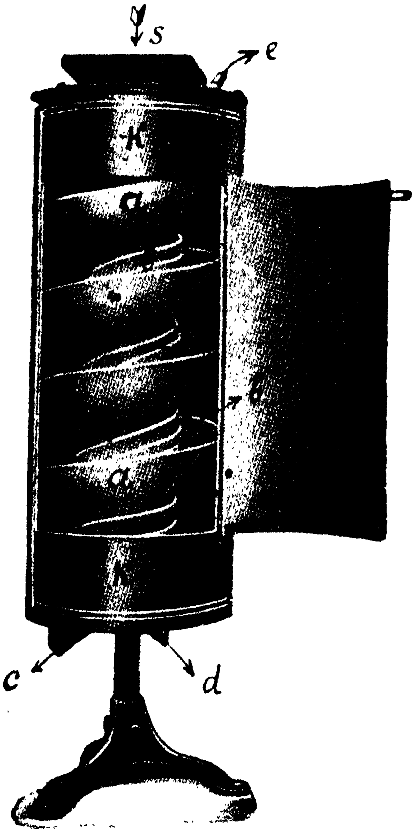


FIG. 73.

The machine is often built without a case, but it is better encased, as this appliance affords the possibility of aspirating the machine by means of an exhaust tube fixed as shown by the arrow *e*. For inspecting purposes the machine may be furnished with closely fitting doors.

This machine operates very efficiently; the thread of the worm and the angle of the cone being carefully calculated, it requires no motive power, and it is of an exceedingly simple construction. The flights of the worm are made of iron plate. The case is also of iron. The capacity of a machine with a worm 2000 mm. in height, the larger worm *a* being 500 mm. in diameter, is from 25 to 40 bushels per hour.

(ii.) *Machines of the Second Principle*

Two types of construction belong to machines operating by a moving inclined plane: the first kind moves parallel to the direction of the rolling grains, the second at right angles.

Fig. 74 exhibits a double machine of the first type manufactured by

Röber. On a timber stand are placed a feed box *A* for the stock, and a frame *B* with working surfaces *D*, which are endless leather cloths rotating in the direction pointed by arrows *s*, by means of a belt-pulley *C* and guides *r* enclosed in the cloths. Through the feed box *A*, the stock is fed on to *D* by the feed rolls *a*. The round grains roll down (arrow *n*), the grains of wheat, rye, &c., are lifted up on *D* and thrown off into a box *F* below. The flow is regulated by a gate *b*. The incline of the working surface is adjusted with the aid of a toothed gearing *E* and bolts *v*, which are screwed into nuts *u*, and support the lower parts of the frame. The lower guides for *D* are mounted on adjustable bearings, which makes it possible to adjust the tension of the cloths.

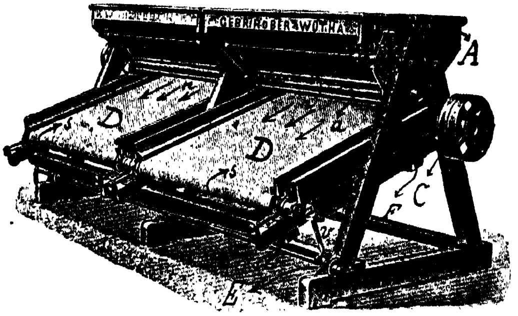


Fig. 74.

The capacity of such a machine attains 12 bushels per hour, the breadth of the cloths being 250 mm., their length 2500 mm., and the speed is 80 revolutions per minute.

Another type of machine in which the cloth travels in a direction at right angles to the fall of grain is shown in Fig. 75. It is likewise a machine of double action. Receiving the grain from the feed hopper the feeding rolls strew the stock on the cloths. The round grains roll off (arrow *s*), and the rest, remaining on the cloths, are carried (arrow *n*) to the receiving box.

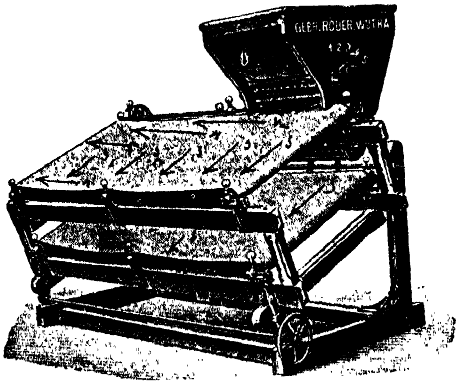


Fig. 75.

As in the preceding machine, the adjustment of the incline and tension of the cloths is provided for.

The utmost capacity of this machine is 20 bushels per hour, having cloths 300 mm. broad and 2200 mm. long running at the rate of 50 revolutions per minute.

(iii.) *Machines of the Third Principle*

The Normal Trieur Type.—In 1845 two Frenchmen, Vachon (father and son), in Lyons, invented a machine which they named a "trieur." The machine was a sheet-iron cylinder bossed on the interior surface with cylindrical sockets. Inside the cylinder, set at an incline, was enclosed a conveyor box, almost throughout its full length, at the same angle of inclination. Into the raised end of the cylinder the grain was poured, and when rotating the round grains of foreign plants, falling into the sockets, were lifted to a sufficient height and then dropped into the stationary conveyor box. The grain travelled down the cylinder by gravity, shaken also by the longitudinal rocking of the cylinder, while the round particles of impurities rolled down the inclined plane of the conveyor box. Both grain and impurities fell into conveyor boxes placed under the lower end of the cylinder.

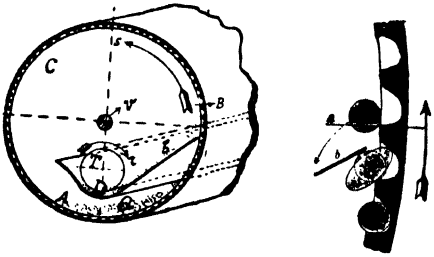


FIG. 76.

During the seventy years' existence of Vachon's cleaner and separator its working principle has not undergone any modification. The modern sorting cylinder has but received modifications of construction, and Fig. 76 gives us its present plan.

A cylinder *C* turns on a stationary shaft *v* in the direction of the arrow *s*. The mass of stock *Q* rolls along the cut surface of the cylinder; the round kernels of the admixture, and the broken grain of the stock to be cleaned, fall into the sockets, and are lifted up and dropped into a stationary conveyor box *D*, rolling down its sloping surface *b*. The impurities are pushed along the conveyor box by a worm *T* revolving in the opposite direction.

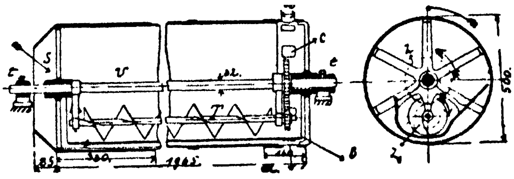


FIG. 77

A full drawing of this machine is to be found in Fig. 77. The shaft of the cylinder is placed on props *t–t*. When the set screws of the props are loosened the shaft may be turned. On the revolving hub of the cylinder is set a gear *z* coupling with the gear z_1 of the worm conveyor *T* of the box which is fixed to the shaft. The refuse is delivered by means of the worm down *b*. The taper imparted to the cylinder is usually 0·08 to 0·1, *i.e.* 8–10 mm. to 100 mm. of its length.

The capacity of the trieurs depends on the circumferential velocity of the cylinder. It is obvious that their capacity increases with the velocity. Nevertheless that velocity must have a highest limit of signification, otherwise the centrifugal force of the grains will press them to the surface of the cylinder, and they will not fall into the conveyor box.

Let us examine the conditions which allow of the most profitable work. Fig. 78 shows us various positions of a socket with a grain. If the revolving velocity of the cylinder is v, the grain develops a centrifugal force $\frac{C = mv^2}{r}$, r being the radius of the cylinder. Besides that the grain is under the influence of its proper weight $p = mg$.

When the grain is in a diametrical plane, position I, it is evident that it will not fall out of its socket, whatever the rotatory velocity may be, as the resultant $Z = \sqrt{c^2 + p^2}$ will press it into the socket. When in position II, the grain being raised to an angle a, the resultant is (in the triangle $Z_1 pII$)

$$Z = \sqrt{c^2 + p^2 - 2cp \sin a}$$

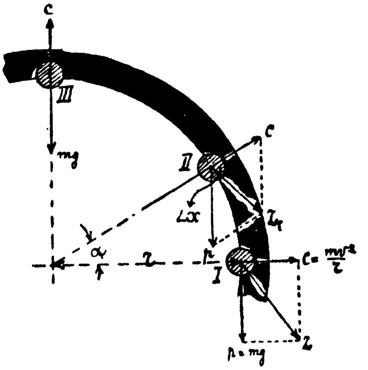


FIG. 78.

Thus, Z differentiates in accordance with the angle not only in size but also in direction, which is of great importance to us. The angle X, defining the direction of Z, is gradually widened to 180° for the third position of the grain, when $a = 90°$. Let us see when the grain will begin to drop out of the socket.

If $c > p$, we have seen that the grain remains in the socket. When $c = p$, position III proves that the grain is balanced, seeing that $Z = O$ ($\sin a = 1$, $Z = \sqrt{2c^2 - 2c^2} = O$). Therefore the dropping of the grain is possible only when $c < p$, which determines the revolving velocity of the cleaner and separator. We shall have obtained the limit of signification of the velocity of revolution when $Z = O$.

Then $c = p$, or $\frac{mv^2}{r} = mg$, whence $v = \sqrt{gr}$. Theoretically speaking, the dropping out of the grain ought to take place when the difference in $p - c$ is infinitely small, but usually not more than one-fifth $\sqrt{gr}$ is taken, because in greater velocities the falling of the round grains into the sockets will be under a disadvantage (the quick motion of the stock on the working surface), and besides that, we have to take into consideration the friction of the kernels in the sockets.

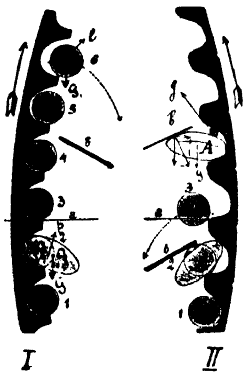
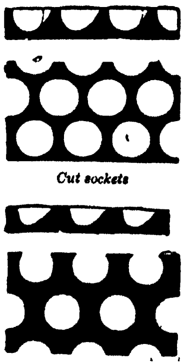


Fig. 79.

Before speaking of the capacity of trieurs, we must give our attention to the shape of the sockets. European technics know only one shape of sockets, semi-spheric, which are made either by bossing or by drilling. Fig. 79 shows drilled (*I*) and bossed (*II*) sockets in operation. An accurate semi-sphere cannot be obtained by bossing, therefore round grains will more quickly fall out of the bossed sockets than out of the drilled ones. The receiving surface *b* of the conveyor box is set higher for *I* than for *II*, and consequently the working surface of trieur *I*, *i.e.* the area of sockets catching the round seeds, is larger than that of *II*. Besides, the distance between the drilled sockets is less than between the bossed ones, for a close bossing would have made the sockets still less regular, and damaged the material. Therefore a unit of surface contains a greater number of cut sockets than of bossed ones, which raises the capacity of trieurs *I*, in comparison to trieurs *II*, working under the same conditions. The difference in the number of sockets to the same area reaches 25 per cent. For instance, a cockle cylinder numbers 29,000 bossed sockets to one square metre of surface, and 36,500 drilled sockets to the same area.


Cut sockets

Bossed sockets

Fig. 80.

Fig. 80 shows us that both kinds of sockets are turned in the direction of rotation not of their spherical, but cylindrical surface. This is to prevent friction and the choking up of the sockets with small refuse when the grains drop out, as shown in the case of the grain *A* in *II* (Fig. 79).

Besides semi-spheric sockets, the Prinz Manufacturing Co. (Milwaukee) offer bossed sockets, shown on Fig. 81, the lower surface of which is either flat, 1, or cylindric, 2. The factory maintains that round impurities *a* will be lifted higher and fall more easily out of sockets of that shape. That is indeed so, but owing to their shape the number of sockets to a unit of surface is small in comparison to the number of semi-spheric sockets, and consequently, the capacity of these trieurs is not large.

The material of which the trieur cylinders are made is zinc sheets. Sometimes the socketed surface of the cylinder is bronzed for the sake of durability.

The number of sockets to a unit of surface in a trieur, speaking generally, depends on its purpose. Besides removing round grains, a trieur may serve as a barley or oat separator. To this end larger sockets and a smaller incline of the cylinder are adopted. In this case the wheat and rye fall into the feeder, while barley and oats, being larger, roll off the cylinder.

The Capacity of Trieurs of the Normal Type.—The capacity of the trieurs depends on the length, the diameter of the cylinder, and the circumferential speed of its rotation (see the table below).

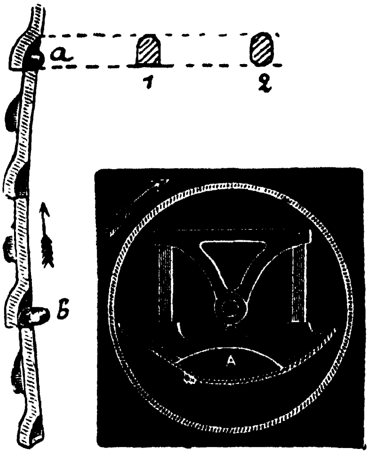


FIG. 81.

The barley and oat separators, being trieurs for larger grains, are larger in diameter. The incline, 35 to 40 mm. to 1 m. of length of the cylinder, is less, as a longer period in the cylinder is needed for high-class work.

TABLE XI

CAPACITIES OF COCKLE CYLINDERS

Dimensions of Cylinder.		Number of Revolutions per Minute.	Approximate Capacity per Hour.		
Diameter, mm.	Length, mm.		Wheat and Rye, Bushels.	Controlling or Re- Trieurs, Bushels.	Oats, Bushels.
300	1120	21½–16	7–5	4–3	4–3
350	1250	20–15	10–7	5–4	7–5
400	1500	18–14	17–14	8–6	10–8
450	1750	17–13	24–20	12–10	14–12
500	2000	15–12	32–26	16–12	18–16
550	2250	14–11	40–32	20–16	24–13
600	2500	13–10	50–40	24–40	28–24
700	2750	11½–9	75–45	38–26	36–31
800	3000	10–8	100–65	50–32	44–38

TABLE XII

CAPACITIES OF TRIEURS FOR SEPARATING BARLEY AND OATS FROM WHEAT AND RYE

Dimensions of Cylinder.		Number of Revolutions per Minute.	Approximate Capacity per Hour, Bushels.
Diameter, mm.	Length, mm.		
350	1250	22	4
400	1500	20	6
450	1750	19	10
500	2000	17	13
550	2250	15	16
600	2500	14	20
700	2750	13	26
800	3000	11	33

Trieurs of other Construction.—Making a theoretical estimation of the capacity of trieurs of the normal type, it is easy to note that the defect of this machine is the impossibility of utilising its full working surface, owing to the very nature of the construction. The working surface is used only from *A* to *B* (Fig. 76); this constitutes 30 to 33 per cent. of the whole cylindric surface, as has been proved by practical tests. Here we meet, in fact, the same constructive principle that is applied in the round and hexagon separating-reels. But the problem of the most efficient bolting machine was brilliantly solved by the invention of the plansifter, in which almost the whole working surface is utilised, whereas the normal type of trieur has not yet been supplanted by a more perfect machine.

The trieur with an inclined table "Record" patented by Heinrich Seck adopts the idea of an inclined plane. The working surface of this machine (Fig. 82) consists of an endless cloth 15, with trieur sockets. The cloth is combined of separate narrow plates connected by joints, and, embracing the drums *A–A*, is set at an incline. The grain is delivered into the feeder 1, and falls on the band which travels upwards. The flow of grain is regulated by hand with the gate 3, by means of a handwheel 2, and a gear drive. The round bodies dropping into the sockets are carried away by the band, and, at the curve of the band on the drum, fall into hopper 4, while the grain rolls down the inclined surface of the band into hopper 5.

Besides rotating, the cloth makes about 250 transversal vibrations per minute, and the motion is shafted in the following manner. The drum bearings are placed on iron cross-head and shippers 14, which in their turn are mounted on flexible stands 12 and 13; when the driving shaft 8 rotates, the eccentric drive 18 reverses the motion of the cloth. From the shaft 8, by means of a belt, worm 16, and chain-gearing 16, the rotary motion is imparted to the upper driving drum which moves the cloth.

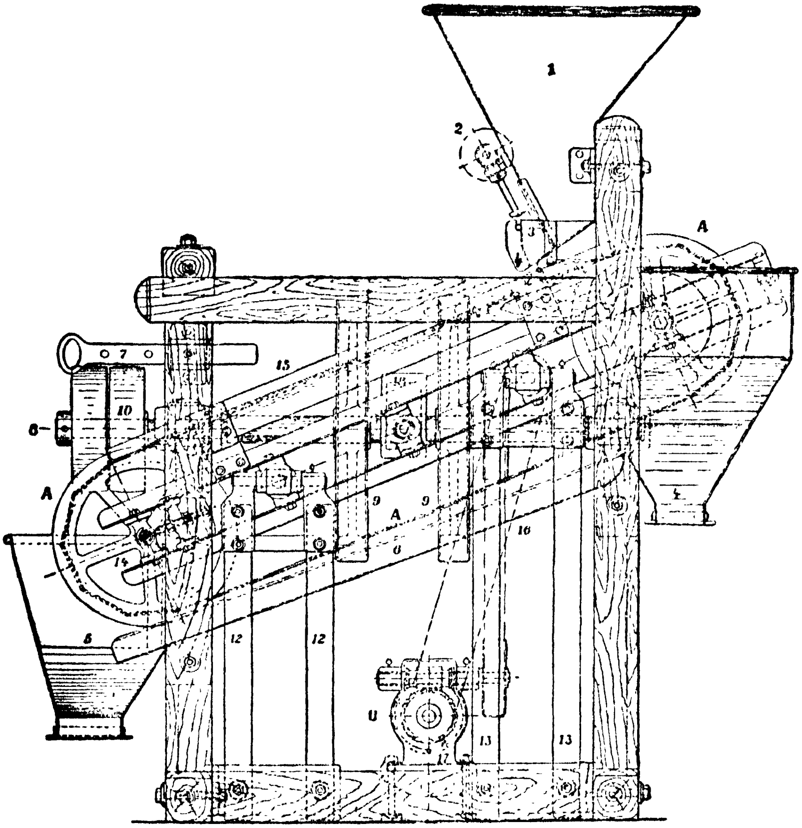


Fig. 82.

Being no innovation in its constructive idea, this machine possesses all the defects of machines with reciprocative motion, and besides, its construction is exceedingly complicated in comparison with the trieur of the normal type, yet it affords no larger working surface than the common trieur. The possibility of revising its design is of no value, as the machine cannot be aspirated. The absence of means of regularly lubricating the link joints of the band, must lead to their speedy wear.

IV

MACHINES FOR SEPARATING STONES

The mass of grain often contains stones of such shapes and sizes that they can be removed neither by means of aspirators nor of trieurs. In such cases the aid of machinery, the working idea of which is based on the utilisation of gravity, has to be invoked.

Hignett's Stone Separator.—Hignett's machine consists of a triangular wooden box (Fig. 83) with a low rim, inclined towards the vertex of the triangle. On the bottom of the box are placed triangular boxes of smaller size, with rims *nm*. The first box *a* serves as feeder for the stock to be cleaned, which passes out of it in the direction pointed by arrows, there being no front partition to *a*. Another box *D*, with higher rims, is placed at the top *c* of the box. This box collects the stones owing to the absence of a part of the rim in the point *c* encased on the box *D*. In the rim at the back *AB* of the box, there are holes *OO*, through which the grain is discharged. This box is mounted on flexible rods *F*. By the body of the connecting rod *T* of a crank mechanism, a vibration is communicated to the box (90 to 120 revolutions), owing to which the grain leaving *a* is hit by the sides *mn*. These blows throw the grain in the direction of the discharge openings *OO*, while the stones, being heavier, roll down the inclined plane influenced by their own gravity. Of course, the incline, the oscillation, and the number of reciprocations of the box, must be so calculated that the gravity of the stones (its component on the plane of the bottom of the box) is greater than the resultant of their friction against the wood of the box, and greater than the inertia from the oscillations. When suitably inclined and vibrating, the same machine may be used for separating the light kernels from the heavy ones.

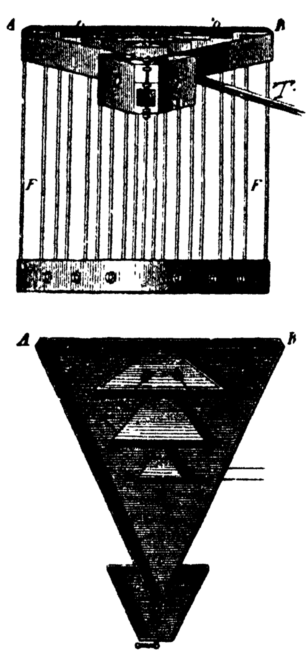


FIG. 83.

G. Luther's Machine.—Luther's machine (Fig. 84), constructed on the same principles as that of Hignett, is more perfect. A box *A* is set on sixteen flexible props. The inclination of the stone-separating box *e* with triangular rimmed boxes *s* as in Hignett's machine is adjustable, being adjusted with the aid of screw rods and hand-wheels *d* fixed to the frame of the box. On the box, down its full length, is set a conveyor box *C*, with discharge openings 1, 2, 3, 4 into box *e*. By means of a crank mechanism, the machine is oscillated (up to 120 revolutions). The stock flows into the feeder *C*, and travelling as shown by the arrow passes into the machine through openings 1, 2, 3, 4. The grain is carried upwards, and is delivered through spout *a*, while the stones roll down the inclined plane and pass out through spout *b*.

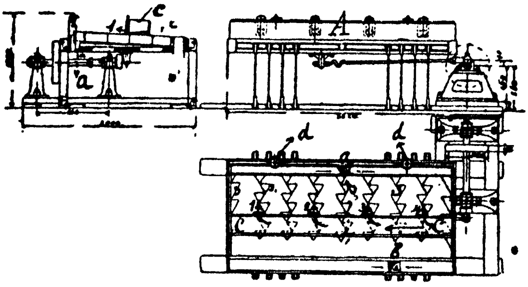


FIG. 84.

The capacity of the machine is 70 to 100 bushels per hour.

V

SCOURING AND POLISHING THE GRAIN

1. *Principles of the Processes and the Character of the Working Parts*

After the removal of foreign matter from the grain, it has to be cleaned of the dirt that has stuck to it, and the husk, smut, and beard. The dirt is sometimes noticed here and there on the surface of the grains, but generally it lies in its groove. As to the husks, which encase the grain in a compact armour, they must be removed, because they contain no nutritive substances for the human organism, and then, triturated together with endosperm, they impart a darker colour to the flour, and reduce its properties in every respect.

The modern processes of removing the dirt and husks may be divided into two categories: (1) the dry process of scouring, and (2) the wet process, when the dirt is washed off previously.

In the first instance, the working parts of the machinery either by friction or by striking, oftenest both by strokes and friction of rough surfaces, remove the dirt, shells, germ coat, and beard, or hairs covering the grain (oats). The second process consists in a preliminary removal of a part of the dirt by washing, and then both the husk and the remaining dirt are removed by dry scouring. From the structure of the berry we have learned that the first three shells grow very closely together. The outer skins are comparatively less firmly attached to the seed-shells, but the latter are so solidly welded to each other and to the endosperm, that their removal, without partially injuring the endosperm, is an impossibility, even by chemical means. For this reason the effect of the working parts on the grain must not be so powerful as to destroy the grain, for the particles of grain broken off together with the shell in the process of cleaning are irretrievably lost to the flour. Consequently, in modern flour milling technics, the so-called "washing of the grain," originally designed to remove the dirt off the grain, plays a prominent part. But an explanation of its real aim will be found below.

The dry as well as the wet processes of cleaning have the removal from the berry of the "beeswing," and the dirt covering it, in view. As the washing process requires mechanical treatment of the grain for removing the beeswing as well, the machines employed for that purpose must be examined first.

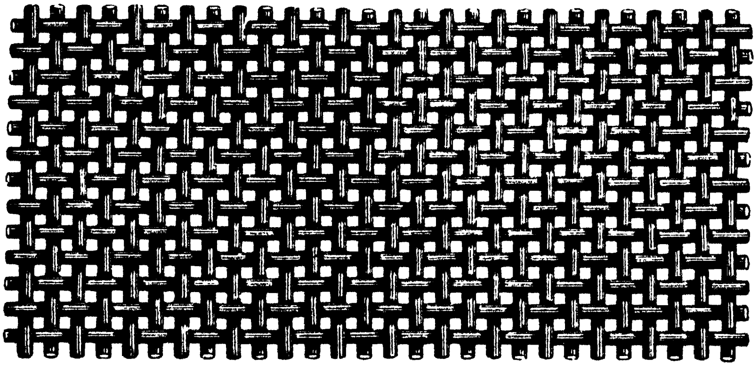


FIG. 85.

The scouring of grain is best carried out by means of rough surfaces, having, as it were, microscopic knives which shave the outer stem off, or rough metal surfaces. Therefore the working organs of the machine must be:

(1) Sharp and rough surfaces, such as stones of natural and artificial origin.

(2) Surfaces of thick wire-cloth of round or square section (Fig. 85).

(3) Perforated iron or steel plates with a grating surface, which operate with the edges of the torn metal in the place of knives (Fig. 86).

(4) Ingot cast-iron or steel surfaces with cutting facets.

The Shape and Motion of the Working Surfaces.—In every machine, be it a motor-engine, or an operating machine, if its construction will allow, reciprocal motion should be avoided. This is particularly important as regards operating machinery in which a constant speed of the working organs is necessary for a uniform effect upon the product. This is indispensable to the uniformity of the quality of the work.

Consequently, from the general fact of transmission of work, it must be admitted that an even motion of the working surfaces is absolutely necessary, as the greatest efficiency is yielded by such work.

Taking this into consideration, engineers should ignore the reciprocating motions (rectilinear, or tangential) where either an empty run of the working organ or variable speeds of motion are observed. But, as a steady motion can be attained best by a gyratory one, it is evident that the working parts of the machinery must be a rotating surface: (1) of a terminal radius (cylinder, cone, globe, &c.), (2) of an endless radius (plane).

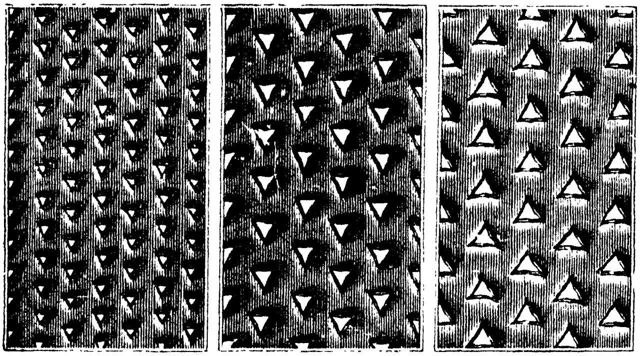


FIG. 86.

In selecting the face of the working surface, a steady speed at all points of its motion has to guide the choice. In that case the effect of the working organs upon the product will be uniform at all points of contact, keeping up a steady productivity to a unit of surface, and an even wear of the working surface. That condition of uniform treatment of the product and economy of machine-work, precludes the use of conic, hyperbolic, and suchlike working surfaces, and leaves us only the cylinder. The simplicity of construction, and the cheapness of such machines, both of which demand consideration in practice, speak for the expediency of adopting the terminal surface, *i.e.* the plane, in machinery.

Thus the shape of working surfaces decided upon as the most efficient is the rotating surface, and its motion a steady gyration.

Let us examine the shape of the working organs of machines accepted in practice. They have cylindric, conic, and flat faces. In respect to the position of the axis of rotation of the working organs, the machines may be divided into those with a horizontal axis, and machines with a vertical axis of rotation. The treatment in regard to stock requiring two working organs, two states in regard to the degree of activity of each are possible : (1) one of the working organs is in motion, and the other one is stationary ; (2) both organs are in motion.

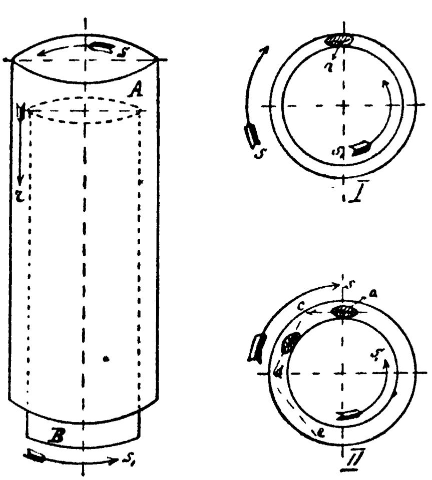


Fig. 87.

Cylindrical Surfaces of Rotation.—The machines with cylindrical working surfaces can be divided into two groups : with a vertical, and with a horizontal axis of rotation. We shall examine the first group (Fig. 87).

As regards the motion of the working surfaces, three combinations are possible : (1) only the outer cylinder *A* rotates, (2) only the inner cylinder *B* rotates, (3) both cylinders revolve in opposite directions.

In the first case (Fig. 87, *I*), the stock fed in the direction of arrow *r* can be treated only if the distance between the working surfaces is less than the largest measurement of the grain. A grain of corn *a* pressed by the surface *A* travels in between the surfaces *A* and *B* in a helical curve (it would represent a parabola on a plane), influenced by its proper gravity (*mg*) and by friction. But the grain is liable to be crushed by the pressure. Therefore the first combination must be rejected.

In the second case (Fig. 87, *II*), the cylinder *A* being stationary and *B* rotating in the direction *s*, the distance between *A* and *B* may be greater than the length of the grain. Falling on the surface *B* the grain receives a percussion, and rebounds to *A* ; being thrown back by *A*, it is again thrown on to *B*, &c. Its route on the plan is marked *c*, *d*, *e* . . . (Fig. 87, *II*).

In the third case, *i.e.* when *A* and *B* rotate in opposite directions, the grain, rebounding from *B*, would be thrown against *A* by centrifugal force. It will be enabled to travel downwards, if the velocity of rotation of A is so small that the friction generated by the centrifugal force of A is less than the gravity of the grain, *i.e.* $f\frac{mv^2}{r} < mg$, where f is the coefficient of friction of the grain and the surface A, r the radius of A, m the mass of the grain, and g acceleration of the gravity. This defines $v < \sqrt{\frac{rg}{f}}$. Though the calculation of such a velocity is possible, by making cylinder A of a corresponding radius, the building of the machine will be complicated.

In addition, in regard to the character of the motion given to the grain, this type of machinery approaches the second combination and, therefore, it would be purposeless to complicate the machine by adopting two moving surfaces.

Of the combined motions of A and B, just reviewed, general practice has adopted only the second form.

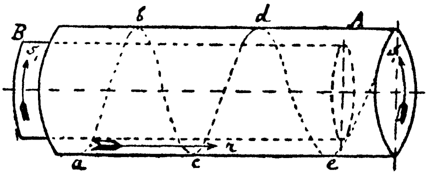


Fig. 88.

Fig. 88 represents two cylindrical surfaces A and B, having horizontal axes of rotation. As in the case of vertical cylinders, we shall give our attention to the rotation of but one cylinder B, for the rotation of the outer cylinder imparts a centrifugal power to the grain, which presses it to the surface, but there is nothing to impel it out by way of arrow r. It would be possible to treat the grain between two moving cylinders, but the complexity of the machinery makes it inadvisable in practice. The only remaining combination is that of one stationary cylinder A and one rotating B. The cylinder B must be furnished with helical blades to give the grain a travelling motion. The route of the grain will be a, b, c, d, e, after the manner of the thread of a screw.

Thus we shall occupy our attention with two types of machines having cylindrical working surfaces, which answer their purpose. Both machines have an outer stationary cylinder A, and an inner rotating one. Comparing the two styles, the advantage of the first one (accepted by engineers in America) must be acknowledged, as the work is evenly distributed over the whole inner surface of A, whilst in machines with a horizontal axis the lower part of A, where the bulk of grain collects, is used more than the upper side, which brings about an uneven wear of the working surface. But as regards the simplicity of construction and an easy access for inspection, machines with horizontal rotation are preferable.

Conic Gyrating Surfaces.—Fig. 89 presents the same combinations of conic surfaces and their motions as those of the cylinders; the sole difference lies in there being two combinations for the vertical axis, with the cone pointing upwards and downwards. The considerations mentioned respecting the combinations of motion of the surface, and of the product in the cylinders, may be repeated here. But the defect of machines with conic surfaces in general, is the variability of their circumferential velocities of motion, and consequently, an uneven wear of these machines. Besides, if for *I* we adopt a speed of the rotating cone *B* at its top *D* sufficient to rub the husk off or take the germ and beard away, at base *E* that speed will be greater and might destroy the grain. If vice versa, the upper part of the casing will not work.

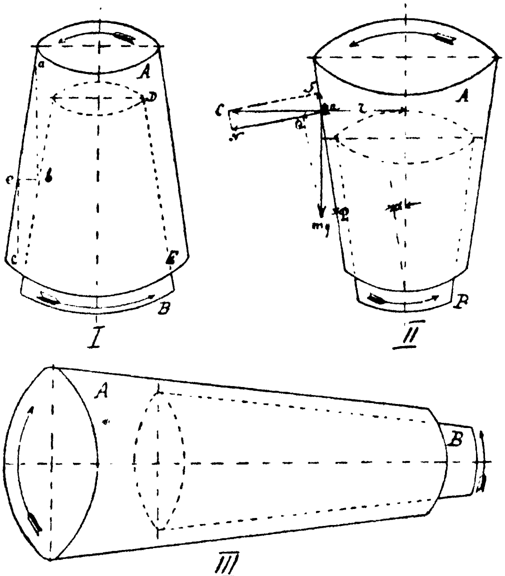


FIG. 89.

Of all combinations of conic surfaces, practice has adopted *I* and *III*, in which only the inner cones gyrate. Yet, we must admit that a very grave defect in these machines, viz. the variable speeds of the gyrating working organ, makes the machines with cylindrical surfaces preferable in practice.

In combined machinery we often meet conic surfaces pointing downwards. It is interesting therefore to find out when the motion of the stock is possible. We shall follow the movements of the cone *A*, while the cone *B* remains stationary.

The grain *a*, lying on the inner side of the cone at the point *a*, has a centrifugal force[1] $c=\frac{mv^2}{r}$, where *m* is the mass of the grain, *v* the velocity of gyration of the cone at *a*, *a* a half of the angle of the cone. Besides that, the grain lies under the influence of its own weight *mg*. To allow the grain to travel downwards, the force *P* must exceed the sum total of the power of friction and *S*, *i.e.*:

$$P > (N+G)f+S,$$

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[1] See p. 87.

where f is the coefficient of friction of the grain upon A. After due substitutions, transferring S into the left-hand side of the equation, we have:

$$P-S>f\left(\frac{mv^2}{r}\cos\alpha+mg\sin\alpha\right),$$

or

$$mg\cos\alpha-\frac{mv^2}{r}-\sin\alpha>f\left(\frac{mv^2}{r}\cos\alpha+mg\sin\alpha\right),$$

and we define the significance of v supplanting $f=tg\varphi$:

$$v<\sqrt{gr\cos tg\,(\alpha+\varphi)}.$$

It is clear now that since the angle of the cone is given, the largest corresponding r has to be chosen.

Movement of the grain upwards is possible, if $v<\sqrt{gr\cos tg\,(\alpha+\varphi)}$. Here also a value must be chosen which would satisfy the inequality.

Flat Surfaces.—As in the two preceding cases, here (Fig. 90) we also have a vertical and a horizontal axis of rotation, or the working surfaces *I* and *II*. For *I* we shall suppose the upper surface alone revolving. The stock fed into the space between the working surfaces, to be impelled to its exit requires pressure which generates a centrifugal power. But that pressure results in the breaking down of the grain, and, therefore, such a combination may be adapted only for millstones. If *B* is in motion, the grain falling on it develops a centrifugal force without the aid of pressure. Consequently, this combination is more suitable. The rotation of both *A* and *B* presents an acceptable combination, though complicated in construction.

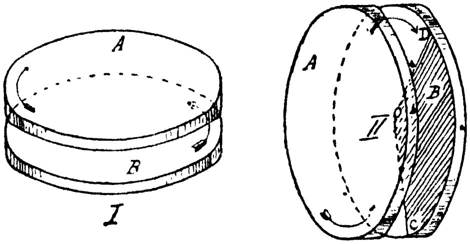

FIG. 90.

A horizontal axis of rotation for *A* or *B* separately, or both together, will effect the treatment of grain, if the space between them is less than the largest measurement of the grain. Therefore the breaking down o the grain is unavoidable here. Besides that, the stationary surface will wear unevenly. For example, *B* being stationary, the sectoral hatched part *OCD*, *i.e.* the part receiving the fresh supply of grain, will be the most worn.

We shall now pass to the description of machines used in modern flour-milling practice.

2. *Construction of Scouring Machines*

(i.) *Machines with a Vertical Axis of Rotation*

It was mentioned above that scouring machines with a vertical axis are being almost exclusively constructed in America. Some ten years ago the European factories imitated the American ones, but at present scarcely one of the large factories in Europe builds vertically rotating scouring machines. The reason for this lies in the difficulty of finding the equilibrium of the gyrating drum, and the heavy load on the step-bearing of the drum which carries the whole weight. The lighter machinery with a vertical axis of rotation, however—brush machines, for instance—are also built by European factories.

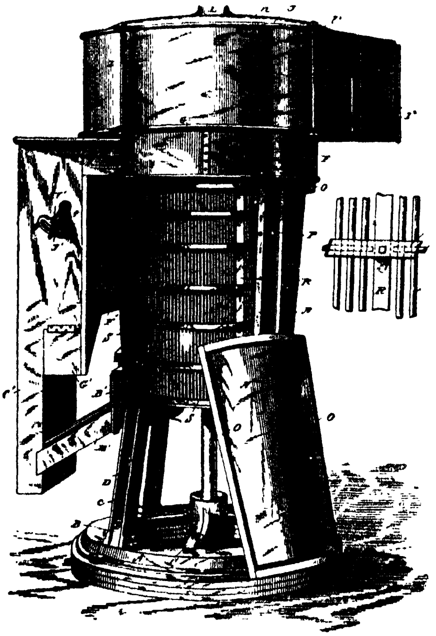

FIG. 91.

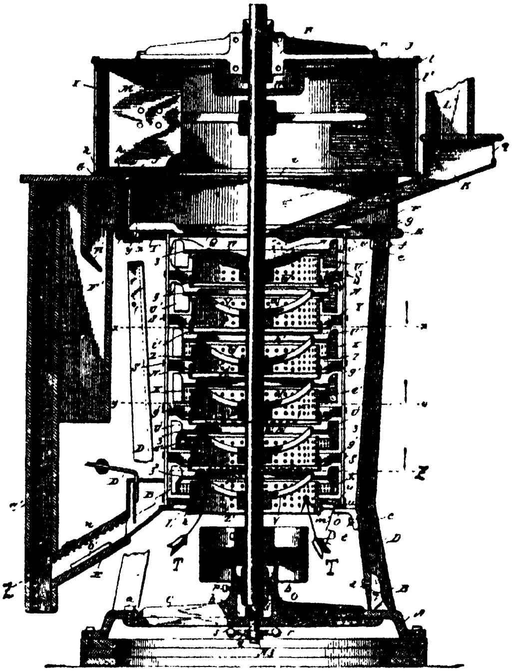

FIG. 92.

A typical American scourer employed for removing the germ coat and beard, as well as scouring the shells, is Prinz's machine in Milwaukee. Fig. 91 gives a general view of the machine, the casing being removed, Fig. 92 a longitudinal section, Fig. 93 a section down *Z–Z*, the step-bearing, details of the wire-cloth, working casing, and a detail of a beater of another construction, with a casing of bossed iron plate.

The machine is mounted on a solid cast-iron foundation, with a bolted cross-head for the step-bearing. The perforated or wire casing is stationary; to it are attached conic plates Y forming five floors. The revolving shaft carries six discs with beaters U_1. The upper disc is solid, the nether one is perforated to give access to the outer air. Each disc, the top one as well, is covered with a cylindrical sieve, to keep the grain from rolling down the plate to the shaft. The work is performed in the following manner: the grain falls through the spout K^1 on the disc W, and is thrown by centrifugal force to the drum. Here it is caught up by the beaters and whipped against the wire several times, till it falls on to the first plate and rolls down to the second scouring disc, &c. On reaching the last scouring disc, the grain passes its last stage of treatment, and is then delivered through the spout B_1.

The spout B_1 has a valve D_1 which automatically regulates the discharge of finished stock. The grain flows through the tube C_1, which supplies the fan with air, carrying the heavy extraneous matter away with it. The heavier refuse settles on the sides of the leg F_1, while the lighter particles pass through the fan, either to the dust collector or into the dust chamber.

The machine is aspirated in the following manner: the arrows T–T mark the influx of the air. Streaming in through the holes in the casings in a direction opposite to the flow of the grain, it drives the loose husks, dust, beeswing, beards, and other light matter out through the fan.

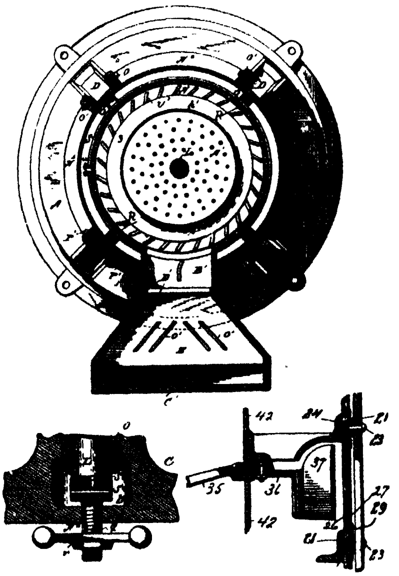

FIG. 93.

The space between the wire caging and the beaters is greater at the top and less below, owing to which the grain undergoes a gradually increasing scouring, and is treated with most energy on the last floor, before leaving the machine. On Fig. 93 we see that the scouring blades 37 are bolted to the discs, which allows them to be replaced when worn.

"*Eureka*" *of Schneider, Jacquet & Co.*—This (Fig. 94) is one of the combined type of machines. One shaft v carries a fan F, beaters C, and brushes D. The stationary working drum H is made of perforated wire and covered with an iron casing. The grain flows down *A* and is thrown against the drum, where it is energetically dealt with by iron beaters. Then, down the conic plate of the upper stationary brush, the stock rolls on to the revolving brush. and thrown by centrifugal force into the space between the grass or wire-brushes, is freed of the partly-cut skins, and of that part of the dirt still adhering to it after the scouring, and lastly flows down the spout *B* through tube *V*, where it is aspirated. The heavy refuse is discharged by spout *G*, the medium through the valve *K*, and the light matter passes out through the fan. The air current running through the machine is marked by arrows pointing upwards. The distance between the brushes is regulated by raising the step-bearing with the aid of a hand-wheel *m* that lifts by a screw the cross-head *t*, upon which the step-bearing rests. The whole machine is mounted on two hollow cast-iron columns, and driven by a belt pulley *S* which may be placed either at the top or below. The number of revolutions is 400 to 500 ; its capacity, according to the size of the machine, is 20 to 30 bushels per hour.

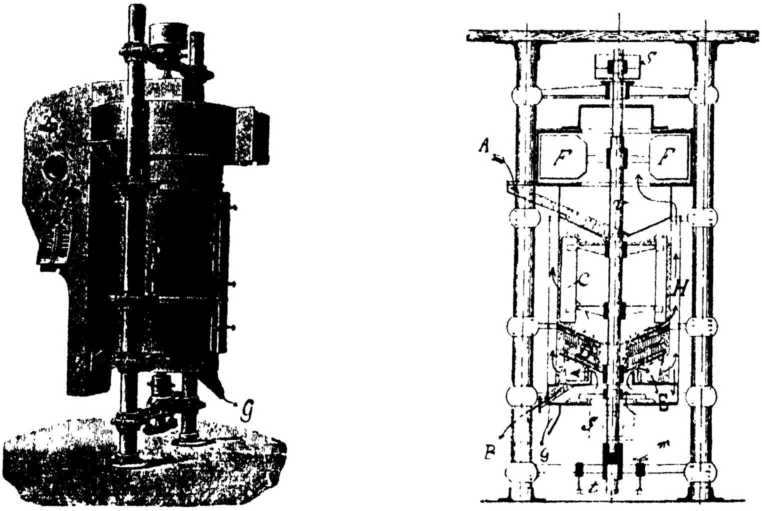

FIG. 94.

A Brush Machine from the Works of form. Seck Bros. (Fig. 95), with conic working surfaces of grass brushes, is designed for the final removal of abraded bran not quite separated by the scouring machines, dust collected in the crease of the grain, and the semi-separated germ envelopes. The grain flowing along spout *A*, on to the conic surface of the stationary upper brush *B*, falls on the disc of the revolving brush, and is thrown by centrifugal force into the working space between the brushes. On leaving the first pair of brushes the stock passes to the second pair, &c., until it reaches the bottom, where it is conveyed by scrapers revolving conjointly with the brushes to the discharge spout, and there undergoes a final aspiration.

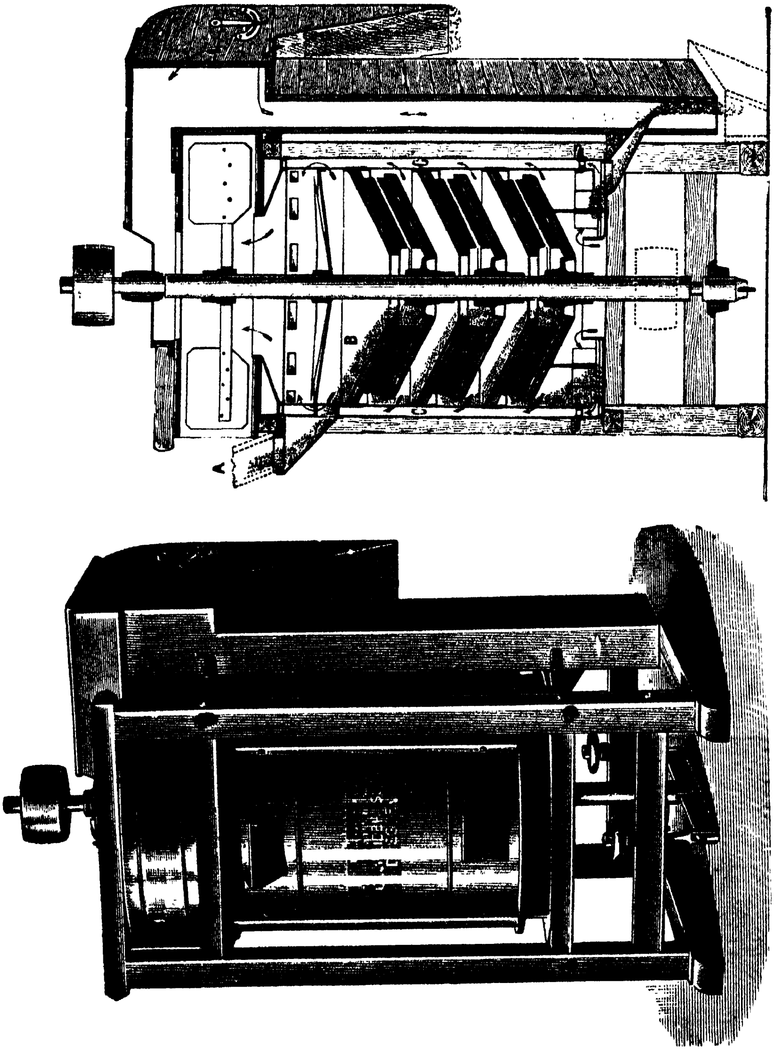

Fig. 95.

The stationary brush-drum is perforated. With the aid of an air current, the scoured shells, germ membranes, &c. are impelled through the perforations of the casing into *C*, the ring space between the drum and the casing. The lighter refuse is carried away through the fan, the heavier particles return to the grain, and are finally removed by a more powerful draught of fresh air at its exit through the discharge spout.

The factory produces these machines in seven sizes, and the following table shows their capacity:

TABLE XIII

CAPACITY OF BRUSH MACHINES

No.	Number of Floors.	Number of revolutions per Minute.	Horse-power Required.	Approximate Capacity per Hour, Bushels.
0	1	500	1	12–20
00	2	500	1½	24–36
000	3	500	2	40–50
1	1	500	1½	20–32
2	2	500	2	40–60
3	3	450	3	75–80
4	4	450	4	100–120

The space between the brushes is regulated, as in the preceding machine, with the aid of a supporting cross-head, which may be raised and lowered by means of rods carrying hand-wheels on their upper screw ends.

Before ending our review of the scouring machines with a vertical axis of revolution, it must be noted that all attempts on the part of constructors to build a machine with two revolving surfaces failed, for the result was either a very complicated construction or the treatment sustained by the grain was too severe. The grain was not only scoured, but broken down at the same time.

(ii.) *Machines with a Horizontal Axis of Rotation*

The most convenient shape for working surfaces in machinery with a horizontal axis of rotation is the cylinder, though conic and flat surfaces are also employed in practice. In all machines with cylindric, conic, or flat surfaces, generally but one of them is in motion, this being the interior surface in the first two types.

In describing the operation of a machine with horizontal surfaces of rotation, it must be pointed out that only under the most favourable circumstances is the whole of the stock caught up by the inner surface and travels in a helical line over the working space. The outer stationary surface is usually whole, while the rotating interior one is built of separate parts in the shape of beaters or brushes, set in a helical line, to drive the stock through the machine to its exit.

The stationary working surface of these machines is generally made of metal (perforated metals or wire cloth), or of artificial stone (mostly of emery, carborundum, &c.). The rotating surface is made of steel beaters, artificial stone, and metal or fibre brushes.

In calculating or verifying the capacity of cylindrical machines, one may be guided by the following considerations:

Suppose we have a scouring machine of the normal type, with an emery or perforated metal casing, on which the grain is thrown and treated by beaters. The beaters are arranged aslant, in respect to the generating circle of the casing; owing to that inclination, the grain moves over the surface of the casing and describes a helical line the length of which depends on the magnitude of the angle α at which the beaters are inclined (Fig. 96).

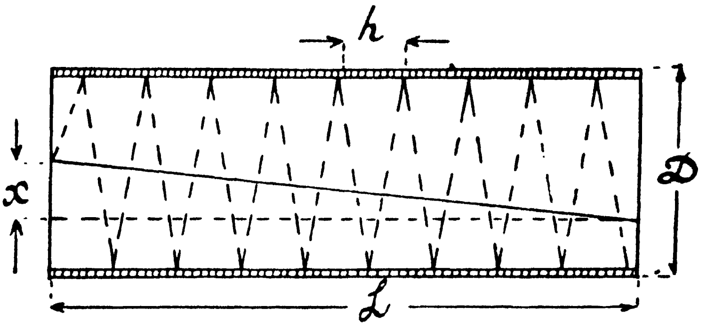

FIG. 96.

The longer that helical trajectory of the grain is, and the thinner the layer of grain moving along that trajectory, the better will the stock be cleaned.

The degree of inclination x of the beater will be expressed in dependence of the size of the casing thus:

$$X = L tg\,\alpha.$$

The pitch of the helical trajectory of the grain is:

$$h = \pi D tg\,\alpha.$$

The number of threads in the screw of the trajectory is:

$$Z = \frac{L}{h} = \frac{L^2}{\pi D x}.$$

The length of the helical trajectory of the grain is:

$$A = \frac{\pi D}{\cos\alpha}\,z = \frac{L^2}{x\cos\alpha} = \frac{L\sqrt{L^2+x^2}}{x},$$

whence

$$X = \frac{L^2}{\sqrt{A^2-L^2}}.$$

For the wheat to be satisfactorily cleaned after a triple scouring, the trajectory of the grain A has to be 1400 inches long.[1] The value of A being so great in comparison with the length of the casing L, the latter may be ignored under the radical; the inclination of the beaters then is

$$X = \frac{L^2}{A}.$$

If over 1 inch of the pitch of the helical trajectory of the grain B bush. of grain will be passing per hour, the capacity of the scouring machine may be expressed as

$$Q = Bh = B\pi D tg\,\alpha = \frac{B}{A}\pi Dl.$$

If the length of A is 1400 inches, as defined above, B must be reckoned at 20 to 24 bush. per hour (the length of D and L is reckoned in inches).

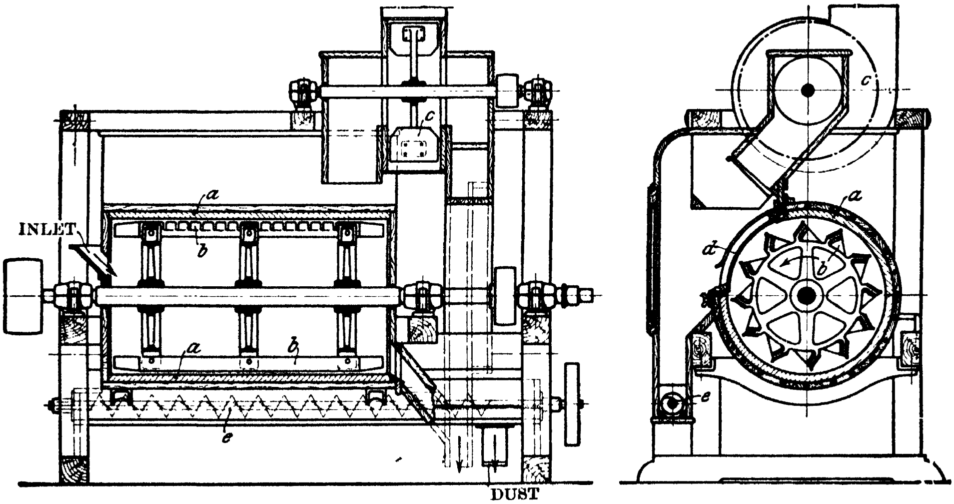

Fig. 97.

This formula coincides almost perfectly with the practical data obtained by personal observation of the operation of horizontal emery scouring machines in Russian and foreign factories.

Let us now pass to the constructive description of these machines.

The emery scouring machine of the factory form. Seck Bros. (Fig. 97) may be regarded as the normal type of machine of this kind.

In a stationary emery casing a there rotates at a speed of 350 to 700 revolutions per minute (varying with the size of the machine), a drum furnished with beaters b, which fling the grain fed (Einlauf) into the casing against its sides, where the shells are cut open and torn off by the sharp edges of the emery.

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[1] The circumferential velocity of the beaters employed was 15 mt. per sec., their direction radial.

When thrown with great force and severely scoured, the grain is freed of the germ membrane and beard as well. The separated light husks are sucked up by the exhaust *c*, while the germ membrane and heavier shells fall into the conveyor *e* and are carried out.

With a view to keeping the operating chamber of the machine communicated with the fan for ventilating purposes, a part of the wall of the emery casing is removed, and in its stead is placed an iron sliding section *d* with sifting meshes. This section is so arranged as to exclude the possibility of any bran-dust settling on it. In passing through the automatic discharge valves at the exit of the machine, the grain is once more thoroughly exhausted.

For the operation to be always accurate, the emery casing must be suitably fitted. In the first place, the material must be very porous, otherwise the working surface soon becomes dirtied, but, at the same time, the emery must be very hard to stand the wear. A complete obviation of wear of the emery surface, however, being impossible, the beaters may gradually, in proportion to its wear, be set nearer to the working surface, thus keeping them and the surface at a normal distance from each other.

This machine is used for cleaning wheat and rye. Its construction is very simple, it allows of easy access to all its parts, and the working parts, if damaged, can without difficulty be replaced by new ones.

The scouring drum and the fan are mounted either on ball-bearings or bearings with ring lubrication, according to the speed.

The frame and the outer parts of the machine are either of timber or iron (the first four numbers) for fire-proof mills. The size of the casing and the capacity of the machines are mentioned below.

TABLE XIV

CAPACITY OF HORIZONTAL EMERY SCOURING MACHINES

No.	Dimensions of the Emery Casing.		Number of Revolutions of the Drum per Minute.	Approximate Capacity per Hour.	
	Diameter, mm.	Length, mm.		Rye, lbs.	Wheat, lbs.
1	820	1500	350	4000–4800	6100–7000
2	720	1500	400	3000–3600	4500–5200
3	720	1250	400	2100–2700	2700–3600
4	620	1100	450	1600–2000	2100–2700
5	520	1000	550	900–1300	1600–2000
6	420	900	650	540–720	900–1300
7	370	800	700	430–540	650–900

The Scourer by Dobroff & Nabholtz.—To the same type of machinery belongs the emery scourer constructed of iron by the Dobroff & Nabholtz factory in Moscow. In this machine the time the grain takes to pass through it may be regulated.

In Fig. 98 we see that the scourer consists of a rotating drum containing iron beaters *a*, a leather casing *b*, and a fan *c*. The beaters in the drum have a less angle of inclination here than in scourers of the normal type.

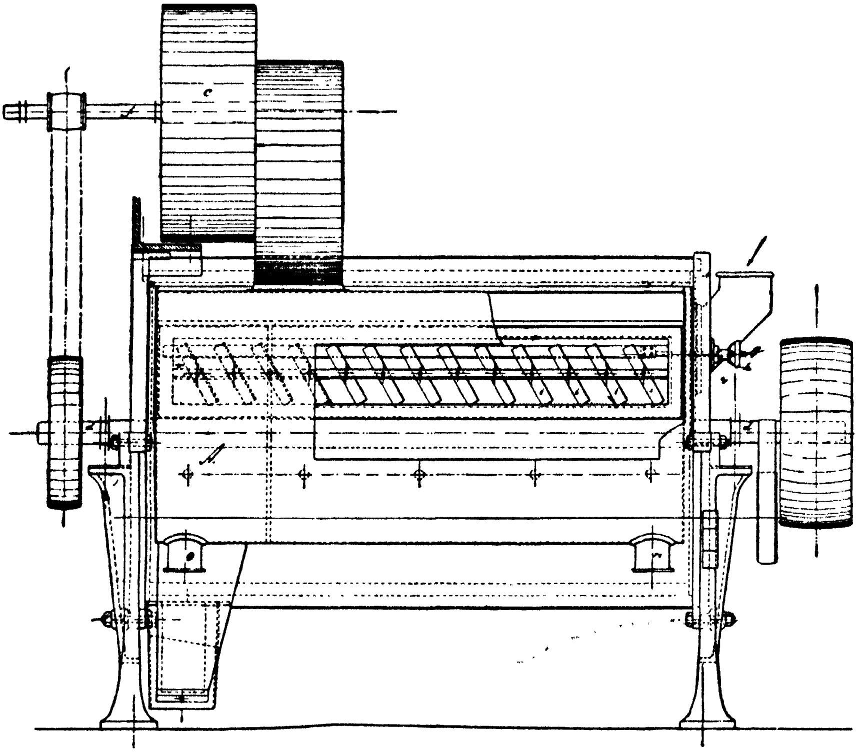

FIG. 98.

The appliance adapted to regulate the time of passage through the machine consists of the following: Opposite the sieve covering the opening of the emery casing on the inside there are arranged valves *ii*, forming a venetian blind. These valves are connected by a common rod, ending on the outside in *g* with a screw-thread and a hand-wheel *h*. The venetian blind conveys the stock in a helical line defined by the angle of the inclination. By means of the hand-wheel *h* and the rod *g* a greater or smaller inclination may be imparted to the valves, in accordance with which the grain will pass faster or slower through the working chamber, owing to the influence the venetian blind (patent of the factory) has in this case upon the pitch of the helical route of the grain.

The shaft of the drum rotates on ball-bearings (Fig. 99). As regards other details, in its main outlines the machine does not differ from the normal type of scourer.

T. Robinson's Emery Scourer.—The greater part of English and American factories have developed their own type of scouring machinery, different from the European normal type of construction, the fan and the scouring drum being set on one and the same axis, while the conveyor which carries the heavy refuse away has been supplanted by a hopper from whence the screenings pass out by themselves. Besides that, the machine is enclosed in a chamber which ends in a box for heavy refuse at the bottom.

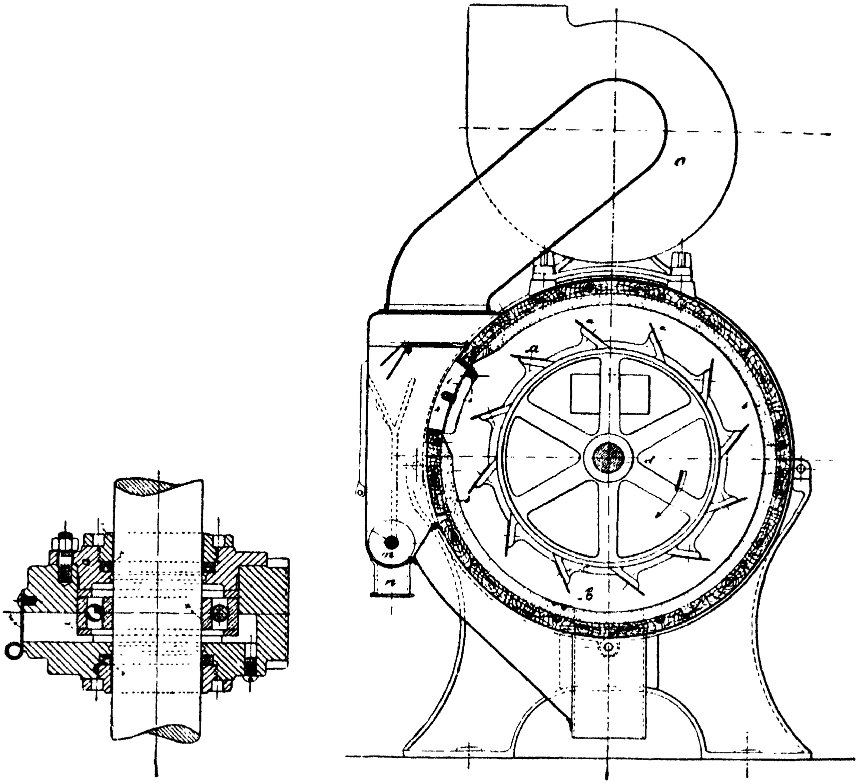

FIG. 99.

Fig. 100 represents a scouring machine of Thos. Robinson's works, at Rochdale (England). In the stationary casing *K* covered with emery-mass on the inside, there rotates a scouring drum *D*. On the same shaft *v* as the drum is set a fan *A*. The drum is enclosed in a chamber ending in a hopper *B* below. The machine operates in the following manner: The stock is delivered into the feeder provided with a balanced valve, and passes through the aspirator leg *s* to the hopper *b*, which conveys the grain into the machine. While passing through the tube *s*, the stock is subjected to the first aspiration, and freed of the light matter. In the emery casing the grain is separated from germ covering, beard, and shells, almost all of which pass through the sieve *d* down the whole length of the casing, because through the meshes the casing is played on by a strong exhaust. The light particles, passing through *d*, are sucked up through the spout *Q* to the fan, leaving the less light matters on their way in the refuse box *r*, while the heavier impurities fall down into the hopper *B*. The cleansed grain flows to its exit down *c*, and is for the third time aspirated here by a contrary air-current *c*, which carries away all the light matter remaining after the bolting on *d*. Thus, the air is conveyed to the fan from the casing chamber and by the two spouts, *T* and T_1, where the grain is purified at its ingress and egress.

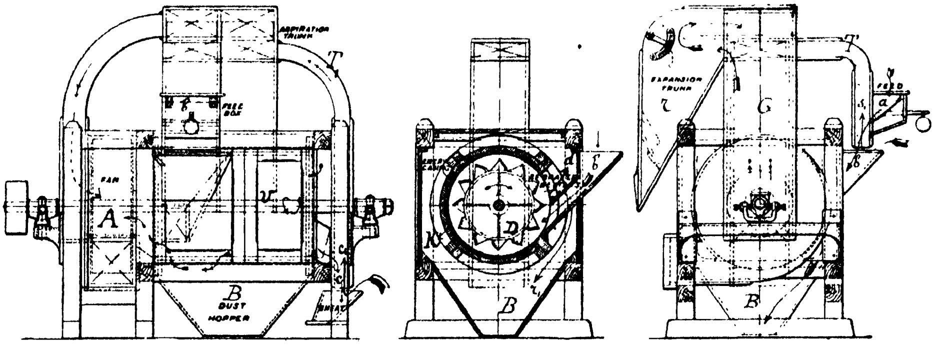

Fig. 100.

The fact that this machine has a common shaft for the fan and the scouring drum, and the absence of a conveyor, simplify its construction to a large extent, and reduce the expenditure of power for driving the fan and the conveyor. But a common shaft compels both the fan and the scouring drum to perform the same number of revolutions. However, if the expenditure of air be correctly calculated, an equal rotation may be assigned to the drum and the fan, and consequently, this circumstance cannot be viewed as a defect.

The drum of the machine rotates with the velocity of 350 to 480 revolutions per minute, and the capacity is 40 to 280 bushels per hour, according to the size of the machine.

An Emery Scouring Machine with an Elliptic Casing.—An interesting scouring machine in its idea is described by Fr. Kettenbach.[1] It is to be regretted, though, that he mentions neither the works where it is built nor the patent (Fig. 101).

The scouring drum of this machine is like the normal type one, but the upper part of the emery sleeve is of an elliptic shape in section, while the lower end which is of the usual form is clothed with a sieve for bolting the beeswing, the broken grain, and heavy screenings. Down the full length of the casing there stretches a plank *A*, which may be turned by means of a lever on its axis *O*. This plank carries paddles *d* which, like a venetian blind, may be turned by a common rod protruding outwards beside the lower fastenings. The grain passing into the scouring machine through the feed *C* is caught up by the beaters and thrown upon the curved emery surface of the casing *E*, over which the author supposes it to slide. In its sliding path the outer bran coats are rubbed off. On reaching a certain height, and having expended its power of inertia, the grain falls on the plank *A*, down which it rolls into the crevice between the casing and the plank. Owing to the adjustability of the plank *A* round its axle *O*, the size of crevice may be altered. If the venetian blind *d* be inclined to the side reverse to the movement of the grain in the casing, the grain rolls down to that part of the beaters which receive it at the bottom of the casing. The blind may be so inclined that the path of the grain will be in a zigzag line, *i.e.* the beaters will be impelling more grain than will return along the plant. That will prolong the time of treatment of the grain. The grain undergoes a triple aspiration by fan *F*, when fed in by an air-current in the spout *T*, in the machine, through the sifting part of casing *S* (the air is conveyed into the machine through *B*),and lastly, on its exit through *s* into the spout T_2,

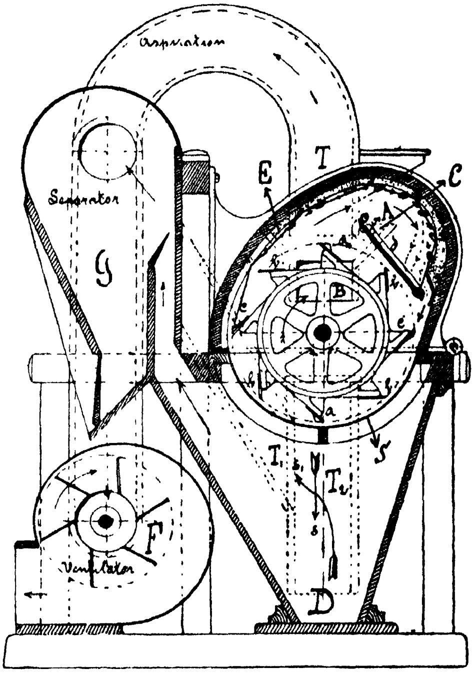

FIG. 101.

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[1] *Der Müller und der Mühlenbauer*, pp. 143–144. Leipzig, 1907.

by a draught in s_1, impelled by the fan up T_1. The heavier particles of refuse passing through *S*, fall into hopper *D*, the less heavy ones settle in the dust air-chamber *G*, while the light matter is carried out through the fan.

This machine is interesting in its conception, but, firstly, it is complicated in construction, secondly, the path of the grain will not be sliding, as the author maintains, but will run in a broken line 1–2–3–4–5, for the angle of incidence of the grain generates an identical angle of reflection. Consequently, the grain will be scoured through its successive percussions against the emery surface of the casing.

Brush Machine.—Fig. 102 represents a horizontal brush machine, the essential points in the construction of which are as follows. The arrow *a* marks the path of the grain into the chamber *A* of the machine. Passing through the feeder, it is exposed to a draught *r* induced by the fan *F*, which removes light impurities. The chamber *A* is a rectangular box with a semi-cylindric bottom formed by the surface of a bolting-cover *B*. The rotating drum *D* carries a brush arranged in a spiral. In cleansing the grain of the dust secreted in its creases, and abraded bran, the brush drives the product to the exit a_1, where it encounters the air-current r_1 which carries the light refuse remaining after bolting on *B* into the worm box *E*. The throughs of the sieve *B* are taken by the worm to the discharge spout and delivered through *a*. The shafting is sufficiently outlined in the drawing. Sometimes a belt drive takes the place of the gear drive k–k_1 between the brush and the worm.

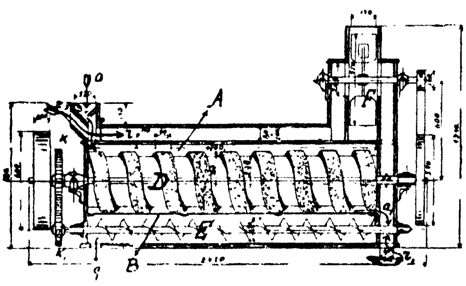


Fig. 102.

This machine, with slight alterations, is built by almost all European works.

The brush-drum runs at the rate of 75 to 90 revolutions per minute, the fan 500 to 600. The capacity of the machine is 10 to 50 bushels per hour, varying with the size of the machine.

(iii.) *Combination Scourging Machines*

In cases where the process of grain-cleaning must be shortened out of considerations of economy, separate bolting or brush machines for the final freeing of grain of the shells are not installed, but combined machinery is generally brought into use. Such machinery is mostly designed for small mills.

Wolf's Combination Machine.—Fig. 103 shows an American machine from "The Wolf Co." works in Chambersburg. It is a combination of the scouring and brush machines. The product is fed on a longitudinally rocking tray *A*, where large and small impurities are separated from it. Then it runs down s into the scouring drum, meeting a current of air s_1 on its way, which carries off the dust and light refuse, and is then conducted through tube t to the fan F (the full length of the tube t is not shown in the sectional drawing). The scouring part of the machine consists of a perforated metal casing *B* and a drum *C*, the latter being a shaft on which several corundum (kind of emery) discs are set aslant. When the drum is rotating, the discs compel the grain to move to and fro over the lower part of the casing, the backward movement being shorter than the forward. Travelling to the exit k in this way, the grain is scoured. The spout *L* takes it to the brush machine *D*, from whence, following arrow s_2, it passes to the outlet, encountering an air current s_3, which removes the light particles that had not passed through the perforated casing delivering them to the hopper *E*.

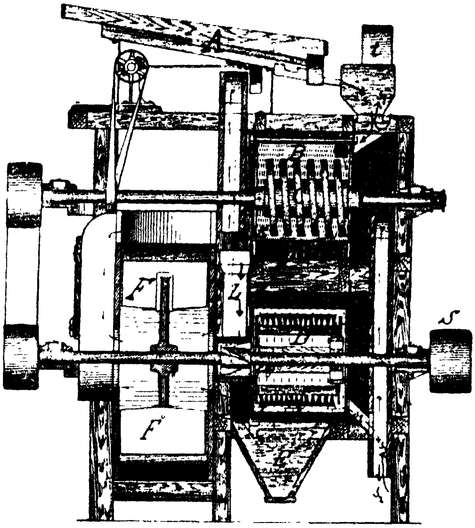


Fig. 103.

Both the corundum scouring and the brush machine are so aspirated as to subject the stock undergoing treatment to a triple exhaust, viz. when fed to the machine, in the working chamber, and at its delivery; while in addition, if we take into consideration the fanning the grain receives in passing out of the corundum scouring part to the brush machine, we may reckon the aspiration to be quintuple.

G. J. Zolotuchin's "Record."—This machine represents the combination of a zigzag separator and a scourer, and pertains, therefore, to the class of machines serving for decorticating the grain.

It works in the following manner. The grain, when fed into *a*

(Fig. 104), before falling on the first sieve of the separator *B*, passes through a current of air induced by the fan *C*.

The light matters, such as dust, chaff, husks, and shrivelled grain, differing from the sound grain in their specific gravity, are carried out through the spout *b* to the chamber *A*. In that chamber, as outlined in dots, there are arranged a system of partitions and a valve *n* to regulate, as required, the draught which carries the lightest particles through the delivery spout *f*; the heavier particles collect in the chamber *A*.

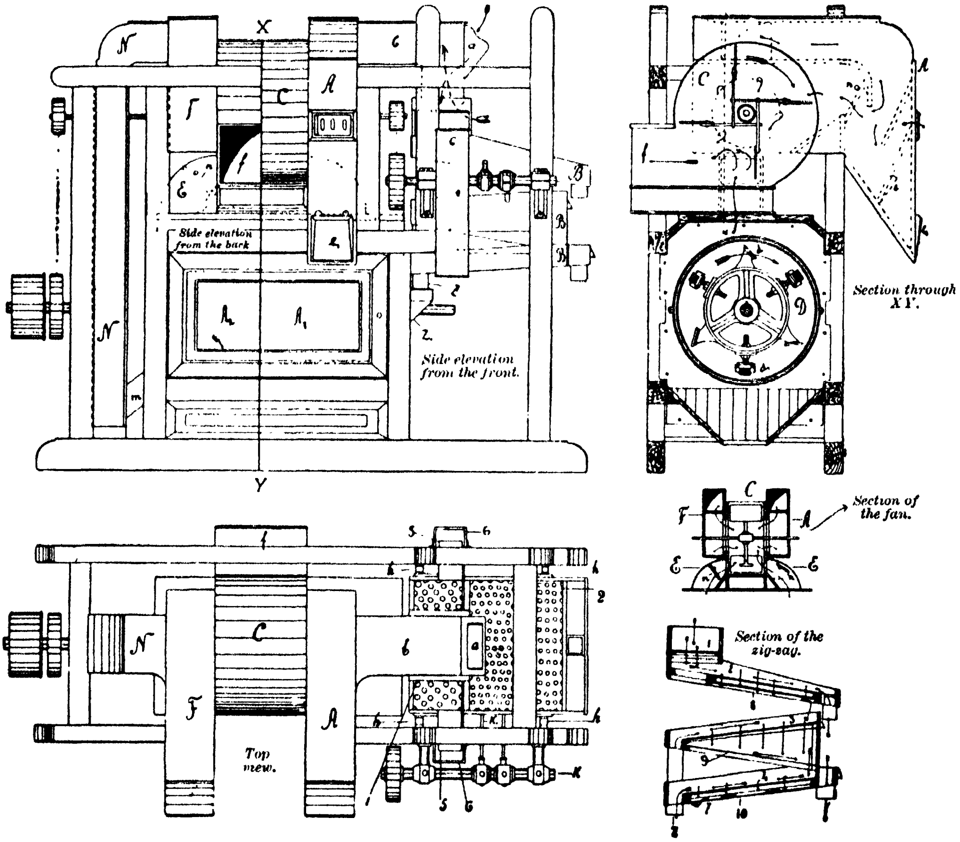


FIG. 104.

The impurities settling in the mouth of the chamber *A* overcome by their weight the pressure of the outer air upon the valves e_1 and e_2, and opening them automatically, fall out. In this way, free of all light foreign particles and dust, the grain falls out of the feeder on to the sieve of the zigzag separator.

On sieve 1 are eliminated the largest impurities, such as straws, lumps of earth, &c., which roll down a sheet 5 into the sleeve 6. The grain, passing through, falls on the sieve 2, where, again, impurities larger than the grain are sifted off, while the grain falls through on a sheet-iron bottom 8, which transfers the mass of grain to the sieve 3.

The meshes of the sieve 3, also, bolt the grain and tail over matters of somewhat larger size. The grain bolted on sieve 3, totally free of all impurities exceeding it in size, is transmitted by a sheet-iron tray 9 to the last sieve 4.

The meshes on sieve 4 are smaller in diameter than the cross section of the grain, thus retaining it on the surface.

Consequently, on this sieve all the smaller impurities are separated from the grain, and falling on a sheet-iron tray 10, pass off into spout 7, while the grain, perfectly cleansed of large and small matter, rolls off the sieve 4 into the spout *Z* and is conveyed to the receiver Z_1 of the scouring drum, the construction of which is shown separately. The grain falling on the drum is caught up by rapidly revolving beaters, and the brushes d_1 fling it on the inner surface of a casing made of woven steel cloth, or of emery.

The rapidly rotating brushes polish the grain and remove the dust settled in the crease. In this manner the grain is scoured in the drum, polished with a brush, and passes through the spout *N* to the spout *m*. In passing out, the mass of grain is again aspirated as it flows through the spout *N*, which is connected with the dust air chamber *F* and the fan *C*.

The dust chamber *F* is arranged similarly to the chamber *A*, *i.e.* it is furnished with partitions and a valve *n*.

(iv.) *Scouring Machines with Flat Working Surfaces*

Koloonock.—One of the first machines designed for the removal of germ coverings, beard and husk from the grain, was the millstone "koloonock," still in use in some old mills (Fig. 105). It consists of an upper revolving stone *A* and a fixed lower one *B*. The distance between the two stones does not exceed the average thickness of the grains under treatment, and is adjusted by means of a crank worm gearing *C* driven by a hand-wheel *D*. The stock is fed, as shown by arrow *s*, to the hopper, passing through a magnet apparatus *a*. On leaving the working space of the millstones, it is bran. The loosened exhausted husks, &c., are carried away by a draught in the direction pointed by arrow s_1 and caught up again by a fresh air-current s_2 at the bottom of the spout *e*. In the expansion chamber *E* a series of partitions is arranged, owing to which the swirling air currents develop a centrifugal force which throws the heavier particles into the spout *l*, where they slide down to the outlet. The less heavy matter falls into the spout *c*, while the lightest particles are sent to the fan through *d*.

This machine is rather bulky, and the inadjustability of the distance once established between the stones, blocks the passage for grains of a larger size, thus producing a large percentage of broken grain. The natural result of this has been its dropping out of use.

An Emery Scourer by the Mechanical Engineer, V. A. Moskaleff.—Moskaleff's machine, with vertical grindstones, is designed to adjust the distance between the surfaces automatically. Consequently, the aim of this device is to set aside the defect of the millstone, *i.e.* the breakage of grain (Fig. 106).

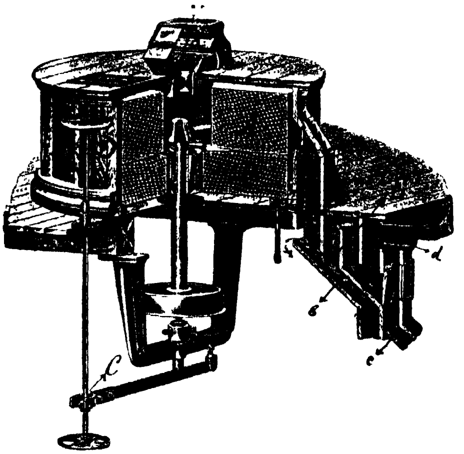


FIG. 105.

On a horizontal shaft 1 there is set a metal disc 2 enclosed in a casing 3 of the same material, and rotated by a belt-pulley 4. To the front annular part of the disc an emery washer 5 is fixed by bolts, the heads of which are sunk into the washer. A similar washer 6, but composed of two halves, is attached to the bottom of the casing. The grain is fed into the machine by pouring it through the hopper 7 into the funnel 8, which covers the middle concave part of the disc, shaped to suit the form of the basin 9.

The funnel 8 is adjustable and set on three bolts, the heads of which rest on the flexible plates attached to the funnel, and by which it is pressed against the disc. The grain poured into the funnel is thrown by centrifugal force to its edges in an even layer. A sufficient quantity of stock in the basin 9, being given a centrifugal motion, presses back the rim of the funnel, and the grain is evenly distributed in a fan shape, through the annular aperture now open, into the working space between the emery washers. In this manner the funnel plays the part of an appliance for the equable feeding of the working surfaces.

The pressure of the grain against the rotating washer 5 is transmitted by a spring through the footstep-bearing to the stop 10 with hand-wheel 11.

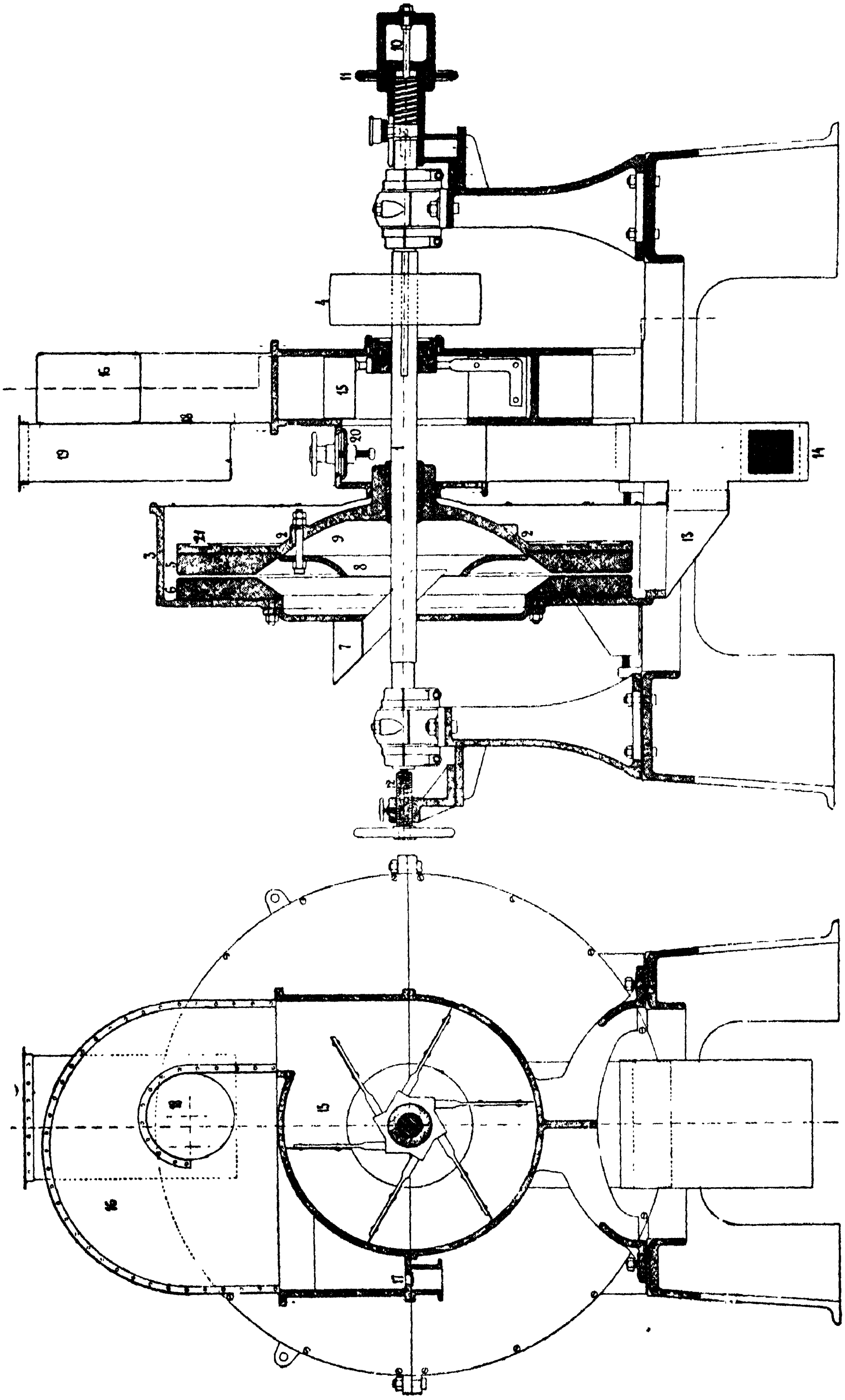


FIG. 106.

This spring is the tension-brake of the washer 5. The spring must be so calculated as to contract when the washer is pressed by grains of larger size, and then the distance between the washers increases, and the grain leaves the working space unbroken.

The action of the hand-wheel 11 controls the degree of pressure of the washer 5, and the distance between the washers. At the other end of the shaft 1 there is a guard bolt 12 which defines the least distance between the washers. The finished grain passes through the spout 13 in the lower part of the casing and through the trunk 14, where a draught of air aspirated by the fan 15 carries the husks and beeswing away. The air laden with light impurities is driven out of the fan to the expansion chamber 16, where it deposits the less light matter in the hopper 17, while the lighter refuse passes through the discharge opening 18, and is carried out through the tube 19. The air draught is controlled by a lid 20, which is opened more or less, as occasion demands.

For the balancing of the disc 2 on its reverse, there is a slide 21 along which two iron plates are shifted, and may be fixed in any particular spot.

The idea of this machine is undoubtedly correct, and we shall return to it again, when speaking of millstone sets with vertical working surfaces.

3. *Special Machinery*

Grain Cleaning with Bran.—In the scouring process of grain cleaning, the germ covers, husks, and beard are supposed to be removed as well as the mud sticking to the berries. Generally, after a series of machines separating away all extraneous matter, the stock is treated on the "impure" scourer with the view of removing the dirt together with the germ covers and a part of the husks. For this reason Haggenmacher's new machine must be referred to that type of machinery which cleans the outer skin of the grain. It is well known that almond bran is used for cleaning furs. Fine rye and wheat bran is often made use of too for cleaning delicate leathers (chamois, &c.). The sharp edges of bran seem to work like chisels in scraping the thin coating of dirt off the surface of the object. Evidently, these considerations led Haggenmacher to his idea of "washing" the grain with bran.

The machine for cleaning the grain with bran (Fig. 107) consists of an iron drum *A*, 710×310 mm. in dimensions, mounted on two U-shaped iron beams. On four bearings *B* and *C*, resting on the same iron beams, there are two shafts rotating in opposite directions one with the velocity of 100 revolutions, the other of 120 revolu-

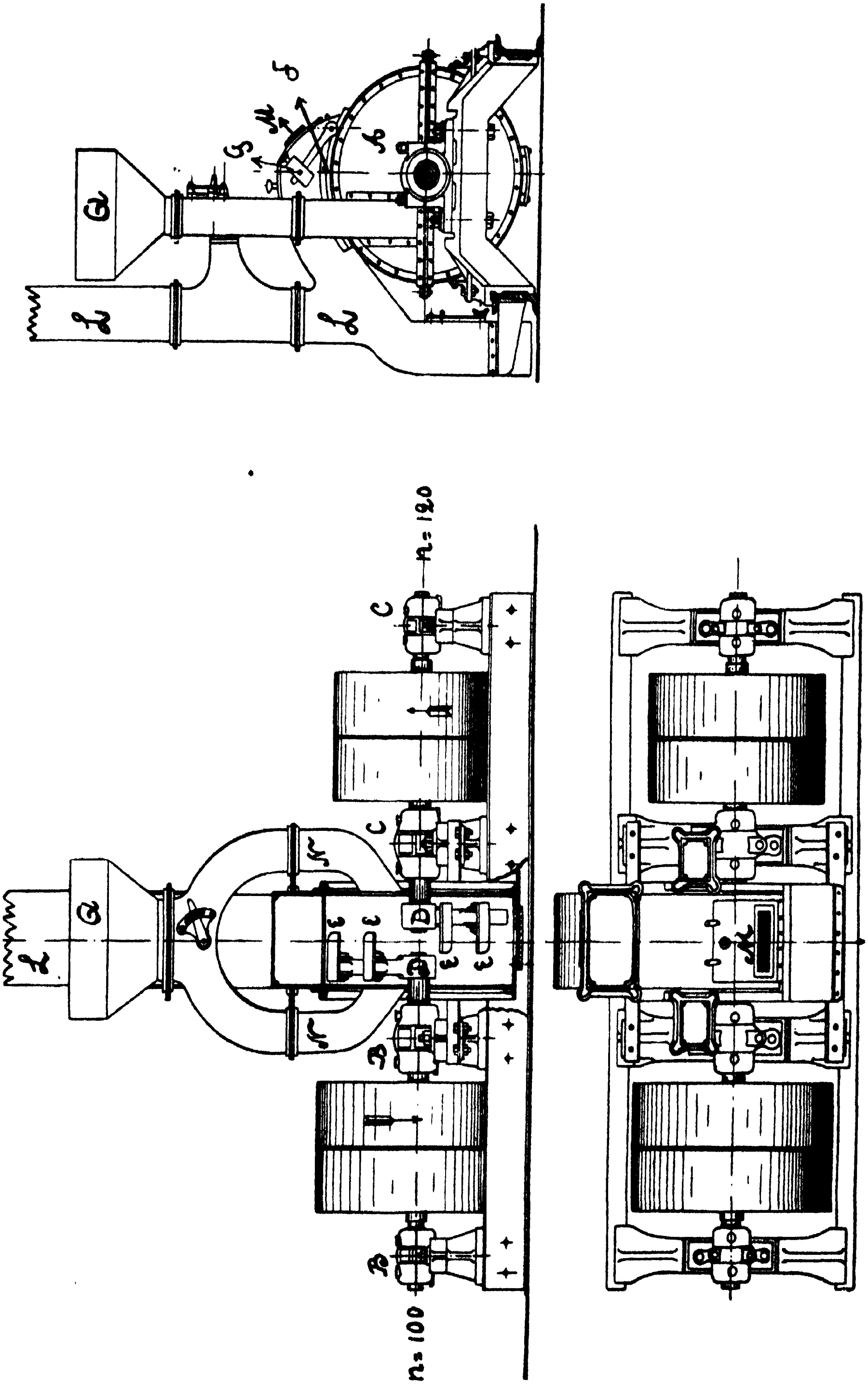


FIG. 107.

tions per minute. The ends of these shafts let into the drum *A* carry two journals *D–D* with pins *E*. In the upper part of the drum there is an outlet 200 × 200 mm. in size, covered with a valve *F* which is pressed against the drum by two weights *G* set on levers, on either side of the valve.

The grain mixed with bran on passing out of the drum through the outlet flows into the exhaust trunk *L*. The air is sucked into that trunk through an aperture *M*, covered with a net. The grain and bran are fed to the machine through the funnel *Q* and then through two spouts *N–N*. In the lower part of the drum *A* there is an outlet covered with a gate-valve, for the discharge of its contents at the end of the operation.

When the journals *D–D* are brought into motion in the mass of stock filling the drum *A*, the bran comes into close contact with the grain moving from the axis to the periphery of the drum and rubs the dust off the outer covers and out of the creases of the grain.

The bran used in grain cleaning is fine, and the amount required for that purpose is 10 per cent. of the stock in treatment. Proportionally to the accumulation of the grain and bran, the pressure in the drum grows, until a moment arrives, when valve *F* is lifted, and part of the mixture is ejected out of the drum into the aspirated trunk *L*. From this trunk the grain passes into a whizzer for separating the bran.

A machine with a drum of the above-mentioned dimensions is supposed to clean 1300 bushels of grain per day (twenty-four hours).

4. *The Wet Scouring and Washing Process*

It has been explained already that the so-called grain washing is to be regarded as one of the processes of scouring. To distinguish it from scouring proper and the bran washing method of cleaning, it may be named the "wet-scouring process." This scouring process is applied only to wheat.

When Amandus Kahl's washer appeared in Hamburg some twenty years ago—it appeared earlier still in England—the inventor certainly intended it to wash off the dirt. But even then, in addition to these machines, a whizzer was used for drying and shelling the grain. The grain was carried to the whizzer out of the water-tanks by the same water it was washed in, and energetically stirred with the paddles of the rotating drum.

However, contrary to the primary idea of washing the dirt off the grain, practical experience in grain washing has led the engineers to a type of washing process which by its nature is a wet-scouring process.

According to our observation, the wet-scouring process consists of the following: The grain is immersed in water for a short time (30 to 40 seconds). Then the excess of water covering the grain is removed by whizzing. During this interval, owing to the comparatively great hygroscopic properties of the bran, the skins absorb a fairly even amount of moisture, and swell. Then the grain is dried. In drying, the moisture in the outer skins evaporates faster, and they have a tendency to contract, whereas the seed-shells, still containing part of the absorbed moisture, resist contraction. This causes an inner tension in the outer skins, and they burst. This fact is analogous to the bursting of a hoop on a dry barrel on its being filled with water and swelling, or the radial bursting of wood when quickly dried.

On taking a berry after it has been dried and rubbing it gently between the palms of the hands, we find that it is easily shelled. When inspected under a microscope, the shells prove to be the berry-husks.

Grain washing in mills probably first appeared in England, which used to receive and still receives grain from all parts of the world. Besides being polluted naturally in the places of production, the conditions of transport often contributed their share of impurities to the grain. For instance, in the eighties of the last century, England imported wheat from Russian ports on the Black Sea in coal holds of ships that had imported coal into Russia.

It is evident that much labour fell to the lot of English engineers in inventing washing machinery before the problem was brilliantly solved.

A modern plant for scouring the grain by washing has to perform three operations successively, viz.:

(1) Damping the grain copiously.

(2) Mechanical removal of water from off the grain.

(3) Drying the grain.

In examining the process of scouring by washing, we shall inspect the machines and apparatuses pertaining to it in the order they follow in the process.

Th. Robinson's Washing Process. (1) *Damping the Grain.*—In the damping of grain Th. Robinson's works take into consideration the soft and hard wheats. We shall begin by examining the appliance for damping the soft wheat. Fig. 108 is a sketch of such a plant, the main parts of which are the two tanks Nos. 1 and 2, and a worm conveyor *B*. The tank No. 2 is arranged in the following manner. The upper cylindrical part ends in a cone at the bottom provided with a discharge cock *O*. The cylinder is provided with an inclined lid *K*, and has a drain spout *L* leading to tank

No. 1. Into that lid is set a cylinder *I* open at the top and at the bottom, connected with the casing *H* by means of guides *k* shaped in the style of

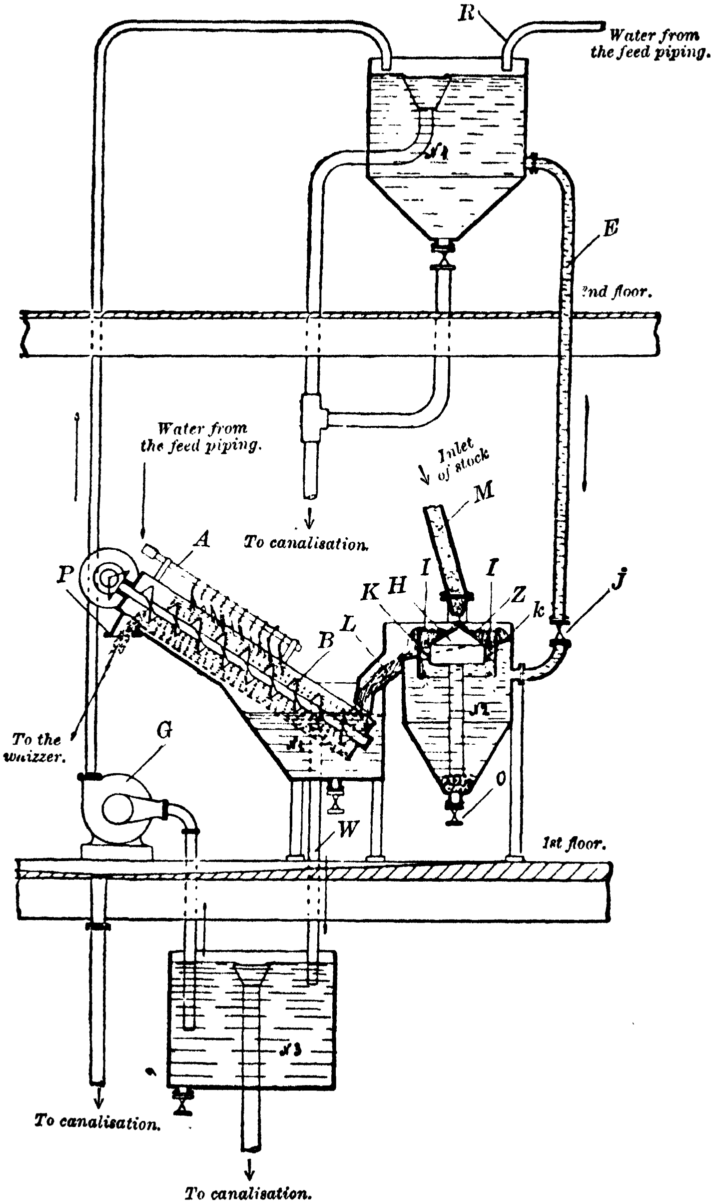


FIG. 108.

the guiding paddles in turbines. The grain falls out of the spout *M* on the cone, while the water flows out of tank No. 4 down the tube *E* under a pressure of up to 0·35 atm. Impelled in this manner, the water, in passing between the guiding paddles and gyrating as in a vortex, encounters the grain which rolls down the slopes of the cone.

Tank No. 2 is also named the stoning tank, for the stones, overcoming the pressure of water, fall to the bottom, while the grain is washed over the rim of the cylinder on to the lid *K*, and thence through the spout *L* to the conveyor *B*. The lower end of the tank which may deliver the stones through the cock *O* without interrupting the work of the conveyor, rests in the tank No. 1. The water level in No. 1 depends on the degree of humidity of the grain, and is maintained by the tube *W*, which receives the exhaust water through the holes in the projecting end and transmits it to tank No. 3. If the water exceeds its level limit, it will drain away, not through the small holes in the sides of the tube, but through the open upper end. The level of water in No. 1 determines the period to be spent by the grain in the worm. The worm *B* resting in a copper spout with holes through which the grain cannot drop, conveys it to the vertical whizzer. During its upward journey, the grain is incessantly washed by streams of fresh water out of the cocks in the pipe *A*, communicating with the water-piping or with a reserve tank. Here only is the removal of a certain amount of soaked dirt possible.

The water circulates in the following way. The exhaust water from No. 1 is conveyed to tank No. 3, and then taken by a centrifugal pump *G* to tank No. 4, out of which tank No. 2 receives its supply. The fresh water is conducted from the water-piping to tank No. 4 through the tube *R*. If the outflow of water during the washing operation exceeds the inflow of fresh water from the tube *A*, the deficient quantity is supplied through the tube *R* to tank No. 4; the superfluous water, on the other hand, is let out of tank No. 4 into the canal or sewer through a pipe with an open funnel. The water-level in tank No. 4, controlled by the height of the outflow-funnel, determines the steady pressure in tank No. 2. The tank No. 3 and the pump *G* may be discarded, if the water in the mill is so cheap as to allow of its being thrown away out of tank No. 1, when dirty. In the conic bottom of tank No. 4 there is a refuse tube for the discharge of the mud that settles there.

For the damping of grain of harder kinds Robinson has the apparatus shown on Fig. 109, with two worms. The end of worm No. 1 is immersed in the water of the tank *B*. At the lower end of the worm casing is a box in which the stones collect. Worm No. 1 carries the grain to the stone separator *C*, described above, from whence it passes to worm No. 2 (the angles of the conveyor worms are 70°), and is then delivered to the vertical whizzer. Out of the general tank the water is supplied by a centrifugal pump *A*. Both worms are played on with fresh water from a series of cocks.

The tanks *F* and *B* are isolated and have different water levels. The drives of the conveyors and pumps are clearly marked out. Fig. 110 represents the general view.

(2) *Mechanical Removal of Water from the Grain.*—After being well dampened the grain falls through spout *P* (Fig. 108) to the vertical whizzer to remove the water. This operation must be performed very rapidly, otherwise the water will penetrate the starchy part of the grain, and its moisture content will exceed the normal limit.

Robinson's centrifugal or vertical whizzer (Fig. 111) consists of a vertical rotating drum containing beaters arranged spirally. The grain is fed in at the base of the drum by an inclined spout from the worm through the inlet, and is met by the beaters revolving at the rate of 70 feet per second (the drum makes 360 to 600 revolutions per minute). The beaters fling the grain against a steel casing, perforated to let the water and abraded bran escape. The grain impelled by the beaters hits the casing, and by the blow, owing to the decrease of the great velocity of motion of the grain, the coating of water is thrown off by centrifugal force and expelled through the holes of the casing. This is the action named whizzing. The casing consists of separate sections, eight or more in number (general view). For the retention of the splashing water, the perforated casing is enclosed in another casing of solid iron. The

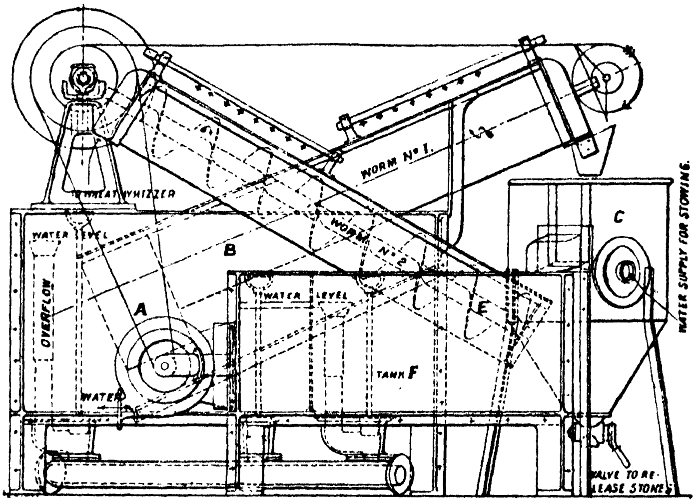


FIG. 109.

spiral lifters rapidly raise the grain to the top and deliver it through an outlet spout. Besides the removal of water, part of the beeswing, bran, and beards is separated on the way up. Consequently, by a second operation the grain is simply scoured, when thrown by the lifters against the casing.

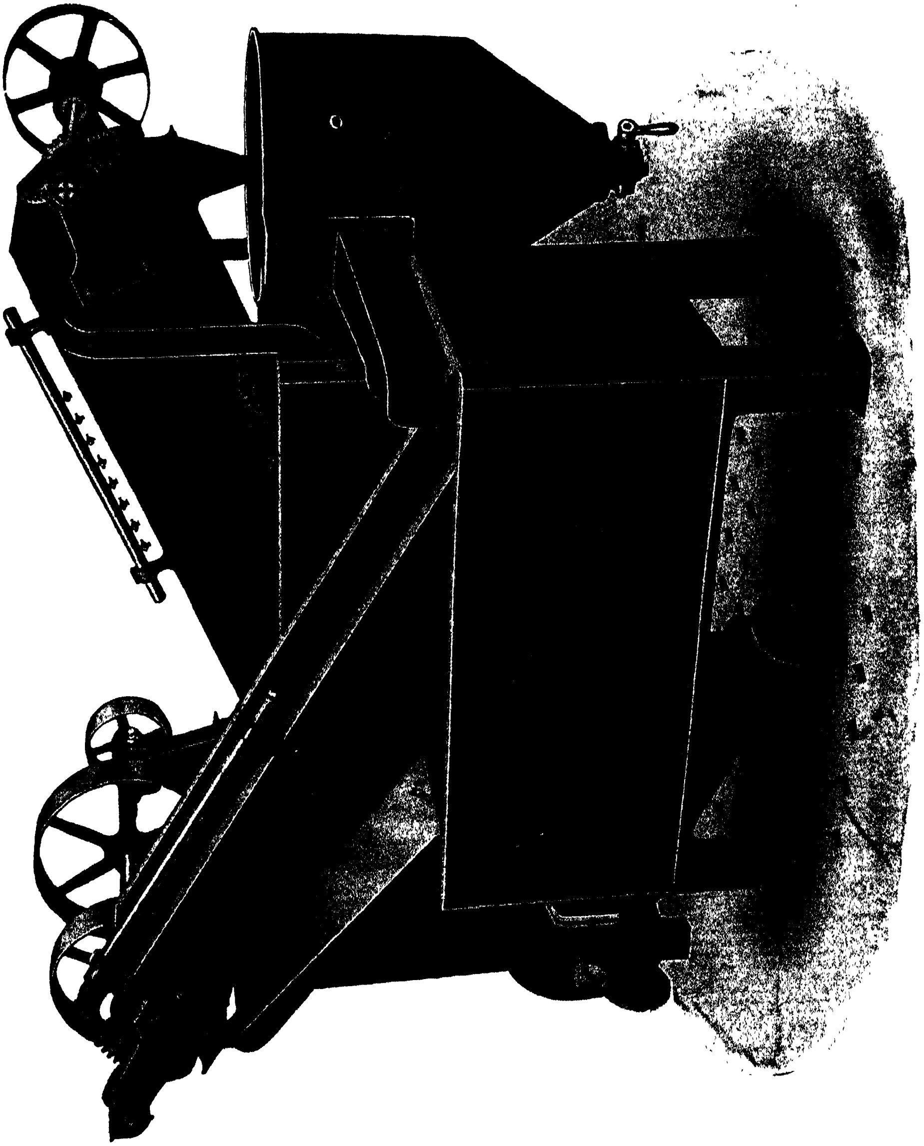


Fig. 110.

(3) *The Drying of Grain.*—The most important stage of the wet scouring process is the drying of the grain. It is dangerous to leave the grain with a moisture above the normal, for that would lead to unfavourable consequences in the treatment to follow. Overdrying is likewise to

be avoided, as the grain then becomes brittle, and gives a large percentage of broken kernels when subjected to dry scouring. In addition, the bran of the over-dry grain will be ground to bran powder during the milling process, from which it is impossible to extract the flour.

It is only by careful experimental treatment of the grain in drying and cooling machines, coupled with observations on the moisture of the grain to be dampened, that the temperature and the volume of the drying air and the quantity of grain to be dried may be defined. For this reason, a rationally constructed drying and cooling apparatus must be adjustable in respect to the temperature and volume of the air in use, and the quantity of grain to be treated at a time.

Robinson's dryer (Fig. 112), like machines of other design, is of a rectangular section (Fig. 96). Two sides of the column are solid, while the other two consist of two parallel perforated walls. The grain fed in through hoppers *A* and *B* flows between those walls, and is subjected to the action of a draught from the chamber *G*, which penetrates through the holes in the walls. The warm air is aspirated from the steam chamber through the aperture *Z* by a fan, and, after passing through the stock, is exhausted through trunk *J*. For about one-third of its way the grain is exhausted with cold air (temperature of the mill apartments) aspirated by another fan and ejected through the trunk *D*. At the warm air inlet *Z*, the column is divided by a solid bottom which prevents the cold air from penetrating into the chamber *G*.

Before proceeding to further descriptions of the construction, the significance of cooling the stock must be explained.

The temperature of the drying air, depending on the dampness of the grain, varies between 25° and 60° C. Sometimes, when the stock is very dry, the column is filled with air of the outside temperature unwarmed. In that case the functions of both the upper and the lower division of the column are identical. But when the temperature of the air has to be raised to 30°–60° C, a cooling of the grain is necessary for the following reasons. The dried and warm grain is deposited in bins to be tempered for the space of eight to twelve hours, to allow the moisture collected in the bran to spread evenly in the endosperm as well, to facilitate the treatment of the stock in dry scouring and milling. The grain deposited in bins without having been cooled previously, retains its high temperature, which acts detrimentally upon it, because, if tempered for a long time, it may first germinate, and secondly the starch may become soaked to a paste. Moreover, during the conditioning the bran becomes cooled first, thus accelerating the process of evaporation

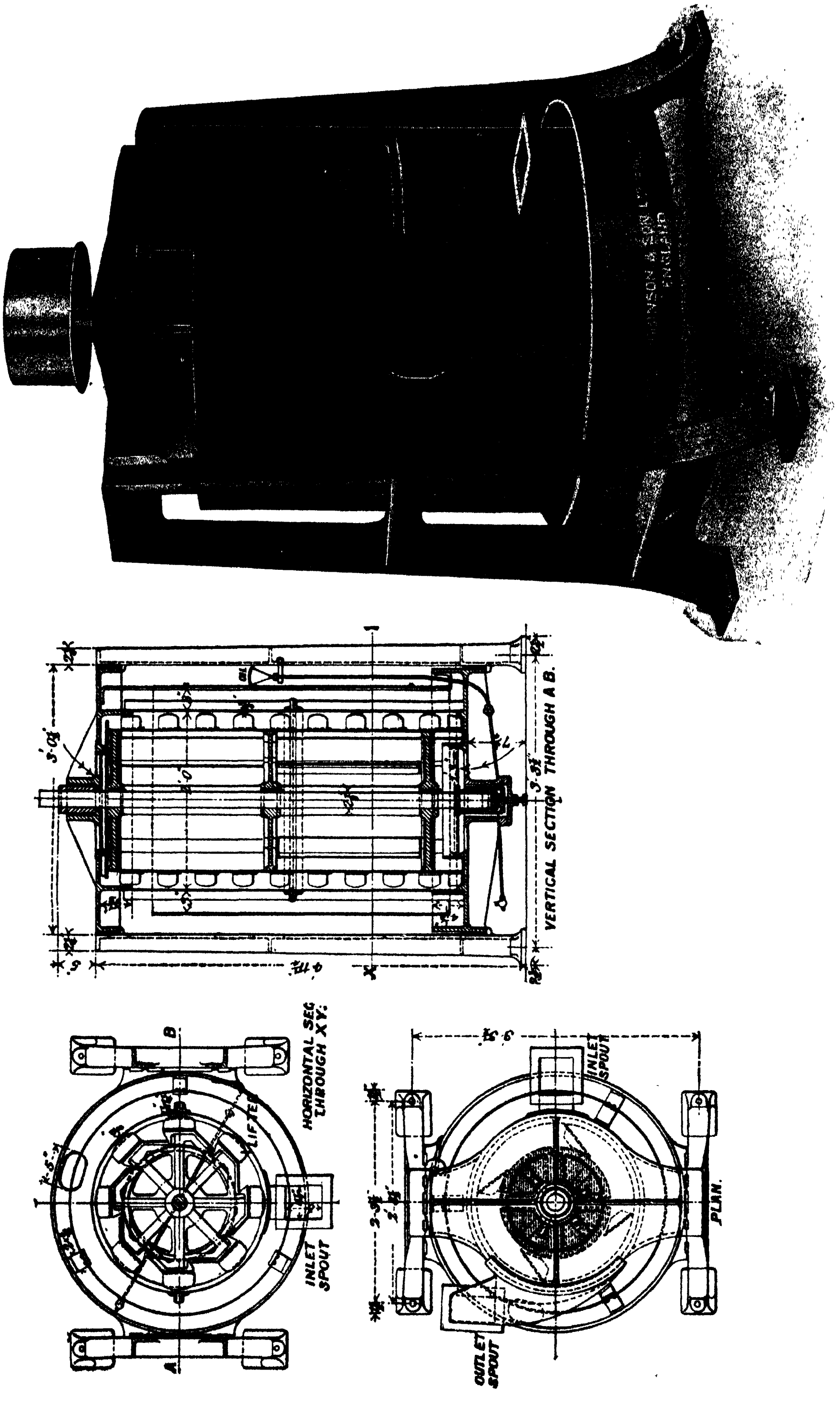

VERTICAL SECTION THROUGH A B.
HORIZONTAL SEC. THROUGH XY.
LIFTER
INLET SPOUT
OUTLET SPOUT
PLAN.
OIL
A
B
X
Y

FIG. 111.

in the outer covers, and the tempering period in consequence is shortened. For regulating the feeding of the column there are valve flaps *K* in the hoppers *A* and *B*, which may be opened wider or less by means of a crank mechanism *M*. That mechanism controls at the same time the

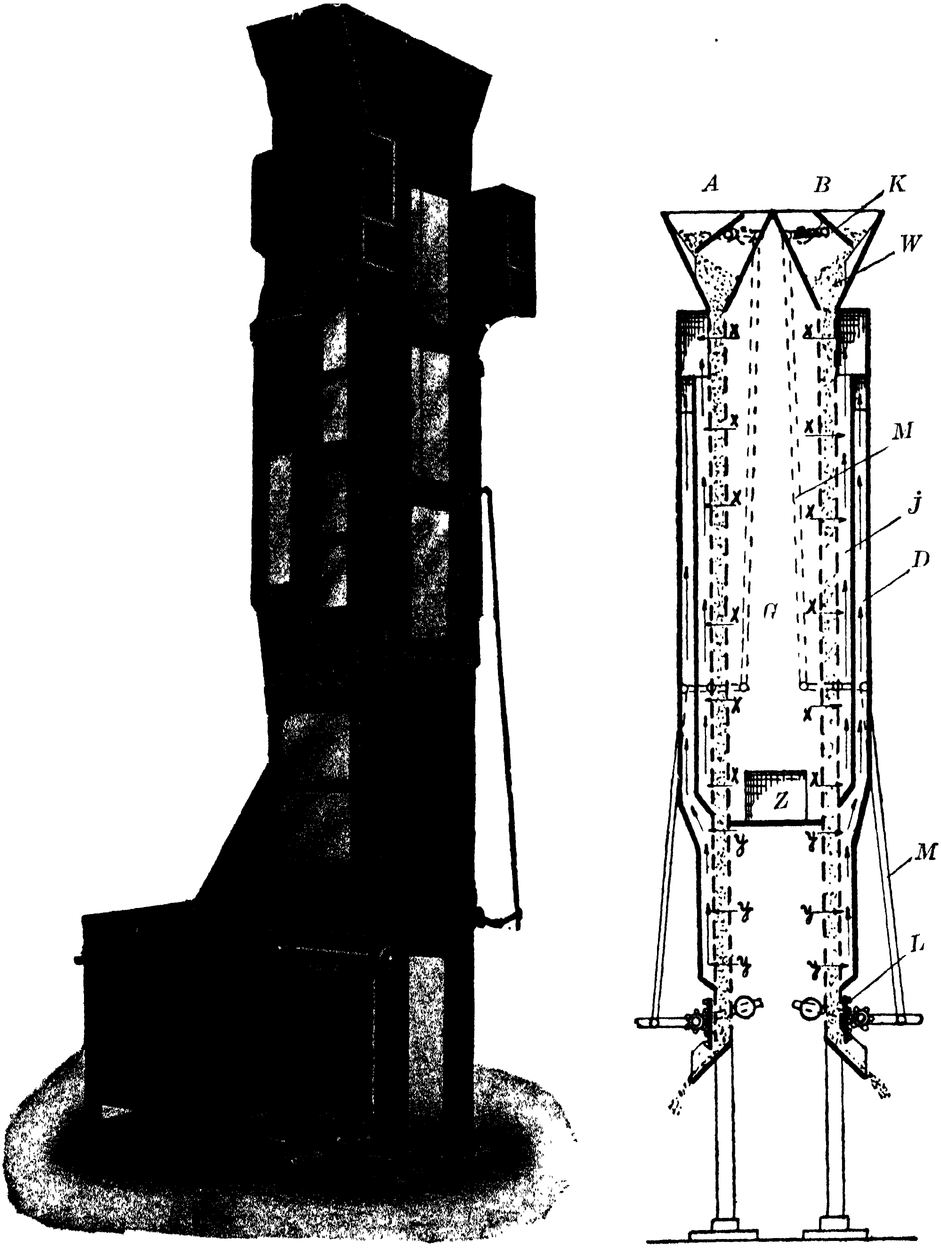


FIG. 112.

grain delivery by a valve flap *L* worked by a gear wheel and rack on the flap. The opposite end of the crank mechanism carries a weight to counterbalance the load of grain on the flaps *K*.

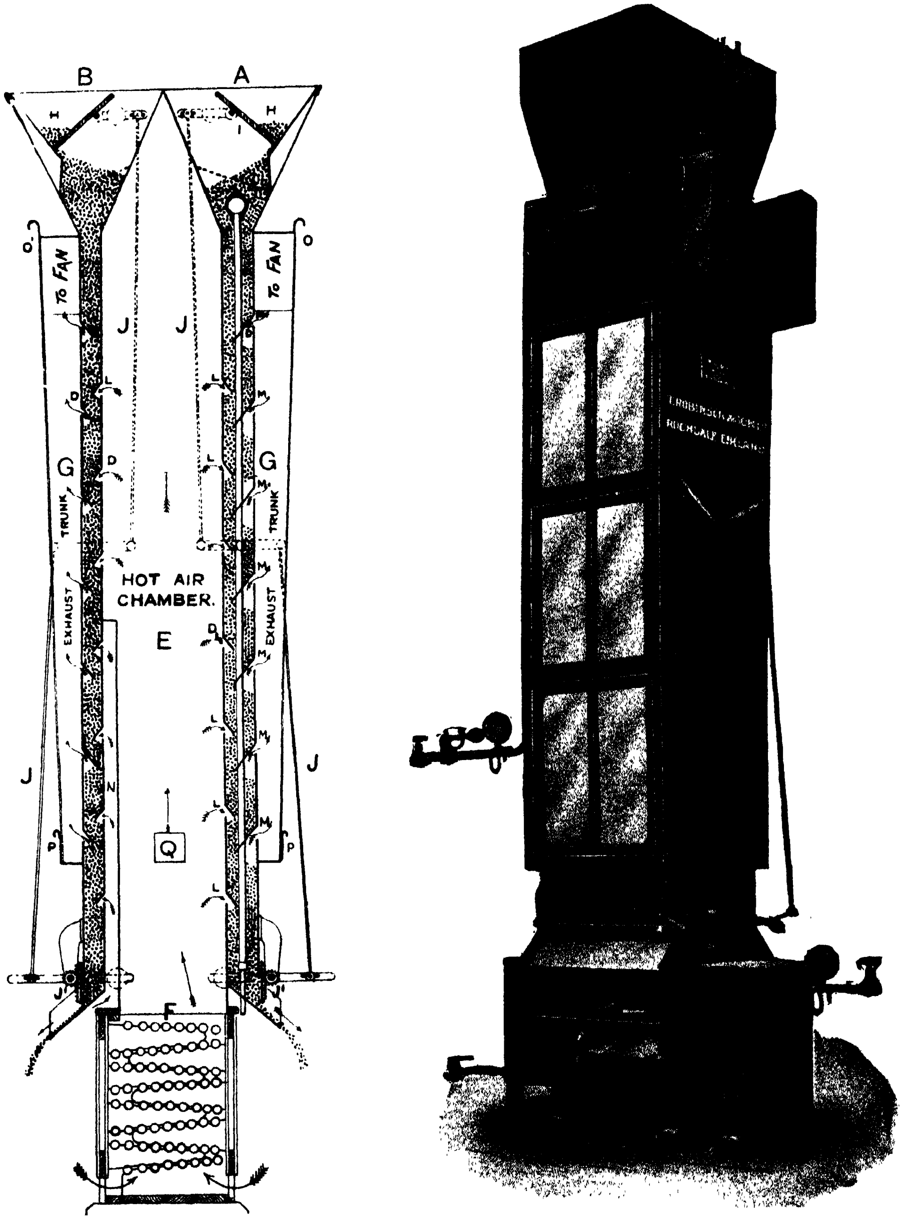


FIG. 113.

Another dryer and conditioner built by Robinson's works (Mallinson's patent), of a more complicated construction, is shown in Fig. 113.

A more equable drying of grain is realised by means of the following appliances. In the working space in the right-hand side of the column, there are vertical spouts fed with steam from the heating chamber *E*. At the top, in the hopper *A*, these spouts are connected

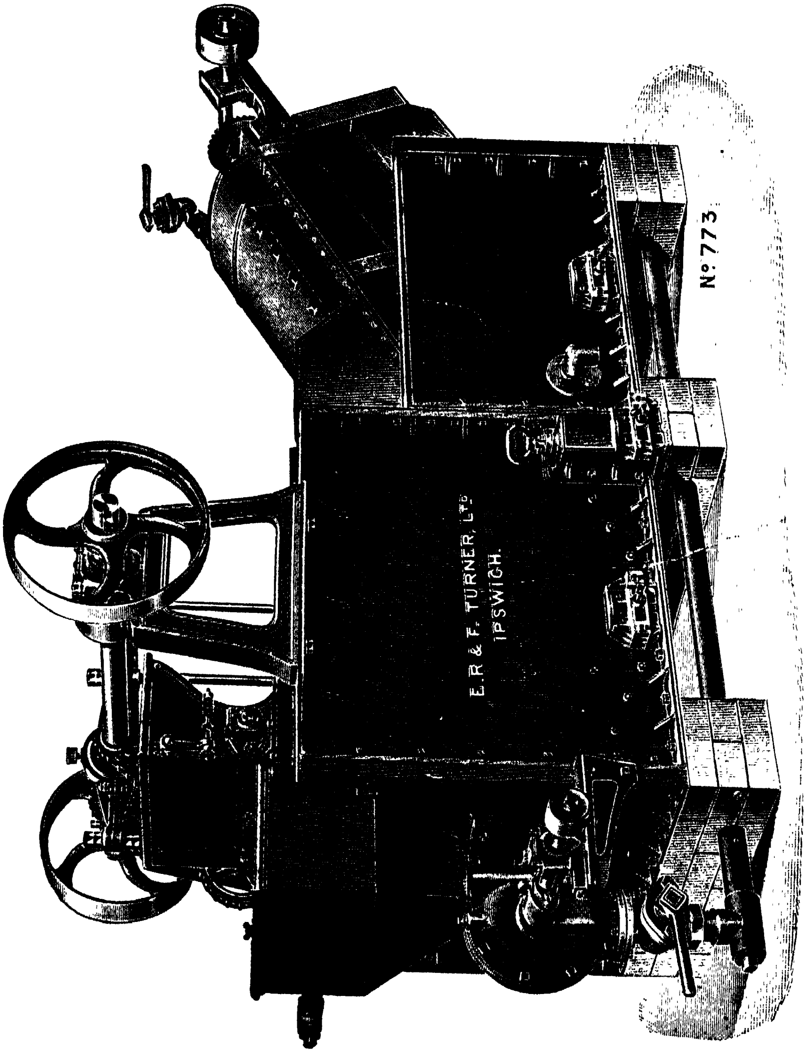


Fig. 114.

by a common horizontal trunk. Within the working space, the grain travels in a zigzag line, owing to the inclined partitions, thus assisting the stirring of the grain. Through openings in the partitions, the warm air exhausted through the spout *G* by a fan penetrates into the stock from the chamber *H*. The vertical steam pipes are designed to maintain an even temperature in the working space, for in the column of the first type, the grain descending close to the outer wall of the working space is treated with air of a lower temperature, and is consequently less dried than the grain travelling close to the inner wall.

On leaving the right-hand side division of the column the grain flows through the feeder *B* into the left division which is not heated by steam pipes. This part of the column in its upper range operates with air from the general chamber *E*, but in its lower part the grain is cooled from the trunk *N*.

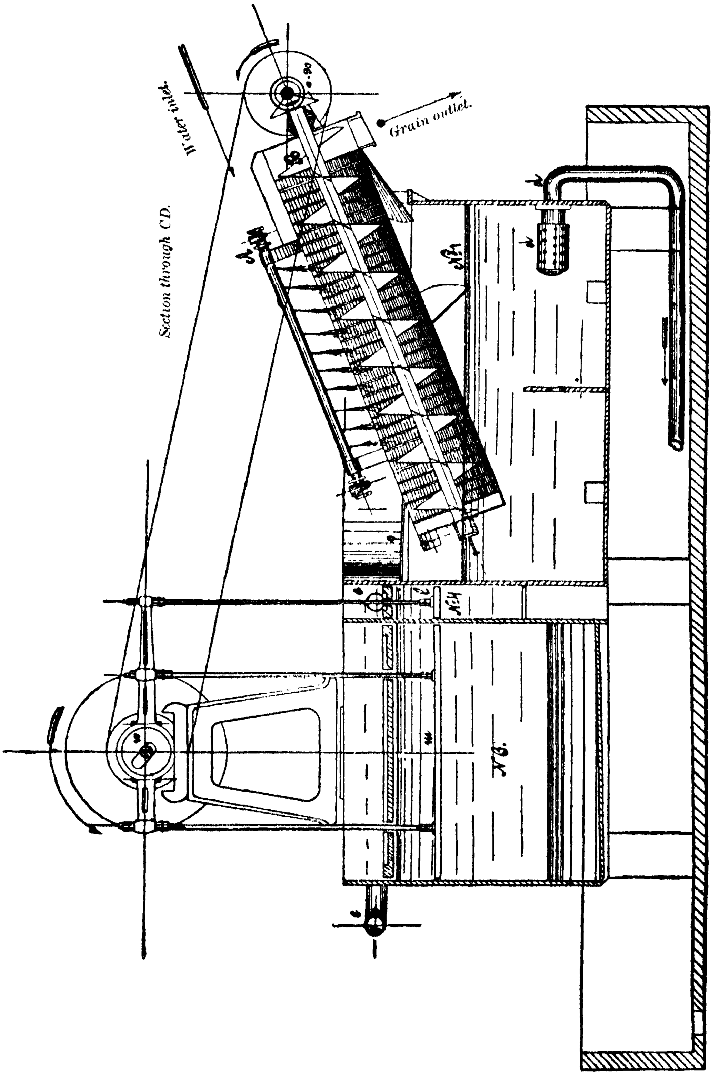


FIG. 115.

The dryers and coolers of various constructions will be compared later.

Washers by Turner, H. Simon, Briddon and Fowler, &c. The Damping of Grain.—A damping machine of another type (Fig. 114) s the English machine for washing coke, slightly modified. The machine consists of a tank divided into six sections, in which the water circulates in the following manner.

The fresh water playing the grain is delivered through holes in the piping, and collecting in No. 1 (Fig. 115) is pumped along the tube *d* to the chamber *F* by a centrifugal pump *C*; from *F* it flows over into No. 5 and No. 6, two vessels communicating with each other (Fig. 116); out of Nos. 5 and 6 the water fills No. 4, which likewise has a connecting channel. In this manner, divisions Nos. 1 and 2 separated from Nos. 3, 4, 5 and 6 have a communicatory opening *b*, while the dirty water flows out of No. 2 through the pipe *g*. The divisions Nos. 5 and 2 (Fig. 117) are covered on different heights with perforated screens; Nos. 6 and 4 encase wooden pistons *m* and *l* driven by an eccentric. During the operation of the machine these pistons agitate the surface of the water over the perforated lid, giving from 180 to 200 vibrations per minute.

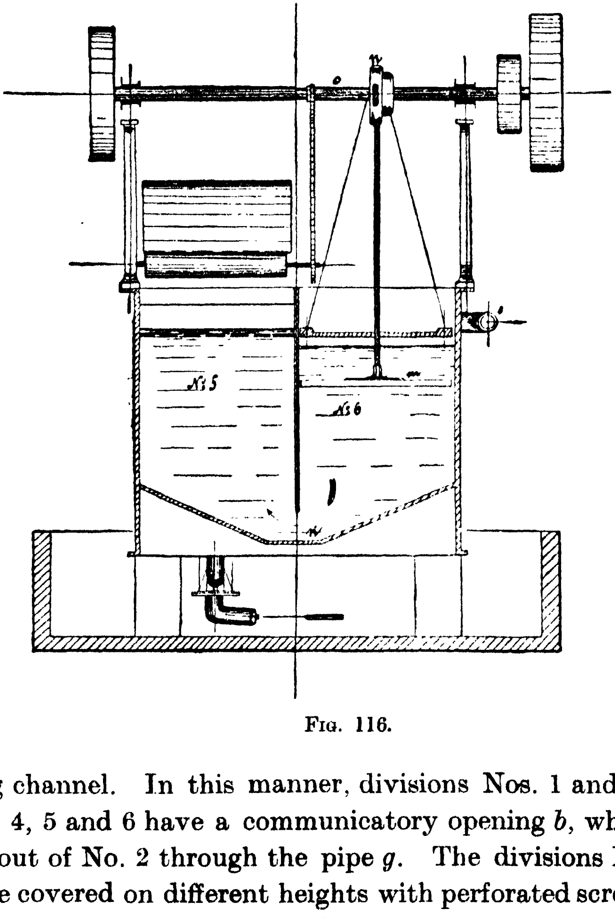
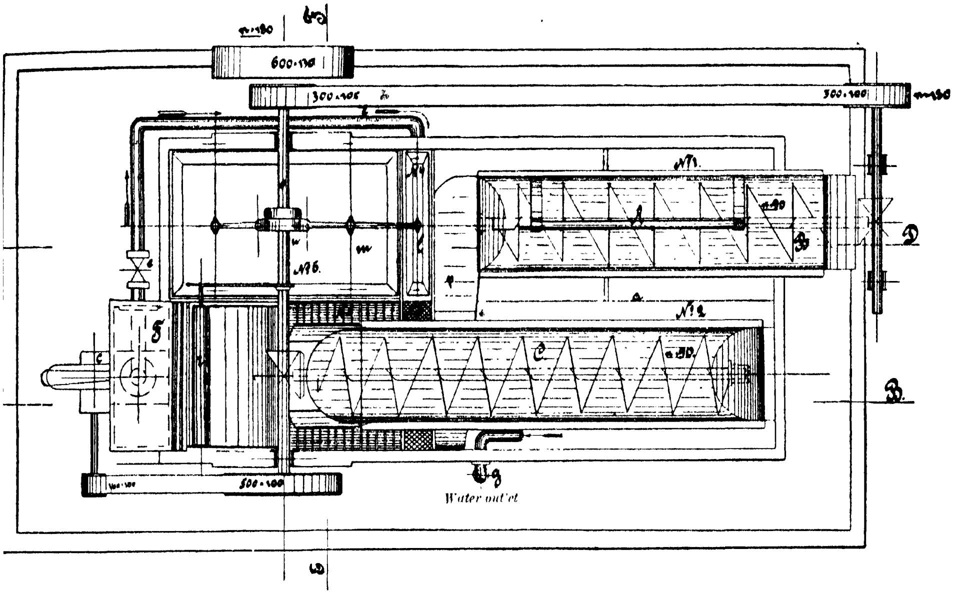
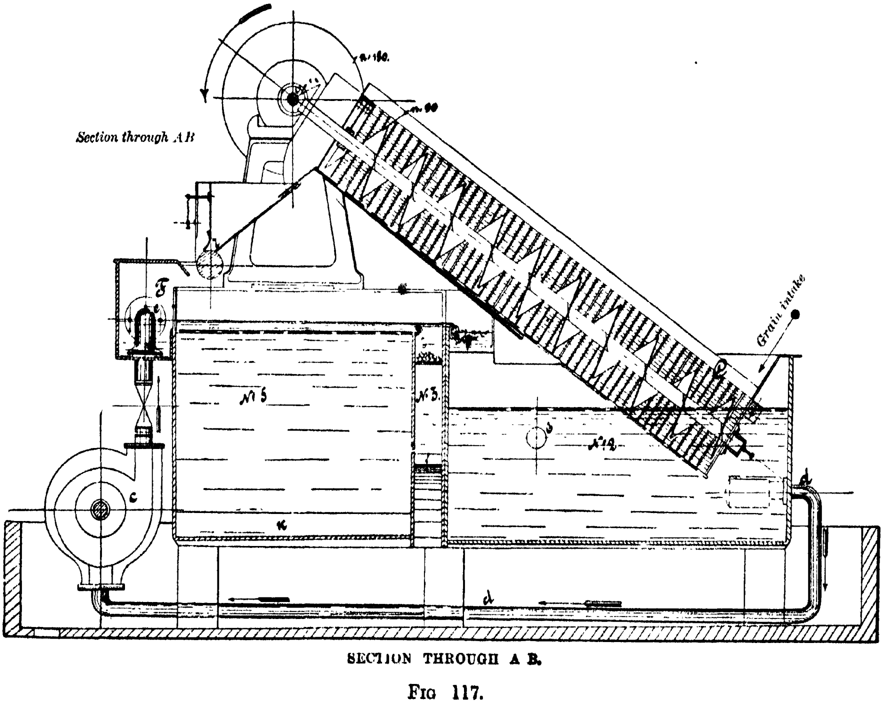


Fig. 116.

The work is performed as follows: the grain is fed into worm *C* in the stream of water. Then it is carried by the worm to the hopper, whence the feed roller *r* passes it on to the surface of the screen of division



PLAN OF H. SIMON'S WASHING MACHINE.



SECTION THROUGH A B.

FIG 117.

No. 5, where the vibrating stream washes it away to the overflow *p*, and further to the lower end of conveyor *B*. In travelling to the overflow *p* the grain passes over division No. 3 with a lowered screen and leaves the heavy extraneous matter (stones, &c.) on it, so that No. 3 serves as a stoner.

To prevent a heavy overflow of water being pumped from the chamber *F* into division No. 5, there is a funnel-shaped opening in F over the water inlet, which is the end of the tube supplying No. 4 with water. Owing to this tube the water level in Nos. 5 and 6 is kept at about the same height.

The washing-machine just examined (H. Simon's) has two worms, though it may be provided with but one, *B* (Turner's machine). In the latter case the grain is fed straight into the hopper, and thence to division No. 5.

We must point out some defects of this machine before proceeding to describe whizzing and drying machinery of other makes. The mistake the makers of these machines make, lies in their supposing the washing of grain to be the chief function of the machine. That is why its construction is complicated by the divisions Nos. 5 and 3 in the tank with vibrating surfaces.

This principle is adaptable in the case of coke, a porous substance, which is indeed washed by the water impelled into the pores by strokes. As to the grain, all it needs is to be well damp. The grain must not be immersed for longer than thirty to forty seconds, which is not a long enough period for the dirt firmly sticking either to the surface of the grain, or in its crease, to be washed off.

A vibratory mechanism is therefore not required. If, on the other hand, the agitation of the water surface is to be abolished, it is evident that Robinson's type of washing-machine, or one akin to it, must be adopted.

Besides this essential defect, resulting from a misunderstanding of the principle of the machine, faults in construction must be mentioned. A wish to make the machine solid induced the engineers to utilise the pressure of the pump in driving the grain to the overflow. This results in a fluctuation of the water levels, in spite of the tube *e* devised for the compensation of the strokes. The opening in the partition between No. 1 and No. 2 regulates the water level of No. 1, but violates the principle of counter current (dirty water washing dirty grain), for there is a possibility of the dirty water being exhausted through the opening out of the division No. 2.

The Removal of Water from the Grain.—As regards the separation of water, H. Simon's centrifugal whizzer (Fig. 117) in its constructive basis differs in no respect from that of Th. Robinson's.

A few general remarks have to be made concerning the whizzing process.

There exist two types of whizzing or centrifugal machines having more or less important differences in the construction of their lifters. The first is Robinson's type, where separate paddles disposed in a spiral line play the part of lifters, or that of Seck (Fig. 118), which has lifters arranged on a generating line, and of a saw-like shape, with teeth bent to one side, also in a spiral line. The lifters in the second type of machinery (Fig. 119) are set at an angle to the generating line of the cylinder, as in scouring machines. In this case not only the wide flanged blades, but the whole lifter is employed in elevating the grain (the construction belongs to the Italian works of S. A. Meccanica Lombarda).

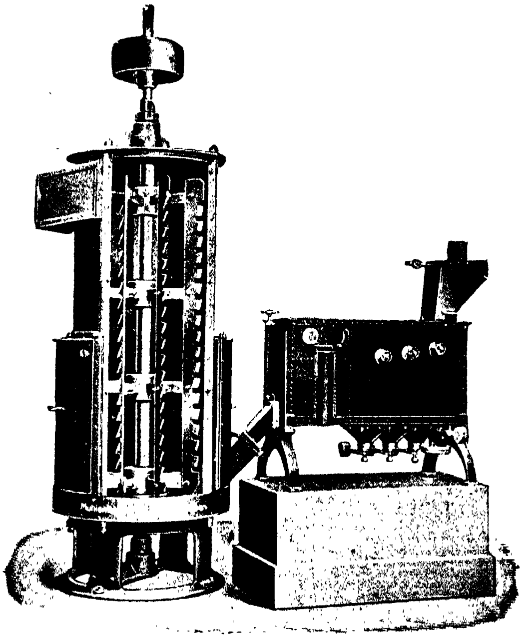


FIG. 118.

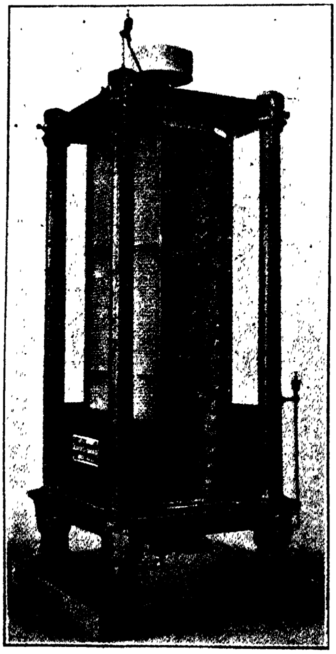


FIG. 119.

Of a much greater significance is the position of the rotatory axis of the lifter drum, which is either horizontal or vertical. In the former case, the whizzer is placed so as to receive the grain together with the water out of the stone-separating and the washing apparatus. Therefore, the lifters in taking the grain scoop up the water at the same time.

Under such circumstances the grain is certainly well rinsed, but this process is somewhat dangerous, because the grain may remain in the water for too long a time, so that the starchy part may absorb too much moisture. For this reason horizontal whizzers are gradually dropping out of use.

The grain is generally fed into the whizzer after the water has been drained off. Some engineers wish not only thoroughly to soak the grain, but actually to wash it. In this respect the washing process of the firm of "Seck Bros." (Fig. 120) deserves attention. Here we have the full process. From the stoner *A* the grain and water flow into the first whizzer *B*. At the bottom of the apparatus the grain is well rinsed in the second apparatus *C*. If the time is accurately calculated, this process may bring good results. Yet the

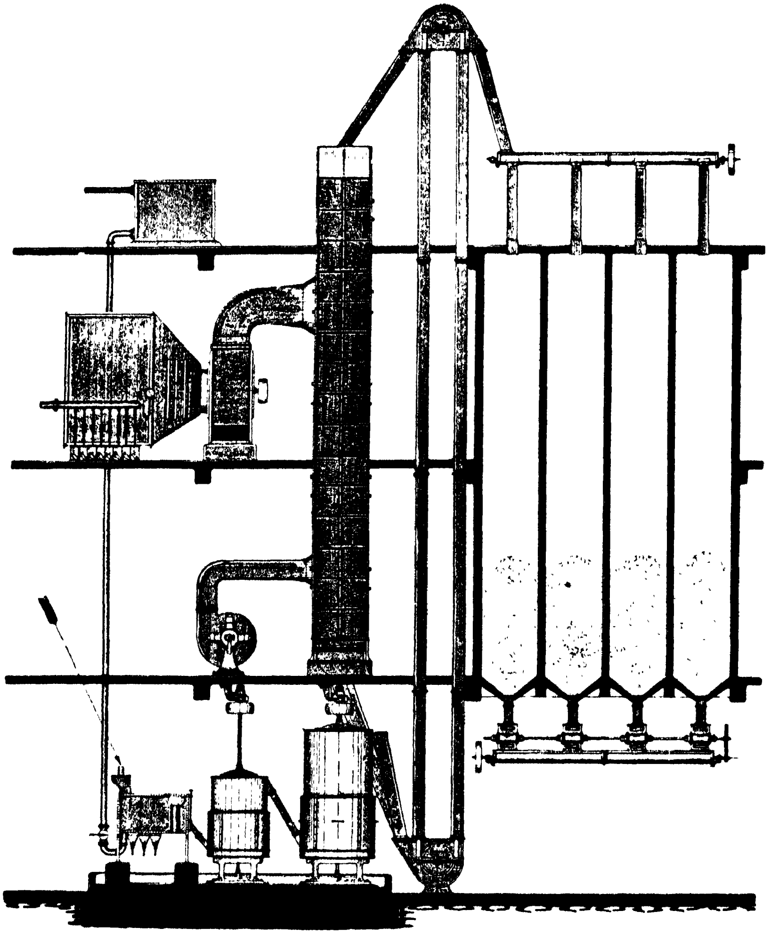


FIG. 120.

engineers ought not to concentrate their whole attention on the washing of the grain, but should remember that we have here an example of the process of scouring by washing.

Fig. 121 represents the washing plant from the works of Luther. Here 1 is a bin, 2 a stone separator, 3 a rinsing appliance, 4 a centrifugal pump, 5 a vertical whizzer, 6 a dryer, 7 a collecting funnel, 8 a hot air exhaust, 9 a cold air exhaust, 10 the heating chamber, 11 a dirt collector, 12 a dryer, 13 a delivery pump, 14 a water cistern, and 15 a dust collector.

The Drying of the Grain.—In drying grain, that most important stage in the wet scouring process, the selection of the type of drying apparatus is a very serious question. In the first place, we must acknowledge that the most active agent in the drying process is the air. This absorbs the greater amount of water-vapour, the higher is its temperature, and the smaller the pressure. The absolute quantity of the vapour absorbed by the air is proportionate to its volume. It follows, therefore, that an efficient, *i.e.* rapid, drying demands :

(1) The highest temperature.

(2) A pressure below that of the atmosphere.

(3) The greatest possible quantity of working air.

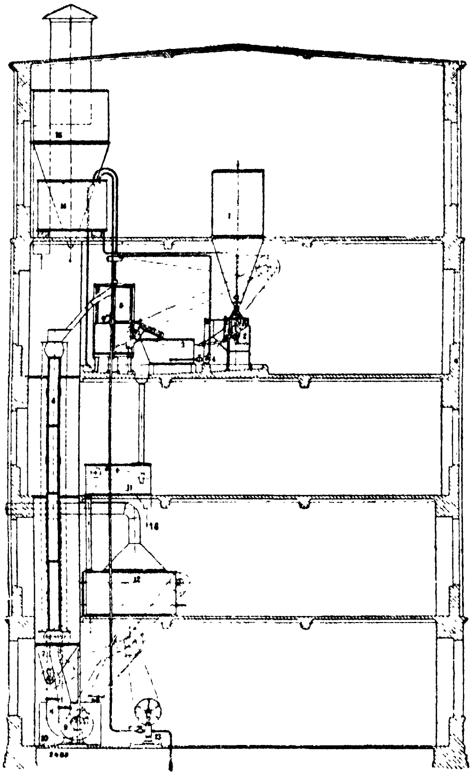


Fig. 121.

These three conditions are defined by the duration of the drying process. The faster the drying is to be performed, the higher must be the temperature, the more rarefied the air, and the larger the quantity of it used. On the other hand, given the limit of significance of the temperature and pressure, and the air consumption, we are enabled to define the length of the drying procedure and the amount of grain, according to its primary and final moisture.

An experimental drying of moist grain has shown that the highest limit of temperature is 60° C. If that limit is exceeded, the bran as well as the kernels burst. However, as far as possible high temperatures ought to be avoided, because firstly, when heated to 60° C. the starch may turn to paste,[1] and secondly, a lower drying temperature requires less fuel.

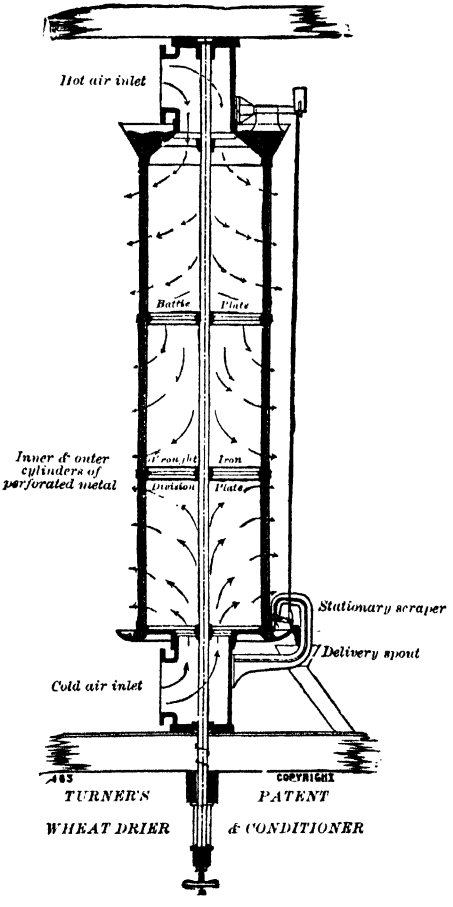


Fig. 122.

These two circumstances suggest the necessity of using rarefied air. And the best result is actually obtained by drying the stock in rarefied air,[2] as is done in large granaries. However, such enormous structures as a vacuum drying apparatus of E. Passburg's are impossible in mills, because we have a washing plant which must be included in the cycle of machinery belonging to the grain-cleaning department, and space is limited.

We have two types of dryers for drying the grain in the wet scouring process: (1) operating by forced air, and (2) by aspirated, *i.e.* rarefied air.

The Robinson dryer we have examined operates by rarefied air. Fig. 122 shows a type of dryer (Turner's works in Ipswich) working with forced air. Nearly all European and American milling engineers favour the second type of dryers.

On Fig. 123 we have a drying arrangement of Simon's (known under the name of "Bühler Bros." in Russia). Here *A* is the air-heating chamber, T_1 a fan impelling the warm air into the trunks *B–B*, and *T* another fan filling the trunks with cold air. Engineers, however, should avoid building dryers which work by forced air, *i.e.* with increased pressure. Besides considerations respecting greater security and economy in drying, there are considerations in regard to their construction.

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[1] Profs. Kick and Zworykin set the limit at 60°, F. Baumgartner at 55°

[2] Vacuum drying apparatus of E. Passburg's system, *Russian Miller*, 1909, No. 10.

Though the apparatus may be fitted up perfectly, there is always a possibility of the dust penetrating into the crevices if the dryer operates by forced air. Its inspection is very much hindered by the fact of the dust blowing into the apparatus through the window when it is opened. Now, if the machine works with aspirated air, these defects cannot obtain in the process.

In the second type of dryer from the works of Robinson (Fig. 113) we see that its right-hand working part is heated by steam-pipes which are adapted for the purpose of completely removing the moisture with the aid of a higher temperature. It must be kept in mind, however, that in employing such a construction we run the risk of choking the grain which moves in the neighbourhood of the tubes. Besides, the air pipe which supplies the left part of the column with cold air is warmed by the hot air, an undesirable effect. In this column the adaptation of a step partition, owing to which the stock travels in zigzag line and becomes mixed, must be acknowledged to be useful; it also promotes a more equable drying of the grain.

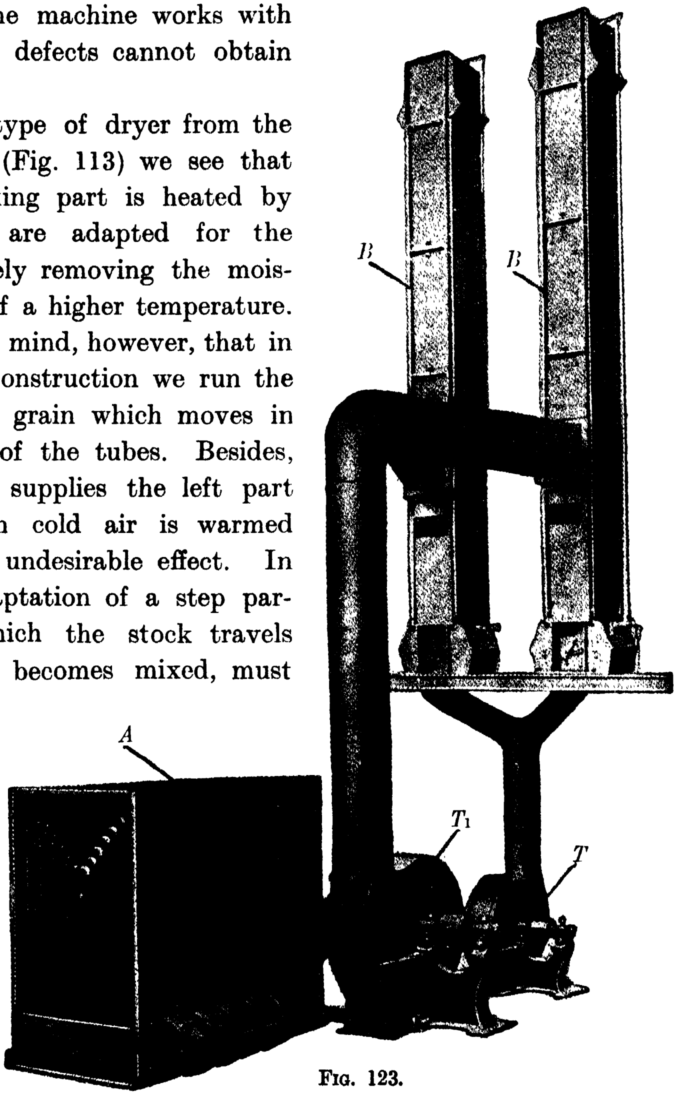

FIG. 123.

Touching modern grain-drying, Professor Zworykin suggests a few very interesting considerations as to the principle and the construction. He finds the following defects in the dryers just spoken of:

(1) The stock which travels along the vertical canal on the side of the drying air inlet is dried more thoroughly than the stock moving on the opposite side of the canal.

(2) The grain flowing down the central part of the drying canal

moves faster than the grain on either side of it, and is consequently dried to a different degree.

(3) The air, during the drying process, in passing through a thin layer of grain equal to the breadth of the drying canal is not saturated enough with moisture, and is therefore insufficiently utilised.

As concerns the two first defects, they are effectually done away with in Mallinson's dryer with step-canals. This is confirmed in the types of machinery suggested by Professor Zworykin. The third defect is to be overcome by the principle of counter-currents adapted by Professor Zworykin in the following two sketches of drying columns.

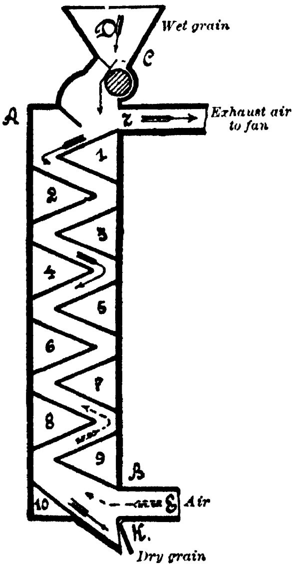

FIG. 124.

Fig. 124 represents a hollow column *AB* of a square or rectangular section provided with a series of jutties of a triangular section inside (1, 2, 3, 4, 5, 6, 7, 8, 9, 10) and a hopper *D* at the top, which contains a feed roll *C* and an arrangement for regulating the feeding. The moist grain passes through the hopper and the feeding apparatus into the column, rolls down the jutties (1, 2, 3, 4, . . . 10), as pointed by whole arrows, and is discharged through the valve *K* below. In the direction opposite to its course a current of air is driven through the inlet *E* : it ventilates the grain several times at the moment it falls from the even on to the odd jutty or vice versa, and then humid with the moisture drawn off the grain, it passes to the fan through the outlet *Z*. Naturally the grain must flow in a thin layer and must not block up the space.

For the action to be regular, Professor Zworykin recommends heating all the jutties or only one side of them with steam or water, while the period spent by the grain in the apparatus may be regulated by making at least one range of boxes (for instance, the even numbers) adjustable so as to alter the angle of inclination of the surfaces down which the grain rolls from 45° to 70°. In Professor Zworykin's opinion, there is no especial need artificially to cool the dried grain, if after drying it is not to be tempered in bins, but, continually passes from machine to machine, and undergoes a gradual treatment.

The second variation of that design is a round cylindrical column with conic (Fig. 125) surfaces *B*. The central part *A* of the apparatus is heated. The grain flowing through the hopper travels over the conic surface of the heated central part A, and aspirated on its way, falls on the conic surface B. Then it rolls off B on to the second cone A and is again fanned, &c., till it reaches the outlet.

Calculations in Reference to Dryers.—An approximate computation of the quantity of air and heat required for drying purposes may be based on the following considerations:[1]

If the capacity of the dryer is stated to be P kilogramme of grain per hour, the quantity of water to be extracted from the grain in one hour will be defined in $\frac{P(p-p_0)}{100}$ kilogramme, where p signifies the percentage of moisture in the damp grain, and p_0 in the dried grain.

Each cubic metre of air extracts γ kilogramme of moisture, consequently the drying of the stated quantity of grain requires $\frac{P(p-p_0)}{100\gamma}$ cubic metres of air. The quantity of water-vapour which a cubic metre of air may hold, when fully saturated, depends on the temperature, and is given in kilogramme weight in the following table :

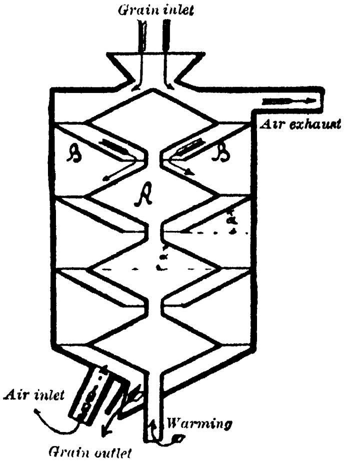

FIG. 125.

TABLE XV

Degrees C.	Weight of Vapour, Kilogramme.	Degrees C.	Weight of Vapour, Kilogramme.	Degrees C.	Weight of Vapour, Kilogramme.
−30	0·00074	−5	0·00368	20	0·0171
−25	0·00095	0	0·00497	25	0·0281
−20	0·00129	5	0·00676	30	0·0301
−15	0·00189	10	0·00935	40	0·0509
−10	0·00268	15	0·01275	50	0·0830
				60	0·1306

If the air entering the dryer contains k per cent. of moisture and its temperature is T', on leaving the apparatus it is not perfectly saturated, having k per cent. of humidity and t^0 temperature. Then the total quantity of moisture γ absorbed by 1 cubic metre of air in relation to the temperature of air after usage, t^0, is formulated thus :

$$\gamma = k_0 l_0 - \frac{kl}{1+a(t_0-T)},$$

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[1] "The Grain Dryer," by Prof. K. Zworykin, *Russian Miller*, 1910, No. 11.

where l and l_0 signify the quantity of steam in kilogrammes saturating 1 cubic metre of air having a temperature of T and t_0 respectively, while a is the coefficient of expansion of the air, equal to 0·003665. Hence the formula defining the volume of air required for drying, in cubic metres at a temperature t_0:

$$V_0=\frac{P(p-p_0)}{100\left(k_0l_0-\dfrac{kl}{1+a(t_0-T)}\right)}.$$

The term $\dfrac{kl}{1+a(t_0-T)}$ is insignificant if cold air is employed, and in a rough calculation may be left out; and the quantity K_0 does not exceed 0·7, for the dampness of the air discharged is assuredly not to be increased beyond 70 per cent. of the absolute dampness.

Assuming the temperature of the medium supplying the air to be 10° C., the temperature of heating and at the discharge of the air 60° C., the percentage of moisture in the air in both cases is 70 per cent., the primary dampness of the grain 30 per cent., and 10 per cent. when dry, after due substitution, the formula of V will be presented as follows:

$$\frac{30-10}{100\left(0{\cdot}7\,.\,0{\cdot}1306-\dfrac{0{\cdot}7\,.\,0{\cdot}00935}{1+0{\cdot}003665(60-10)}\right)}=|=\frac{1}{5\,.\,0{\cdot}7\,.\,0{\cdot}1305}=|=\frac{1}{0{\cdot}045}$$

$=|=2\tfrac{1}{4}$ cubic metres at 60° C. of temperature.

To define the quantity of warmth required in the drying process, it must be known how much warmth is needed for the moisture to evaporate from the grain, and for the heating of the grain and the air supplied out of medium, to the temperature it has when leaving the dryer. That quantity, Q_0, is defined as:

$$Q_0=\frac{P(p-p_0)}{100}(606{\cdot}5+0{\cdot}305\ t_0-T)+\frac{P(100-p+p_0)}{100}c_1\ (t_0-T)$$
$$+V_0d_0c_0\ (t_0-T).$$

Here c_1 is the specific heat of the grain amounting to about 0·6; c_0 that of the air under steady pressure, equal to 0·237; and d_0 the weight of 1 cubic metre of air heated to 60° C., equal to 1·06 kilogrammes.

Substituting these significations in Q, we have:

$$Q_0=\frac{1}{5}(606{\cdot}5+0{\cdot}305\,.\,60-10)+\frac{4}{5}(60-10)c_1+2{\cdot}25\,.\,50\,.\,1{\cdot}06\,.\,0{\cdot}237.$$

$$Q_0=\frac{1}{5}598{\cdot}33+40c_1+112{\cdot}5\,.\,1{\cdot}06\,.\,0{\cdot}237=120+24+28{\cdot}3=172{\cdot}3.$$

So, under the conditions alluded to, 1 kilogramme of dried grain demands the expenditure of about 175 units of heat. Once the heat expenditure is known, it is easy to calculate the quantity of fuel consumed by the heating source of any one particular machine.

Professor Zworykin attaches much importance to the principle of counter-currents, wishing to utilise the absorbing capacity of the air to its utmost within the bounds of possibility. The adaptation of this principle to grain drying in the wet scouring process is not defensible, because the coefficient of the best results in drying, in the present case, is defined not by the greatest saturation of the air, but by a more rapid drying of the bran. If we accept the principle of counter-currents as basis for grain drying in the wet scouring process, the gradually drying grain will not shell in the column apparatus, a fact mentioned at the commencement of our explanation of the wet scouring process.

Before ending the discussion of grain scouring by washing, mention must be made of the fact that by far the greater number of European works favour the Robinson type of washing, or rather stone-separating machine.

Vertical whizzers, further, very often receive the grain together with the dirty water (the works of Kapler, Daverio, Seck, and several others). Lastly, the dryers of all the works, except that of Robinson, operate with forced air.

As regards the consumption of energy, fuel, and water in the wet scouring process, it is to be noted that the plants of the Robinson, Luther, and similar types, are in all respects more economic than the Simon or Turner type. The first cost and working expenses of the wet scouring process are considerably greater than in the usual dry grain cleaning, but the improvement of the medium and the lower grades of flour covers the expenses over and over again.

The expenditure of water in the wet scouring process amounts to from 4·0 to 4·9 gallons for 1 bushel of grain in plants where the dirty water is returned to repeat its work (to the pressure tank by the principle of counter-currents), and 12 gallons for 1 bushel when working constantly with fresh water.

VI

DAMPING THE GRAIN

When the grain reaches the milling department it is important that the offal particles should not be reduced to a fine dust together with the stock. It is impossible to extract finely ground offals from flour. But if the bran coat is broken up into particles larger than the flour, they may be removed by bolting. It is of great consequence, therefore, that the process of milling should be performed so as to leave the bran coats whole.

If we have dry grain during the milling process, the dried bran is very easily ground to dust which mixes with the flour. If, on the other hand, we dampen the bran, it becomes more elastic and offers greater resistance to pulverisation than the starchy mass of the grain.

In that case the force sufficient to break the kernel will leave the bran coats intact. If an elasticity is to be imparted to the bran, it is necessary to temper it. Naturally, a damping is needed only when the grain is dry, and in its process of cleaning has not been scoured by washing.

The damping of the bran of the dry grain in the dry process of cleaning is performed (if the grain is very dry) either previous to the second scouring, or before it is fed into the first break roll. In the first case, the bran envelops the grain so closely that, without breaking it up, it cannot be removed ; when softened by water, it is separated with greater ease. In the second case, the elasticity of the dampened bran resists the triturating effect of the grinding.

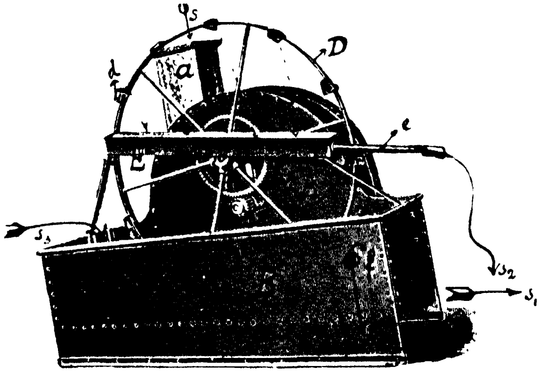

Fig. 126.

There are two types of apparatus for conditioning the bran : (1) the wetting apparatus, and (2) the apparatus for steaming the grain.

Damping.—The grain is wetted with the aid of an apparatus (Fig. 126) which consists of a paddle-wheel resembling the overshot water-wheel, set in an iron casing *A*. The grain fed through a spout hopper *a*, as marked by arrow *s*, falls on the paddles and brings the wheel into rotation. The motion is communicated through gear wheels *b–c* to the wheel *D* which carries a series of cups *d* drawing up water out of the cistern *B*. On reaching a certain height the water pours out of the cups into a long inclined trough *E*, down which it runs and is spouted through tube *e* (arrow s_2) on to the grain, which on leaving the paddle-wheel has passed through the conveyor and is now flowing (arrow s_1) to the bin. The tank *B* is filled from the water-piping along s_3. If the consumption of water is low, its overflow runs out of *B* down tube *f* set on a certain level. The inflow of water is regulated automatically: when the flow of grain diminishes, the revolving velocity of the paddle-wheel diminishes also, and consequently that of wheel *D*, thus reducing the water supply to *B*. With the stoppage of the feeding of grain, the work of the wetting apparatus is discontinued. The water flowing to *B* flows out at *f*, which gives the sign to those attending the grain-cleaning division.

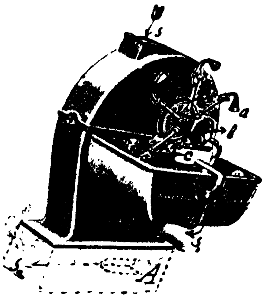

Fig. 127.

Another less cumbrous apparatus is shown in Fig. 127. Here the conic cups *a* are screwed on to tubes d_1. The water scooped up by these boxes is conveyed by pipes d_1 to *b*, whence it pours into the box *c*: from *e* the water flows to the box *d* and then along the pipe s_1 falls on the grain in the worm conveyor *A*, which is carrying it by the way of s_2 to the bin. Owing to a stirring action of the worm, a more or less even dampening of the grain is effected.

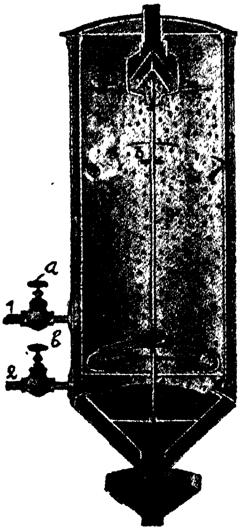

Fig. 128.

Steaming.—However energetically the mixing be performed, still the whole stock is not moistened to an equal degree. With the view to making the tempering of the bran more efficient, the Americans suggest steaming the grain.

Fig. 128 shows Beall's steaming apparatus; its shape is cylindrical, with steam circulating between its double walls. Its mode of action is as follows:

Through the hopper 6 the grain is fed into the inner cylinder, where it falls on the bottom disc 5 with star-shaped perforations.

The flow of grain is regulated by a cone 8, which is fixed in the cylinder by a cross-head 7. The stream of grain is controlled by a cylindrical gate 6 fastened to the same rod 9 on which the disc 5 is set, and which rests on a spring 4. If a large quantity of grain has collected on the disc 5, the gate 6 stops the passage of grain between the cone and its rim. Proportionately to the outflow of grain, the weight diminishes and then the spring 4 begins to act: it lifts the rod and opens the gate. The steam circulates in the following manner. The steam, which is generally exhaust steam, is let into the space between the two walls of the cylinder through the tube 1, its passage being controllable by a valve *a*. The steam enters into the working space by inlets 3, warming the inner cylinder on its way (the outer one is insulated). Part of it condenses on the grain, while the rest, becoming cooled, sinks and is delivered through the lower outlets into the intercylindric space, whence it is discharged through the tube 2. But more often there are no apertures below, and all the steam becoming condensed, dampens the stock still more. The steam cooled in the intercylindric space passes out through the tube 2.

The main point in the steaming process is the warming of the grain in the cylinder. The moisture contained in the kernel of the berry evaporates and is detained by the skin, *i.e.* the grain "sweats." In addition, the condensing steam settles on the surface of the grain and moistens it in an even measure.

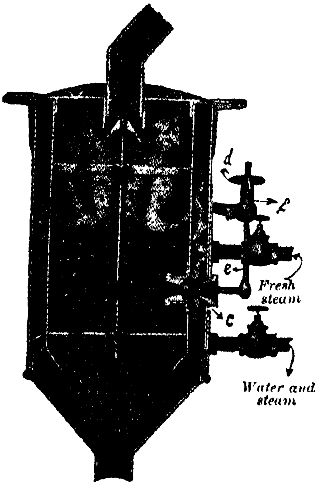

FIG. 129.

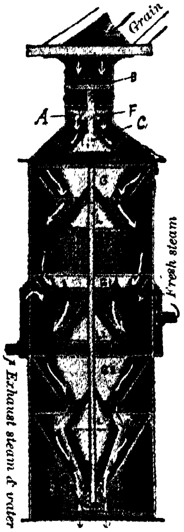

FIG. 130.

Another steaming apparatus is shown in Fig. 129. Here the gate *A* opens under the weight of the grain. The cross-beams *B* serve as guides to the rod *a*, which is connected with a small lever *b* rotating in a ball bearing, owing to the presence of a ball close to the centre *c*. The other end of the lever *b* is joined to the rod *e* moving in the solid journal bearing *f* provided with a spring. By means of a hand-wheel *d* the slide valve *A* is opened to its utmost. When the flow of grain is discontinued, the spring *f* pushes the rod *e* which turns the lever *b*, thus lifting the rod *a* and stopping the spout with the gate.

In the more simple steaming apparatus "Eureka" only the middle part of the cylinder is heated (Fig. 130). The flow of grain here is regulated non-automatically. The stock passes through the cone *A* between a conic gate *F*. Owing to the rotatory motion of a part of the spout *B* the gate set on a rod having a square lower end and the upper one furnished with a screw thread, rises or falls, thus altering the useful area between the cones *A* and *F*.

The adoption of the steaming apparatus produced excellent results, and therefore every large American mill uses it instead of the wetting system. The capacity of these machines, according to their size, varies from 25 to 60 bushels per hour.

Apparatus having no flow regulator are so simple that any tinsmith can make them.

After steaming it is advisable to let the grain temper in bins for 1 to 1½ hours.

VII

GRAIN-CLEANING DIAGRAMS

In the preceding chapters we have examined all the machines and apparatus of the grain-cleaning department. Now the order of sequence of the cleaning machinery of both the dry and the washing systems has to be considered.

In our diagrams the cleaning of wheat and rye will be considered.

We shall begin with the most simplified flowsheets, gradually proceeding to the more modern forms of cleaning.

Dry Cleaning. 1. *Simplified Cleaning.*—Here we have in view the diagrams for a simple roller system producing two to three kinds of flour. The cleaning tackle must be cheap, therefore it is best to adopt combined machinery: a grain-cleaning machine of the Zolotuchin type (see p. 114) and a wetting machine will suffice, if the grain is very dry. The wetting can be simplified by taking a water-barrel and setting into it a cock with a draining pipe leading to the conveyor.

The order of machinery in the improved style of cleaning will be as follows:

(1) A separator with a sieve (preferably with two sieves for large and small impurities), (2) a cockle separator, (3) a combined machine of the Zolotuchin (Fig. 104), American (Fig. 103), or Schneider, Jacquet & Co. (Fig. 94) type, (4) a wetting machine.

2. *A Medium Type of Cleaning.*—The cleaning process is more

elaborate here, because it aims at a more perfect separation of impurities and beeswing. The machines and apparatus to be employed are:

(1) A bolting machine for large and small refuse (reel separator, bolting separator, aspirator, or zigzag separator), (2) a cockle separator, (3) a controlling trieur, (4) a magnet apparatus, (5) first scourer, (6) a bolting machine (reel separator, aspirator, zigzag separator), (7) an emery scouring machine, (8) a brush machine, (9) a wetting apparatus.

If the wheat is very dry, the wetting apparatus is to be placed before the emery scouring machine.

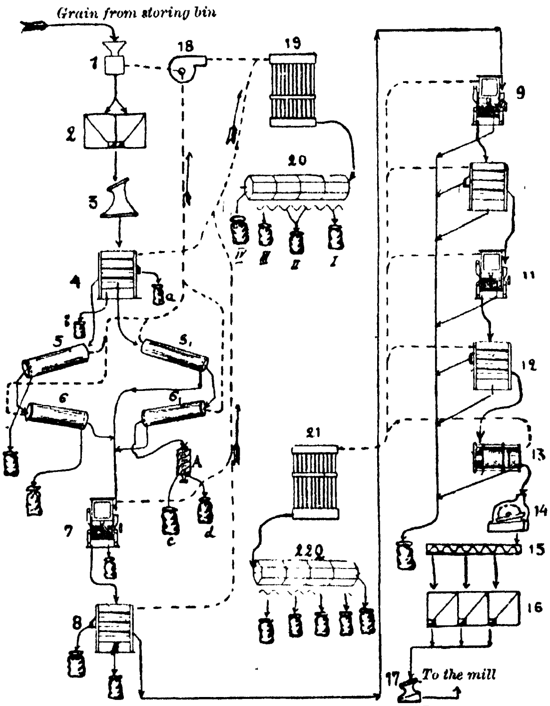

Fig. 131.

There are two scourers already in this diagram, a rough and an emery one. On the first machine the dirt sticking to the grain is removed, and part of the germ coats and beard, while the second separates the shells and the remaining germ coats and beard. Each scourer must be followed by a bolting apparatus, as the fan of the scourer leaves unextracted a certain percentage of husks and broken grain, and other small impurities, which not being sifted away, will pass into the next machine and besmear the rough surface (if it be a scouring machine) or dirty the grain.

3. *The Most Complete Type of Cleaning.*—Beginning with a daily yield of 2000 bushels and more, if the milling is high, the best style of grain cleaning must be employed. It is serviceable to keep an account of the loss in the grain-cleaning department, therefore automatic scales are placed before and after the cleaning process. Fig. 131 gives a rough diagram of the wheat-cleaning machinery.

Out of the storing bin, the grain is conveyed to automatic scales 1 and then taken to bins 2. From the bin it passes over the magnet apparatus 3 to the aspirator 4 which removes the large refuse to the sack *a*, while the dust, sand, and small matter are sent to the sack *b*. In this aspirator (the Seck type, or a zigzag separator) the stock is sorted into large and small grain, the former flowing into barley separators 5, the latter into cockle separators 5_1. After the barley separator, the grain passes on (through a hopper) to re-barley cylinder 6, and the stock from the cockle separator to the re-cockler 6_1. The grain cleansed in 5–6 and 5_1–6_1 (small grain separated from broken grain and cockle) is then treated consecutively on scourer 7, in the aspirator 8, in a clean emery scouring machine 9, aspirator 10, an emery scouring machine 11, aspirator 12 and a horizontal (or vertical) brush machine 13. After the brush the stock may be weighed on another pair of scales, which will inform us of the loss in weight sustained in the grain-cleaning department. The scales are not shown in the flow sheet, and the grain passes to the wetting pparatus 14 here, whence it is carried by conveyor 15 to be tempered in bins 16 for eight to twelve hours. From the bins, over a magnet apparatus, it is taken to be ground. The capacity of the bins must be calculated to give a store of grain for eight to twelve hours.

To keep the scales and trieurs dust free, there is a fan which exhausts the dust out of the machine and drives it to the dust-collector. That same dust-collector receives the dirty fan-refuse of aspirators 4 and 8 and rough scouring 7. The dust-collector passes the refuse to the reel separator which sifts the heavy dust into sack *I*, small refuse into *II*, medium into *III*, while the large impurities (chaff, &c.) are tailed over to *IV*. The broken grain and cockle separated by the re-cockler 6 are then sorted in a worm trieur *A*, and the former deposited in the sack *c*, the latter in the sack *b*. The fan-refuse from the finishing scourers, aspirators, and brushes is sent to the dust-collector 21, and thence to the reel separator 22 ; and the heavy refuse of the same machines and the throughs are discharged into sacks either in bulk, as shown in the flow sheet, or the impurities from the scourers are treated apart from the throughs of the aspirators and the brush.

This flow sheet may be varied to a large extent. If the grain is very hard and dry, the damping machine precedes the first finishing scouring machine 9. The aspirator 10 is often not used even in large mills, though this tends to deteriorate the work of the scouring machine 11. Very rarely three emery passages are included in the plan, besides the rough scouring machine, being an unnecessary luxury. Sometimes the aspirator 12 is discarded, and only the brush is retained. If the cleaning is to be simplified, the barley separator is not included, and the separators employed are only the cockle separator and the re-cylinder.

In well-designed mills of large capacity the large and small berries should not be blended after passing the controlling trieurs, but cleansed parallel on separate scourers, till they reach the brush machines. The drystoner has to be placed before the rough scourer 7.

Grain Cleaning in the Wet Scouring Process.—During the period since grain washing has come into vogue, the cleansing plan has been considerably simplified, it being supposed that the washing process removes the dirt completely. Fig. 132 illustrates the cleaning by washing system recommended by Kapler's works (Berlin) at the beginning of the present century. According to this plan, from the storing bin 1 the grain is taken to the scales 2 and then to the separator 3. The screenings of the aspirator fan are delivered by the cyclone 4, the heavy impurities to the bags *a* and *b*, the small matter (the throughs of the last sieve) to the bag *c*. The grain passes further over a magnet 5 to the trieurs 6, whence the refuse is delivered to the secondary trieur, and then washed, passing the stone separator 8, the whizzer 10, and the dryer 12. The dryer is supplied with warm air by the fan 13 which draws it out of the heating chamber 15, and the cold air is impelled by the fan 14. Out of the dryer, the grain flows to the scouring machine 16, the brush machine 17, and then to the grinding machinery. The fan-re use collects in the dust-collector 18.

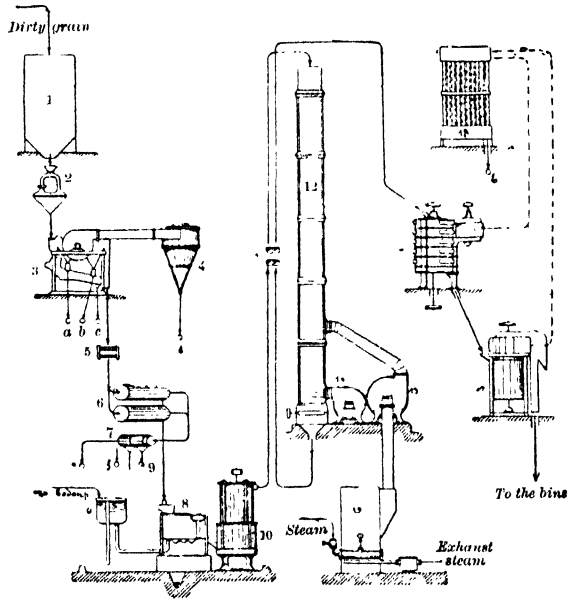

FIG. 132.

In comparing the two plans we find that the rough scourer and one of the finishing machines are left out here.

During the last few years in the grain cleaning with the wet scouring or washing process the rough scourer precedes the washing. This proves that the washing of grain does not answer its purpose as regards the removal of dirt.

Consequently, the modern wet scouring system of grain cleaning has afforded the possibility of shortening the whole process by one scouring passage only.

Cheap water and a steam motor make the adaptation of the wet scouring system profitable, as the cost of the water for washing and the comparatively small expenditure of steam for heating the air supplied to the dryer are recovered.

The warm air is taken from the heating chamber, which consists usually of an iron riveted casing (Fig. 133), containing batteries of steam pipes. The steam is conducted to these pipes along the upper external trunk furnished with a gauge showing the pressure, and let out through the lower tube. There are several globe valves for regulating the steam injection (two, in the present case), by means of which separate batteries of pipes may be included or excluded, thus controlling the temperature of the heated air.

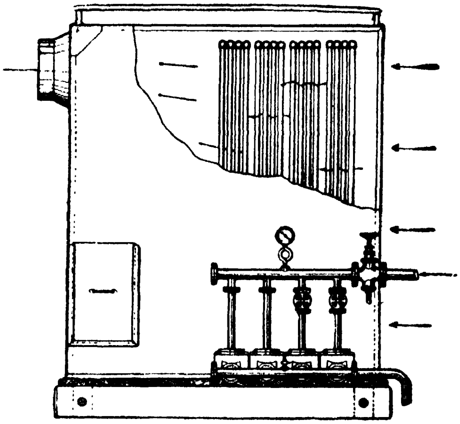

Fig. 133.

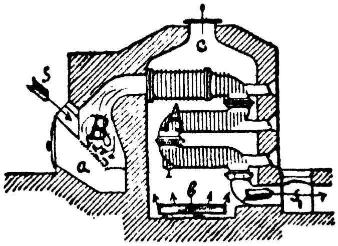

Fig. 134.

In case a motor of internal combustion is employed in the mill, the heating chamber supplying the dryers with air cannot utilise the exhaust steam. Special chambers with air-heating appliances have to be arranged. Fig. 134 shows a fairly simple chamber built of bricks, for that purpose. *A* are the cast-iron tubes down which the products of combustion are conveyed out on leaving the furnace. The burning in the fireplace *B* is regulated by letting a greater or less volume of air into the air blower *a*. The exhaust products of combustion are ejected through s_1. The cold air streams into the chamber through the inlet *b*, and is aspirated by a fan through the outlet *c*.

However simple this arrangement may be, still it demands an extra expense in fuel. It is desirable, therefore, that the engineers should utilise the exhaust gases from the motors of internal combustion, the temperature of which often rises to 600°.

Grain Cleaning with Bran Washing.—The cleaning with bran in Haggenmacher's machine, a process already examined, has been very lately adopted in Austria-Hungary.

The operations of those machines having undergone no strictly scientific trial as yet, it is difficult to give any definite opinion, though in theory, favourable results may be expected.

In determining the place of the bran "washer" in the flow sheet of grain cleaning, it must be mentioned that similarly to the wet scouring, it ought to take place of the second scouring passage. Yet it is often placed instead of the rough scourer.

The Cleaning of Rye.—All the flow sheets reviewed contemplate the cleaning of wheat. The flow sheet for cleaning rye is practically the same, but is curtailed by one scouring passage. Yet, if the grist is high, yielding up to five kinds of flour, the usual three passages must be practised, *i.e.* the plan in wheat cleaning adhered to.

CHAPTER IV

GRINDING THE GRAIN

I

THE FUNDAMENTAL PRINCIPLES OF MILLING

ON leaving the grain-cleaning department, the grain is sent to be ground into flour.

Before proceeding to describe the grinding machinery, the fundamental principles of that most important operation in the industry must be systematically considered.

As was shown in the historical outline of flour milling, the primitive technics of times gone by produced but two principles of reducing the grain—impact and friction; and the materials of which the milling implements were made were almost exclusively natural stones. In this primitive process both the grain and offals were ground. The necessity of removing the non-nutritive bran, however, considerably modified the system by evoking new principles of trituration, while new materials for the working organs of the machinery afforded the possibility of putting those principles into practice.

In classifying the types of milling machinery existing in modern technics, according to the principles of action of their working organs upon the product under treatment, the machines must be divided into the three following categories :

(1) *Cutting* (*chipping off*) *machines.*
(2) *Pressing* (*crushing*) *machines.*
(3) *Machines acting by free impact.*

The machinery of the first principle of reduction requires two working parts moving in opposite directions, or in the same but with different speeds (Fig. 135). It is evident that the working surfaces *A* and *B* in these machines should be sharp and rough.

The second principle of action of the working parts upon the product treated is never met with in its pure form, because those parts move with a velocity different to that of the product, and the grain, besides being crushed, loses particles that are chipped off not by the strain of the cutting facets, but through friction. This process is called triturating the product. In this case, too, the working parts may be moving either in different or in one and the same direction. If running in the latter manner, their speeds must be different. An immovable position of one of the working surfaces, as in millstone sets for instance, is also possible. In Fig. 136 we have a diagram of the treatment the product receives according to the second principle. The direction of movement of the working surfaces is marked by arrows *s*, the pressing force by *N*. Then the forces of friction are *Nf*, *f* being the coefficient of friction of the product against the working surface. The breaking down of the grain or of a part of it will be effected in planes parallel to the acting powers. The working surfaces *A* and *B* may be smooth in that case, but with a high coefficient of friction *f*.

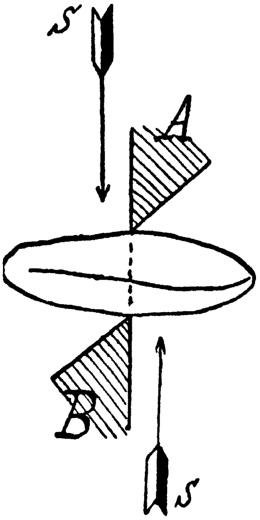

FIG. 135.

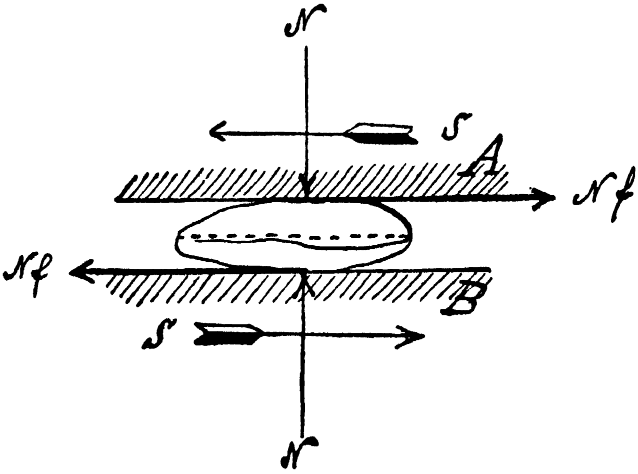

FIG. 136.

The third and last principle of reduction, the free impact, gives us machinery the working parts of which by striking impart a great kinetic energy $\frac{(mv^2)}{2}$ to the grain, which destroys it. In these machines the speed of motion of the working organs must be very great, for the mass of grain *m* is insignificant.

The aim of the machines of the first principle of treatment is to produce, by a consecutive series of cutting, particles (middlings) containing bran and free of it.

In the milling process to follow, we shall separate the branny middlings from the starchy semolina and then proceed to reduce it to flour.

If the machine is to fulfil its purpose successfully, the working surfaces, as mentioned before, must be sharp and rough. Hard natural and artificial stones, coarse-grained and porous, are a good material for surfaces of this kind; as well as metals which are easily shaped to the desired form of a surface with sharp cutting edges, and hardened to a necessary degree, and thus able to stand a lengthy period of work.

When the stock is broken down to semolina on machinery of the first type, we proceed to reduce it to flour. This is performed by machines working on the second principle of treatment. The power of friction plays a part in such machinery, the working surfaces with a large coefficient of friction may be fashioned of fine-grained natural stone, artificial stone (emery, porcelain, &c.), or dull cast iron.

For machinery working on the third principle, only metal is used, this being the most durable material.

II

THE CONSTRUCTION OF THE GRINDING MACHINES

As we have seen, the form of the working parts of the grinding machinery is defined either in the shape of chisels (Fig. 135), or that of a part of the surface (Fig. 136) with a large coefficient of friction in respect to the grain. If a mass of whole grain or particles is to be triturated unintermittently, the chisels are arranged one after the other, thus forming a surface covered by uniformly placed chisels. Consequently, speaking of the working organs in machinery of the first and second principles, we have the right to name those parts surfaces. The working organs of the machinery based on the third principle present separate elements adapted for striking, generally metal pins.

Applying the same considerations that guided us in our choice of the form of working organs for scouring machines, here we select two kinds of working surfaces, cylindrical and flat.

There being two working surfaces necessary for treating the product, a question arises concerning the degree of their activity. There are two possibilities: (1) one of the working surfaces is fixed, the other movable; (2) both are movable.

As regards the arrangement of the surfaces, there can also be two cases: (1) working surfaces having a common axis of rotation, and (2) surfaces with parallel axes of rotation.

The period spent by the grain between the working surfaces is of the greatest consequence, because the degree of uniformity of the triturated particles depends on it. In this respect the working surfaces are divided into two categories: (1) surfaces of reiterated action, and (2) surfaces acting once. In the first case we have mostly to do with planes between which the product is treated; in the second, with cylindric surfaces where the working organs come into contact along a line.

To the category of machines with reiterated action of the working surfaces pertain millstones, desintegrators, &c., *i.e.* machinery having a common axis of rotation; to the second, roller mills, *i.e.* machines with parallel axes of rotation of the working surfaces. This order is established by the historic consecutiveness in the development of flour-milling technics and by the degree of perfection of the two types of machinery. For this reason we shall study the machines in the order of their technical perfection.

III

MACHINES OF REITERATED ACTION OF THE WORKING SURFACES

Millstone Sets (*burrs*).—Before passing to millstones, it is necessary to prove that other working surfaces of reiterated action besides planes are inadaptable from the point of view of the principles we have stated, as well as constructively.

As the machinery of reiterated action of the working surfaces must have a common axis of rotation, the following combinations are possible here: (1) cylindric surfaces inscribed one in another, (2) similarly inscribed conic surfaces, and (3) parallel planes.

In all three cases the axis may be vertical or horizontal.

To begin with, the combination with a vertical axis of rotation must be discarded in the first two cases, for under such conditions the time spent by the stock between the working surfaces is shortened, because, influenced by its proper gravity, the stock passes between the two working surfaces more rapidly, and consequently requires surfaces of large dimensions, which makes the machine more expensive. Further, the combination of cylindric surfaces with a horizontal axis of rotation must also be rejected, because the wear of the working surfaces makes it impossible to keep them within the desired distance of each other, a consideration in regard to its construction which also applies to the preceding cases. Conic surfaces with horizontal or vertical axes of rotation, though affording the possibility of bringing them closer to each other in proportion to their wear, have different peripheral velocities of revolution, and consequently exclude equability in the treatment of the product and in the wear.

Thus only machinery with flat working surfaces, having either a horizontal or vertical axis of rotation, remains.

In machinery of this type the following combinations of rotation are possible: if the axis is vertical, (*a*) either the upper working surface revolves, while the bottom one is stationary, or vice versa, and (*b*) both the surfaces rotate in opposite directions. The same may be said of the horizontal axis—either one only or both the working surfaces may be rotating.

Coming to constructive descriptions and a critical consideration of the existing types of stone mills, it must be mentioned in the first place that the working organs of that machine, the grinding stones, are shaped of hard natural rock or artificial stones, as well as of metal (steel, cast iron). We shall give a detailed description of these materials later, and proceed now to describe stone mills with a vertical axis of rotation.

1. *Stone Mills—Horizontal* (*Vertical Axis of Rotation*)

Stone mills with a vertical axis of rotation are divided according to construction into three types, viz.:

(1) Stone mills with a rotating upper stone,

(2) Stone mills with a rotating bottom stone,

(3) Stone mills with both the upper and bottom stones rotating.

The simplest type of a burr mill having a rotating upper stone is shown in Fig. 137. The upper rotating stone B, the runner, is set on a vertical shaft i_1i by means of a cross-head g, the driving iron. The shaft i is called a spindle and is brought into rotation by a pulley F, or a gear drive. The lower part i of the spindle ends in a pivot-journal p resting on a step-bearing t^0, while its upper part i_1 is held in a vertical bearing k, the mill-bush, and is connected with the cross-head through an octagonal truncated pyramid h. Often for simplicity's sake the end of the spindle is shaped to a square section. The bottom stone C, the fixed bedstone, is set in a frame I. The vertical bearing k is set in a cup r cast in one piece with the frame I. To prevent the grain from falling through the aperture o–o of the bedstone c, this aperture is covered over by a plank *l–l*. The distance between the grinding surfaces *B* and *C* is adjusted by a cone and worm-drive in the following manner; the vertical axle *t* ending in a hub with a square hole, is set upon the square end t_1 of the axle *n* and rotates driven by hand-wheel *s*. The axle *w* which sets the worm wheel *x* into motion is turned by a cone-drive *u–r*. The screw *y* with a square thread ending in a plug *m* rises or falls, lifting or lowering the cup *z*, in which the step-bearing t^0 is set. The spindle, and with it the top stone *B*, is lifted or lowered together with the step-bearing.

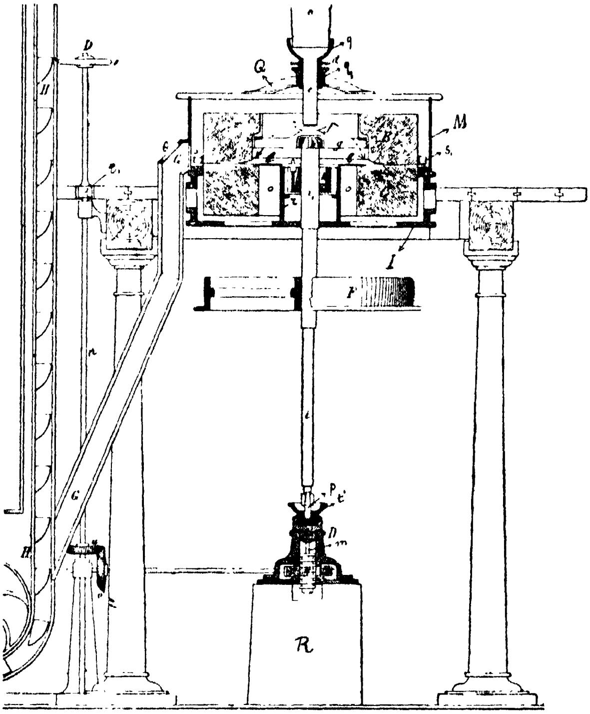

Fig. 137.

Out of the hopper *a*, the grain flows through nozzle *b* and tube *c* into the feeding tube *e* and falls on the table *f* which is fixed to the cross-head, and gyrating together with it, flings the grain into the grinding zone, as indicated by arrows. The feeding tube *e* is raised or lowered by levers *d*, which, with the cup *g* and the screw hub g_1 form one block, owing to which the flow of grain is regulated, for the cross section of the outflowing stream of grain diminishes or increases.

The millstones are enclosed in a timber cylindric casing *M* carrying on its upper lid a cross-head *Q* with a hub for the feeding tube *e*. The reduced product, collecting between the grinding stone and the casing, is shifted by scrapers s_1 to the outlet spout *G* and descends to the elevator *H* or directly into bags. At the head of the spout *G* there is an opening *θ*, usually covered with a lid, through which the product may be sampled.

The stone mill is mounted on a hursting supported by cast-iron columns or timber stands, while the frame of the step-bearing rests on a special foundation *R*. In mills the sets of grinding stones are often planted on the bottom of the second floor.

Fig. 138 shows a millstone plant of the portable type driven by a toothed gearing. The hand-wheel of the mechanism adjusting the distance between the grinding surfaces here is placed below, and the feed is regulated by a lever appliance raising or lowering the feed-tube. On the frame is set a simplified crane for lifting the grinding stones.

From the description of a characteristic design of a stone mill we gather that the fundamental parts of this machine are firstly its working organs, *i.e.* the grinding stones, and secondly, the auxiliary mechanisms setting the stones and regulating their work.

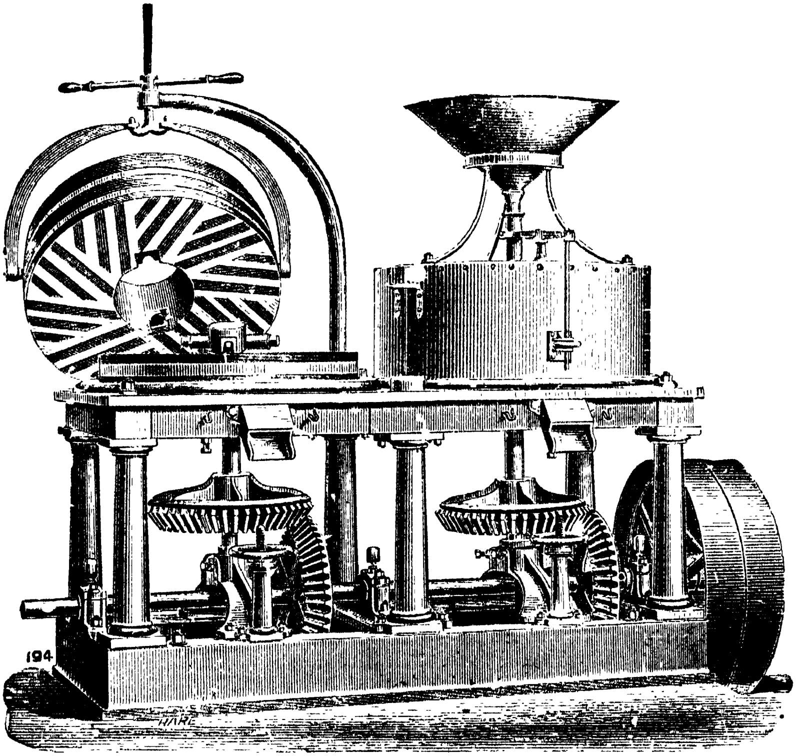

FIG. 138.

In the design examined one important detail is missing, the appliance for aspirating the machine. It is a known fact that a considerable amount of the work of friction is transformed to heat. Owing to this, the product treated between the stones becomes excessively heated, which is detrimental to the quality of the flour.

Fig. 139 represents G. Luther's construction of stone mills with dust-collectors. Between the cap of the casing and the top stone there is a dust-collector *A*, a fan-like circle covered with a dust-proof cloth

—linen, generally. The dust-collector is suspended to the cap of the casing of the same kind of cloth *B*. A trunk *C* communicating with the fan, is let into the dust-collecting chamber. The pulleys *b* and *a* drive the mechanism which shakes the dust-collector; this consists of a worm and cross-head gearing to the rod *t* which is connected with the dust-collector. The frame of the dust-collector being of a strong system, the part of the dust-collector opposite to the rod *t* receives the shocks of the shaking action and returns them by the spring *r*. The air streams in as indicated by arrows *s*, passes between the grinding stones, and is exhausted (s_1) through the dust-collector, carrying the dust with it. The air and grain passage is isolated from the casing chamber likewise by cloth sleeve or a timber spout.

Fig. 140 is a dust-collector for a stone mill from A. Wetzig's works, with a shaking appliance. We see here that, during the shaking motion, the aspirating tube *A* is closed by the valve *b* with a rod *a*, otherwise, if the apparatus were shaken while aspirated, the particles of dust would not be thrown off the dust-collector, because they would be pressed against it by the aspirated air.

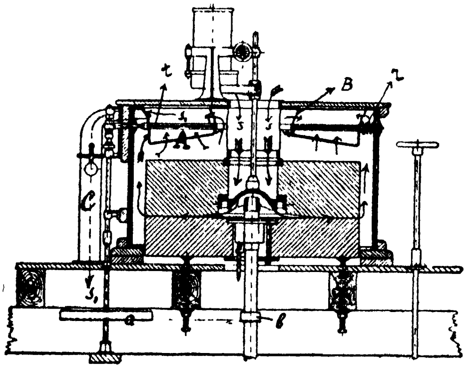

FIG. 139

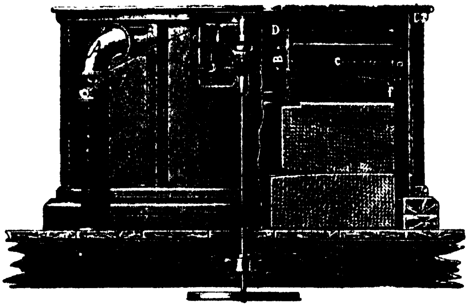

FIG. 140.

Having become acquainted with the type of the machine, we shall proceed now to the details of the stone mills.

2. *Composition and Design of Millstones*

Grinders of Natural Stone.—Before the technics produced any satisfactory results in the preparation of artificial stones, the grinders were shaped of solid rock, and the materials used were: (A) quartz stones, (B) porphyritic and granite, (C) sandstones, and (D) stones of volcanic origin.

When selecting the kind of stones their properties must be taken into account, in order to guarantee a high standard of work and impart a durability to the grinders. Therefore, the quality of the natural stones may be determined by the following properties :

(1) **The hardness** of the stone is the greatest guarantee of a lengthy period of service, and consequently, the hard kinds are to be preferred, if the other qualities of the stones are equal.

(2) **Tenacity.**—If the hard stones crumble very much when struck, they cannot be used as millstones. It is indispensable that the stone should be of a sufficient toughness, making all crumbling impossible.

(3) **Porousness.**—Stones apt to become polished must be avoided. This is possible if the stone is of porous structure. Those stones are to be considered best, which are granulous in structure, on which the porousness depends. In such a case, when the upper coat of the stone is worn off by work, it lays bare a fresh surface just as rough as the one rubbed off.

(4) **Uniformity of Structure.**—Uniform work is obtained only when the coating of stone worn off is supplanted by another of equal structure. For this reason the structural uniformity of the stone is of great importance.

(A) *Quartzose Stones.*—The best kind of quartzose stones, satisfactory in all the above-mentioned respects, are the French stones with a fame of 200 years standing, procured in the vicinity of La Ferté-sous-Jouare in the Department of the Seine. Geological investigations prove that this locality used to be a bay at some epoch, into which a large river flowed. The formation of a quartzose or silicious incrustation leads us to suppose the existence of many hot springs there at the time, spouting water rich with silicic acid or silica.

The real French stone from La Ferté is of a beautiful roseate hue.

Another bed of quartzose stones in France lies in Bergerac. But these stones are less porous. They are almost perfectly white.

In some parts of Hungary also there are beds of stones, closely approaching those of La Ferté in their qualities.

In Russia quartzose stones of a fair quality are to be found close to station Suleya of the Samara-Zlatoust railroad, gov. of Uffa, stone quarry of N. Lazareff. Possessing the fine toughness, porousness, and uniformity of the French stones, they are considerably inferior to them in hardness.

(B) *Porphyry and Granite Stones.*—These very hard stones are generally not porous, and become rapidly polished from work. The best kinds of porphyry and granite for making grindstones are obtained in Germany near Cravincler, and in Austria close to Perg on the Danube.

(C) *Sandstones.*—Grinders of sandstone strata are used almost exclusively on simple farm mills. Sandstones consist of fine quartz crystals, and consequently reduce the integument of the grain very much. In addition, being of an insufficient toughness, these stones easily crumble, leaving small particles of quartzose crystals in the meal.

The sandstone quarries lying in the valley of the Oka near Moscow, and in the Dnieper valley by Poutivl, are considered to be the best in Russia.

(D) *Stones of Volcanic Origin.*—In respect to their quality the stones of volcanic origin closely approach the French quartzose stones. Before the discovery of the La Ferté stones, they were the best.

The best known localities are the volcanic stone quarries along the Rhine in Germany (Andernach). The quarries yield hardened lava of basalt (the stones are called Lavastein), very hard, tough, and porous, grey in colour.

In some parts of Hungary (Bars Geletnek) trachyte stones are obtained of a high quality, and in Italy the lava from Mount Etna gives good grey basalt stones.

Grinders of Artificial Stone.—The difficulty of procuring good natural stones, their comparative expensiveness and variety in structure, compelled manufacturers as far back as thirty years ago to begin making artificial grinding stones. It is comparatively but quite lately, that the attempts have been crowned with success, but now the miller is in possession of more or less perfect artificial stones for milling purposes.

The problem of producing artificial grinders may be regarded as solved when a hard rock reduced to particles is so firmly cemented together, as to form a stone possessing all the qualities of natural stones.

The principal materials used in making artificial stones are quartz, silex, emery, corundum, carborundum, and electrite, very hard rocks. The cementing materials employed are: magnesite (MgO—oxide of magnesium), magnesium chloride ($MgCl_2$), field or river spar, glass solution, muriatic, and several other acids.

In accordance with the purpose of the grinder, the hard stone is broken to small pieces beginning with the size of a wheat berry and ending in particles of the size of coarse sand. Generally there are five kinds of gravel prepared, viz. No. 1, the largest, used for grinding oats (seldom used) and No. 5, the finest, used for grinding stones in millet-scouring machines. Grinders for milling rye and wheat are prepared of the intermediate Nos. (2, 3, 4) of gravel.

The gravel used is either of one kind of stone, or a mixture of two kinds, of equal hardness. The approximate composition of artificial stone is as follows:

Hard stone (quartz, emery, &c.)	70 per cent.
Magnesite (MgO)	16 ,,
Solution of magnesium chloride	14 ,,
Total	100

The magnesite must be perfectly pure, unmixed with any other salts or oxides. The magnesium chloride is taken in water solution 35° to 37° strong according to Bomet's areometer.

At the present time in Russia there are a good many works in which artificial millstones are made by hand, and the composition of the stones, or of the surfaces in emery scourers, is determined according to various recipes. But there are few well-equipped works. The best are in Petrograd, *e.g.* the works of N. Strook; in Samara, "The First Grindstone Works";[1] and in Riga, "The Economical Trading Co."

The best artificial millstone factories import quartzose stone in pieces from France (La Ferté-sous-Jouare) which contains the highest percentage of oxide of silicium (SiO_2); silex having the least percentage of chalk ($CaCo_3$) from Denmark; emery, with the highest percentage of corund (Al_2O_3) from Naxos. The gravel is prepared by the makers on special stone-crushing machinery. The hand-workers generally get ready-made gravel chiefly from French or German works.

Metal Millstones.—The attempts to substitute metal grinders for stone ones date from equally remote times. Much has been done in that respect by the Americans, who have obtained good results in the end.

In Russia machines with metal grinding stones are not widely used, whereas in America they are very much in use for grinding maize, barley, oats, &c., to a meal.

The material employed for making metal grinders is hardened cast iron and hard steel. The impossibility of renewing the working surface once it is worn off, is a great disadvantage. This defect, however, is obviated now, by making the grinding surface removable and thin. Thus the worn grinding disc is thrown away and is replaced by a new one, which incurs no great expense.

The Construction of Stone Grinders.—The normal construction of grinders for upper runner mills was evolved by French works and almost universally accepted. The outline of the working surfaces of the upper and lower stones constitutes an essential part in their construction.

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[1] See *Russian Miller*, 1912, No. 1

Fig. 141 gives us a rough sketch of the upper and the lower stones. We see in this sketch that the grinding surfaces of both the stones are not flat. The opening *A* in the upper runner is named the eye; the zone *B* between points 1 and 2 is called the heart; *C*, between 2 and 3, the intermediate zone; *D*, from 3 to 4, the reducing zone; *E*, 4 to 5, the grinding zone. In this way, the surface of the stone between points 1 and 4 is curved, while its grinding part proper, between points 4 and 5, is a plane.

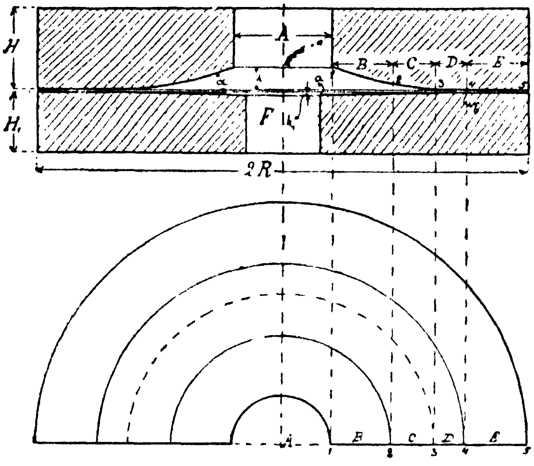


FIG. 141.

The loophole *F* in the bed stone serves for passing the spindle through it and setting the vertical step-bearing. The surface of the bottom stone from the point *b*, corresponding to point 4 of the runner, is chiselled to the shape of a cone up to point *a*.

The outline of the working surfaces given here was developed by French works and accepted almost everywhere. In Russia, the name "grinding zone" or "slide" is applied to *D* and *E*, while the intermediate region *C* is called the region of full contact. The surface *B* and *C* is named in Russia the "swallow." The dimensions characterising the millstones of the examined normal type, are given in the following table, where h denominates the depth of the swallow in the top stone, and h_1 in the bed stone.

TABLE XVI

Diameter of Stone. 2 *R*.	Top Stone.					Bed Stone.	
	H.	*h*.	*A*.	*B*+*C*.	*D*+*E*.	H_1.	h_1.
mt. 1–1·6	cm. 30–50	mm. 2–3½	cm. 25–40	cm. 20–30	cm. 15–25	cm. 15–25	mm. 1–1½

In Russia the stones are usually measured in quarters of an arshin, and according to the number of quarters in the diameter are called "quartuple," "quintuple," &c. The largest sized Russian stone is the "octuple," 56-inch diameter.

The working surfaces of the upper and the lower stones form a common swallow *a* which catches the grain, crushes it, pushes it to point 3, and grinds it to meal on its way from 3 to 4.

The general view of the working surfaces of the grinders is shown in Fig. 142. *A* is the bed stone, and *B* is the upper rotating stone

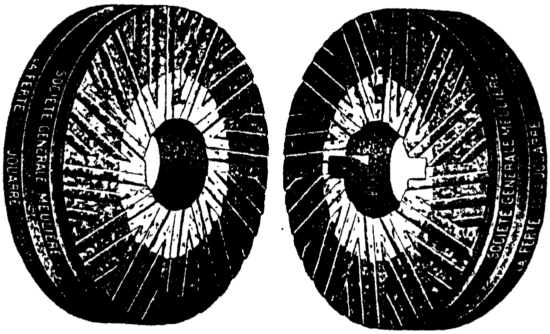


Fig. 142.

For the sake of durability the stones are encircled with hoops (generally two) set on when hot. This is particularly important for the runner, which develops a great centrifugal force, while revolving, and may be torn to pieces if the stone is too friable. *a* and *b*, parts of the swallow, are made of firm concrete. The circles *A* and *B* (part of *C*, *D*, and *E*), the working parts, are of natural or artificial rock.

On the upper, as well as on the lower stone, there are furrows, which if one stone is laid upon the other, cross each other at an angle. The purpose of these furrows is the following: firstly, the sharp edges of the furrows are supposed to cut the grain; secondly, by means of these furrows the working space is ventilated. As concerns the first supposition, it cannot be regarded as correct, for the cutting action is performed by the crystals of the stone itself. The edge of the furrow then, is so rudely outlined, owing to the porousness of the stone, that there can be no idea of cutting, not to mention the fact that the cutting angles of the edges are too large, which is noticeable in the various forms of cross-section of the furrows (Fig. 143).

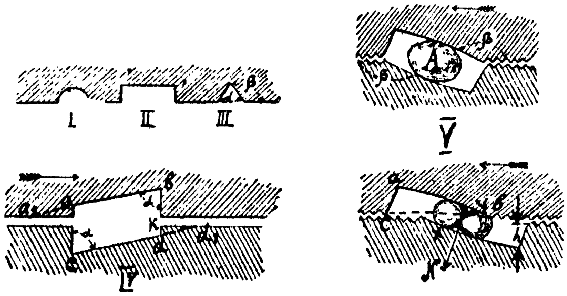


Fig. 143.

Of these forms of furrows the one marked *V* is the most preferable, because the product broken into large pieces is more easily picked out of the cavity of the under furrow by the edge of the top one, and may then be subjected to a further reduction. It is followed by shape *IV*, which may be had in two variations, viz. with the angle *k* and without it, when the bottom of the furrow *cd* is continued to the surface of the millstone, *i.e.* has the plane of cd_1 and a_1b. But this furrow is worse than the *Vth* one, for there will be more product collected in the angle *c* and the difficulty of driving it out will increase.

The bottom *ab* of the furrow *V* lies on a curved plane, but is usually made flat. The difference between the *Vth* form and the second variation (bottom cd_1) of the *IVth* one lies in the fact that the angle *c* in the *IVth* form is acute, while the corresponding angle *a* of variation *V* is obtuse.

The dimensions of the cross section of these furrows are the following: depth $h = 9$ to 13 mm.; breadth $cb = 30$ to 35 mm.

It is evident from the second position of the furrows in variation *V*, that the grain or a particle of it, *A*, is chipped in the plane *xy*, when the planes of the furrows approach each other during the rotation of one of the stones, and the chipping forces are *Nf*, where *f* is the coefficient of friction.

As to the furrows formed, as shown in *I*, *II*, and *III*, they are scarcely ever used in practice, being disadvantageous in all respects.

To arrive at a clear understanding of the significance of differently outlined forms of the furrows, it is necessary to become acquainted with the theory of their functions.

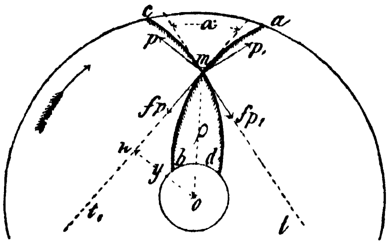


Fig. 144.

It is supposed that the furrows act upon the product under treatment, as a cutting organ and scraper which propel the grist to its exit.

Let us examine the propelling action of the furrows, taking for granted that we have the most common outline of furrows, *i.e.* curved. *ab* (Fig. 144) is a furrow of the upper rotating stone, *cd* that of the lower one. Between them at the point *m* there is a particle of product. Through *m* to the furrows are drawn tangents *t* and t_1, which form an angle *a*, called the angle of inclination of the furrows. The pressure upon the product in the furrows *cd* and *ab* we denominate through p and p_1; *f* is the coefficient of friction. The propelling of the product along *ab* to its exit is possible if the sum of the projections of all forces acting upon *m* on the tangent t_1 exceeds zero, *i.e.*:

$$p_1 \sin a - fp_1 \cos a - fp > 0.$$

There being no movement of the product in the direction perpendicular to *t*, the total of the projections of all forces acting in this direction must be equal to zero:

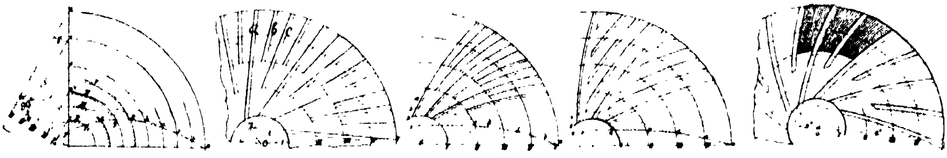
$$p-p_1 \cos a-fp_1 \sin a=0.$$

By placing the signification of $p=p_1 \cos a+fp_1 \sin a$ in the preceding inequality and performing the corresponding alterations, we obtain :

$$\text{Sin } a\,(1-f_2)>2f\cos a, \text{ or } tg\ a>\frac{2f}{1-f^2}, \text{ or } a>2\varphi$$

because $f=tg\ \varphi$. Thus, for the particle *m* to travel along *ab*, it is necessary that *the angle of inclination of the furrows should be greater than the double angle of friction.* And to keep the propelling forces even, the furrows must be necessarily kept at an even angle of inclination.

The Outline of the Furrows.—In Fig. 142 representing French millstones, we have seen the most common and widespread form of outline of the furrows. But besides this outline, there exist several others. The most important ones are shown on Fig. 145.



I II III IV V

FIG. 145.

Here the furrows marked *III* are built in a logarithmic curve, *II* are rectilinear furrows (the main *a*, and the intermediate *b* and *c* have one and the same degree of eccentricity 07, the size of which is equal to one-sixth to one-third of the radius of the millstone), *IV* are Evans' furrows, and *V*, lastly, the novel circular furrows.

The outline of the rectilinear furrows of both types is very simple. That of the furrows drawn in curves is more complicated.

The different outlines of the curved furrows are supported by the theory of the movement of the product mentioned above. From the point of view of this theory, the logarithmic curve furrows are ideal, their angle of inclination being constant. We, however, absolutely protest against this theory, holding it to be wrong at its very root.

First of all, we know that the character of the working surfaces of the grinders is such that the force of friction, as we have seen (p. 154, Fig. 136), must of necessity have a chipping action. Consequently, whatever be the direction of the furrows, the product must not travel under the impulse of the forces considered above, otherwise the stock will not be ground at the intersectional points of these furrows. If, on the other hand, the stock is so fine that the furrows, being rude chisels, are unable to triturate it, it will travel in the furrow because of the effect of the draught of air.

In this way, the furrows perform the duty of ventilating canals on the one hand, and serve as spouts for the delivery of the grist out of the working space, on the other. The furrows in the fixed bed-stone act the part of the ventilating canals and exit passages for the product. The upper stone furrows serve only as ventilating canals for the reduced stock, and ventilate the under working surface of the stone in its whole area. Naturally the large stock caught in between the edges of the furrows is crushed; that is the second purpose of the furrows.

From the point of view of ventilating the working area of the stones, the furrows ought never to be made curved, because this lengthens the path of the passage of air. From this point of view straight radial furrows would be most desirable. But such furrows would form no angle of intersection, and the coincidence of the upper and lower furrows would generate a series of whirls in their common canal, for the motion of the air in the furrow of the rotating stone is the more rapid, owing to the centrifugal power.

Yet another significance is attached to the furrows. It is supposed that the grinder intersected by furrows acts as a fan. However, this opinion we also consider to be erroneous, for the chamber out of which the air passes into the working space through the eye of the grinder and the space into which the air passes out of the furrows, are one. It is the chamber of the casing. And if the set is aspirated by an exhaust and the eye is isolated from the chamber of the casing (Fig. 139), the motion in the air is brought about by the action of the fan; the ventilating effect of the stone is almost equal to zero in comparison to the airing performed by the fan.

We shall direct our attention to rectilinear furrows as being the most efficient, but seeing that in general practice curved furrows have to be dealt with, the practical means of drawing them must be explained.

The furrows shaped in a logarithmic curve are made in a simplified manner as follows (Fig. 145, *I*): at the end of the radius is built an angle $\frac{a}{2}$, equal to one-half the angle of inclination of the furrows, the quotient of which is to be found. From *O*, the centre of the grinding stone, a perpendicular is dropped on the line $5V$. The line OV is divided into an equal number of parts, five in the present case, and through points *I*, *II*, *III*, and *IV* lines parallel to $5V$ are drawn. Then from the centre *O* circles are described with the radius *OI*, *OII*, &c., and 01, 02, 03, &c. Through point *a* a tangent is drawn to the circle *OV*, which crosses the intermediate circle at the point *b*; from *b* a tangent is drawn to the circle *OIV*, which gives us the point *i*. The points *c*, *h*, *d*, &c., are found in the same manner.

Joining those points by an even curve, we obtain an approximate construction of the logarithmic curve of the furrow.

Evans' furrows are built in this way (Fig. 145, *IV*). A circle 1 is drawn with the radius of one-third R (R=radius of the stone), and circle 4, one-fourth R in radius. The space between circles 1 and 4 is divided into an equal number of parts (three in the drawing); in a like manner the space between the circle of the eye *I* and that of the stone *V* is divided, but with one more part than the preceding. A tangent is then drawn from point *V* to the circle 4 and the point *a* obtained; from *a* a tangent drawn to 3 forms point β, &c. The points thus obtained are joined and form δV, the curve of Evans' furrow.

The novel circular furrows, the most popular kind, have the simplest outlines (Fig. 145, *V*). From the centre of the millstone *O* a radius equal to 3 inches is projected. Then a radius equal to $2R+3$ inches is taken, and the circles described by it are the lines of the furrows.

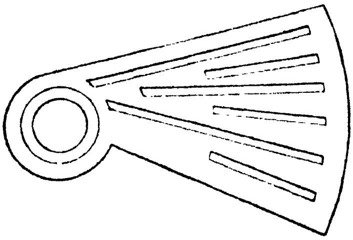


FIG. 146.

The practical way in furrowing the stone is to do it by means of a timber or iron-plate template (Fig. 146), which is prepared according to the chosen type of furrows. In forging on the furrows intersections in them ought to be avoided, for the angles of intersection may stop the delivery of the product.

Tools for Dressing Millstones.—The grinding surface, having become polished from work, ceases to give satisfactory results and requires dressing, which the miller himself usually performs by hand. For this purpose the furrow hammer and hoes or picks of different kinds are used.

The tools employed for renovating the worn furrows are the furrow picks with a broad edge of the best hardened steel. In Fig. 147 two kinds of these picks are shown: with eyes for wooden handles, and solid. For solid picks wooden handles *a* or handles with a metal head *b* are used. There are many various patented hammer holders, but these handles too, work quite satisfactorily. The picks are made in sizes up to 250 mm. along their edges and 50 mm. in breadth.

A pick is a hammer with the striking part grooved to a series of pyramids, and is used for roughening the polished surface of the millstone. The number of pyramids to a square centimetre amounts sometimes to fifteen. The area of the striking part reaches 8 × 8 cm., the length of the hammer 15 cm. The striking part of the flat hammer, as well as the edges of the furrow hammers, are made of the best hardened steel.

Millstones without Furrows.—The defects of the grooved millstones lie in their tearing the integuments with their edges, and grinding them too finely. The sifting away of the bran reduced to flour becomes impossible, owing to which the meal acquires a dark colouring. A preliminary crushing of the grain in the heart has the same effect. Besides that, the grain being but slowly delivered by the heart, a considerable part of the working surface is left without stock, and therefore the capacity of the millstones in spite of their large working area is insignificant in comparison with roller-mills. With a view to avoiding these defects an engineer, I. Noll,[1] proposes to abolish the furrows and the heart and diminish the working area. Instead of a heart (Fig. 148) I. Noll sets on the spindle a disc of zinc sheet-iron *a*, 1040 mm. in diameter (the diameter of the millstones is 1300 mm.). This disc by gyrating and developing a centrifugal force in the grain feeds it into the grinding circle, the breadth of which is 70 to 100 mm. I. Noll maintains that

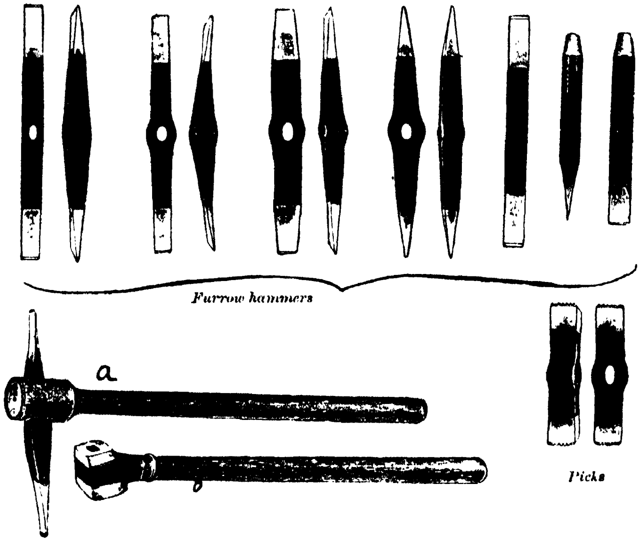


FIG. 147.

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[1] *Die Mühle,* 1911, No. 40.

the capacity of such a stone is considerably higher than that of a common grinder.

The disc a is set on a cast-iron washer b. The part e of the millstone is of concrete, and f of plaster-stone. Such a construction diminishes the weight of the stone and simplifies its dressing.

The idea of such grinders deserves careful attention. Too small a number of experiments, however, has been performed, to allow us sufficient grounds completely to reject the old construction of millstones.

The Erection of Millstones.—A correct fitting up of the millstones and the balancing of their motion is of great importance.

The fixing up and balancing of the stationary stone is very easy. Only a spirit-level is required here for establishing the working surface in a horizontal plane and a plumb-bob for centring it. The setting of the rotating stone is much more difficult.

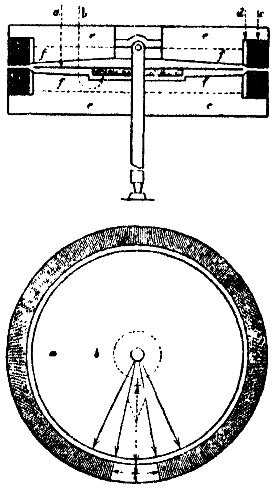

FIG. 148.

If we set the lower working surface of the runner in a horizontal plane while at rest, this surface may assume a slanting position when rotating, should the structure of the stone not be uniform, as frequently happens. This phenomenon is easily explained. Supposing we have (Fig. 149) a wire cylinder k k_1 k_2 k_3 set on a spindle A with the aid of a movable connection c. At points k_1 k_2 there are equal weights attached

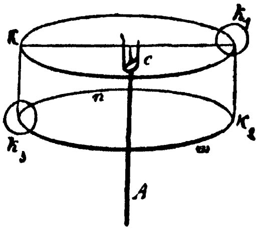

FIG. 149.

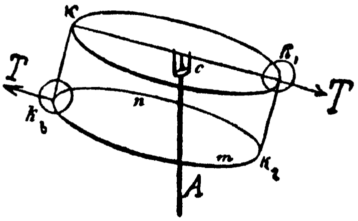

FIG. 150.

In a state of repose the cylinder will be balanced, *i.e.* its axis will coincide with the axis of the spindle. But as soon as we commence revolving it, the cylinder will slant (Fig. 150), because the centrifugal forces T at points k_1 and k_3 form a couple of forces the shoulder of which is equal in size to k_1 k_2.

The axis of rotation of the couple T k_1 k_2 will be in the fulcrum point of support c of the spindle. To obviate slanting similar weight must be attached at the points k and k_2.

It is necessary to find a general solution of the problem, which would show how the supplementary weights are to be disposed in the grinder, so as to attain an equiponderate motion. Let us suppose we have an immobile axis OO_1 (Fig. 151), and a stone A of irregular shape rotating on it. The centrifugal power developed exercises a pressure upon the axis. If we mark the reaction of the axis by forces P_1 and P_2, applied in the fulcrum of the axis O and O_1, then, including those forces in the number of active forces, we may regard the whole system as free, and apply to it D'Alambert's principle. The motion of the stone being a steady rotation, the sum total of projections and the sum total of moments in respect to the three reciprocally perpendicular axes OZ, OX, OY must be equal to zero. By denoting the angular velocity of rotation through ω, through m the mass of any particular part of the stone, x, y, z its co-ordinates in respect to the corresponding axes, P the weight of the whole stone, a and b the distance of the centre of gravity of the stone from the planes yoz and xoz, M its mass, and h the quality OO_1, we obtain the following equations :

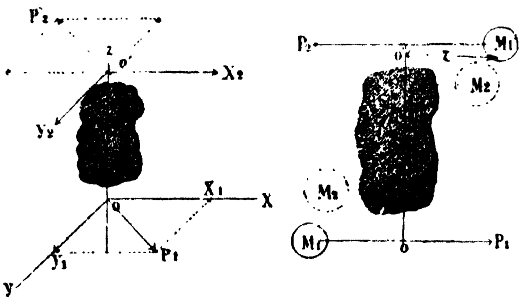

FIG. 151.

The sum total of projections:

$$M\omega^2 a+X_1+X_2=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$
$$M\omega^2 b+Y_1+Y_2=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$
$$P-Z=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The sum total of moments :

$$Pb-\omega^2\Sigma myz-Y_2h=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$
$$-Pa+\omega^2\Sigma mxz+X_2h=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The moments of each acting force in respect to the axis OZ are equal to zero, for the direction of those forces intersects the axis OZ.

If the axis of rotation passes through the centre of gravity, a and b are equal to zero ; the forces X_1, X_2, Y_1 and Y_2 then are equal to zero. If, at the same time, OZ is the main axis of inertia, then $\Sigma myz=0$ and $\Sigma mxz=0$. Under such conditions the axis of rotation of the stone will be exposed to no side pressures, *i.e.* we obtain a free axis.

As regards the millstone the first condition is fulfilled when the axis of the spindle coincides with the axis of the stone, *i.e.* passes through its centre of gravity. Should the grinder, however, be of different density Σmyz and Σmxz will differ from zero. The millstone will then slant like the wire cylinder. In that case supplementary weights must be added.

If a and b are equal to zero, we shall obtain from equations (1) and (2) :

$$X_1 = -X_2, \text{ and } Y_1 = -Y_2.$$

The resultants of X_1 and Y_1, X_2 and Y_2 will be P_1 and P_2. A couple of forces are thus obtained, which tend to overthrow the axis of the stone. For counteracting this couple of forces (Fig. 151) there might be applied weights M_1 and M_2 of a size which would produce centrifugal forces $\omega^2 M_1 r$, equal to P_1 and P_2.

In general practice the supplementary weights are applied by means of a special adjustment in the revolving grinder.

Three or four cavities are made in the stone, in which cast-iron boxes (Fig. 152) A covered with a lid B are deposited. In such a box there is a cast-iron weight p, which is adjustable along the rod a to the right or left and up or down with the aid of screws b and nuts c. By moving the weight p to the periphery of the millstone we augment its centrifugal force, while by moving one weight up, and the other, on the opposite side of the stone, down, we lengthen the shoulder of the counterbalancing couple.

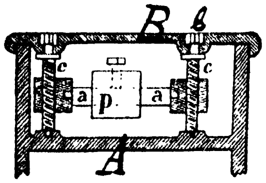

FIG. 152.

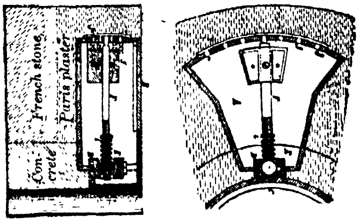

FIG. 153.

Another appliance is shown in Fig. 153. The weight H here slides along the rod F with a collar t, which rests on a spring E and is fixed to the rod by a bolt. The rod passes through a cast-iron ball which is held by a bearing D. In the opposite side of the box there are openings J. By placing the end of the rod in different sockets, the height of the weight may be altered.

Simpler appliances consist of boxes with lead in them, the quantity of which may be either increased or diminished. Sometimes there simply are cavities made in the stone and filled with melted lead. If too much lead is poured in, part of it is cut out; if too little, more is added

On Fig. 154, showing the building of a millstone of pieces of French stone, we see the cast-iron boxes *E* for lead, which are hermetically set in when the top part of the stone is covered with concrete.

When the stone (runner) is ready, it is balanced in the following way (Fig. 155). An apparatus consisting of three plates *ef*, *cd*, and *ab*, and two bolts, *g* and *h*, is set in the eye of the stone. The plate *cd* slides freely on the bolts and is kept back by nuts *k*. By the upper nuts, the apparatus is screwed up in the eye. Then the stone is placed on a hursting, in which an iron rod *m* is set upright, tapering to its point *n*. The rod passes through the opening *O* in the plate *ab* and rests with its point *n* in the small cavity made with a centre-mark in the plate *cd*. This plate must be set so that its centre (the cavity for *n*) would correspond to the fulcrum of the driving iron. The rod *mn* rests with its lower end on a lever which lifts it together with the stone. The stone raised by

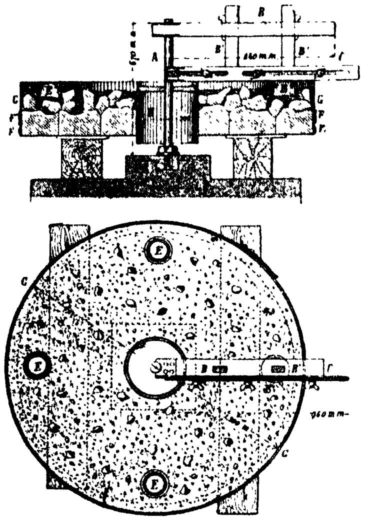

Fig. 154.

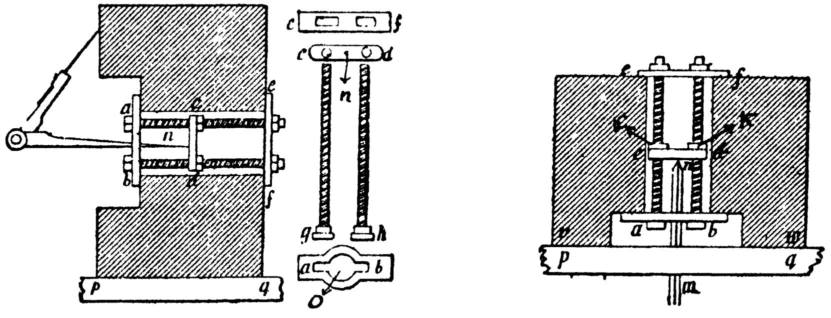

Fig. 155.

the rod is carefully revolved and watched, to see if it slants. In case of a slant, the position of the apparatus is altered in the direction required and the weights in the boxes are transposed, the stone having been previously lowered on to the hursting, and the upper screws loosened.

These manipulations are repeated until the stone rotates without a slant. Once the right centre of the driving iron is found, the stone is lifted off the rod *mn*, placed on its side, and a circle is drawn with a pair of compasses from the centre *n* of the plate *cd* on the grinding surface of the stone. On this circle in two or three places holes are drilled, 3 to 4 mm. in diameter and 7 to 8 mm. deep, filled with melted lead, which is smoothed to the face of the stone and then the circle on them is redrawn. These lead dots serve for proving the centre of the cross-head in marking the spot for it.

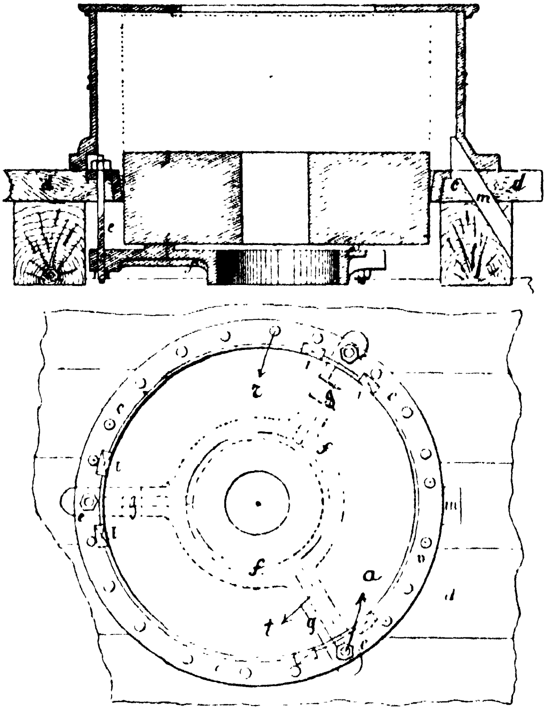

FIG. 156.

Fixing the bed-stone.—In fixing up a stone mill either on the floor of the mill or on a hursting prepared for it, a circular hole is made in the boards *d* (Fig. 156), and a cast-iron ring *c* is placed in it with a flange in which holes *r* are drilled for the bolts, by means of which the circle is fixed to the hursting. Besides those small holes there are three larger ones for bolts *e*, which support the cast-iron frame *f* with ribs *g* on its lugs *t*. By tightening the bolts *e* the working surface of the stone may be brought to a horizontal position. For adjusting the axis of the stone, there are wedges *i* (six in number) placed in between the grinder and the ring *c*. If the stone is to be moved to the left, for instance, the two wedges on the left side are loosened, while the other four are driven in deeper with lead hammers.

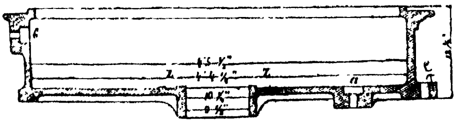

FIG. 157.

A better frame is shown in Fig. 157. It is a cast-iron cylinder with a perforation in the bottom for the spindle. The frame is fixed to the floor with bolts, which are screwed into the lugs *c*. At three points of the bottom there are ribs *a* with holes for the bolts, by means of which the working surface of the stone is set in a horizontal plane. In the sides of the cylinder are three holes for bolts, which help to centre the stone. To make the construction lighter, the solid bottom of the cylinder may be substituted by three lugs. A still lighter design is represented on Fig. 156. There are simply three castings *A* made with regulating bolts. These lugs are set independently on the floor in a circle at an angle of 180°.

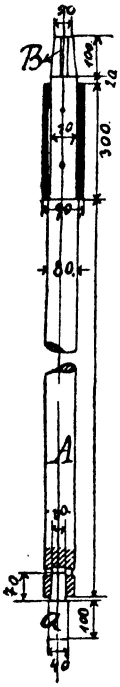

FIG. 158.

For the plainest kinds of machinery in peasant mills, a simple planting on beams may be recommended. The adjusting bolts may be let through the beams into which threaded nuts are set.

The dimensions in all the figures are given in mm.

The spindle supporting the runner is an iron or steel shaft *A* (Fig. 158) with a vertical journal *a* set in its base. The top part of the shaft *B* is turned to a cone or planed smooth to a truncated pyramid. In the first case it is coupled with the cross-head of the driving iron by means either of a wedge or a key.

The mill-bush (Figs. 159 and 160), stationed in the eye of the bed-stone, and arresting the side-movement of the shaft, has timber (oaken, beech-tree, or pock-wood) or bronze wedge-shaped bushes *a*. In it the centring of the shaft is done with the aid of bolts *c* and nuts *b*. This mill-bush is attached to the stone by means of lugs *d*,

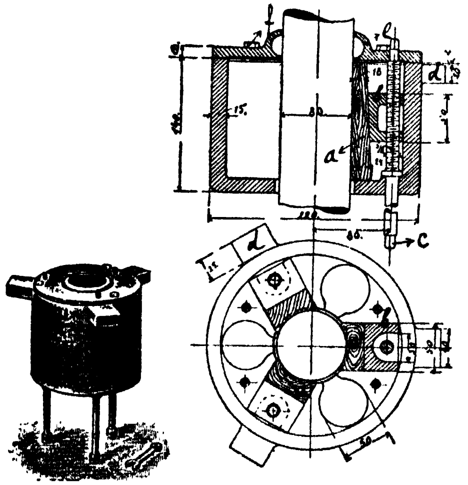

FIG. 159.

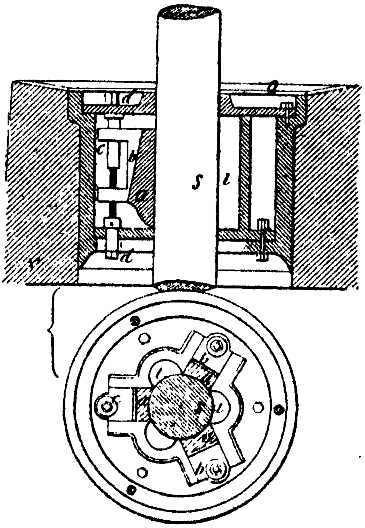

FIG. 160.

which are covered with a cementing composition in their respective seats in the stone. The lubricant is poured into the cup *e*.

There are mill-bushes of various design but always with bushes. Sometimes those mill-bushes are set on the frame.

A **step-bearing** of the ordinary kind is shown in Fig. 161. *A* is the lower end of the shaft, into which is set a journal *B*, resting on a steel bush *c*. The side-bush *d* is of bronze. The oil is poured into *s*, and after passing through the bearing is drained through drilled canals *f*. The hole *g* in the end of the shaft is to afford access to the journal *B*, which is knocked out with a wedge-shaped plug in case a breaking off must be made. The liner *E* of the step-bearing, cylindric in shape, is generally of cast iron. The frame of the step-bearing is shown in Fig. 162. The spindle is lifted by a lever *D*. The bearing *F* supports the shaft of the toothed gearing to the spindle.

The design of the step-bearings varies very much, but the ball collar thrust-bearings are to be preferred most.

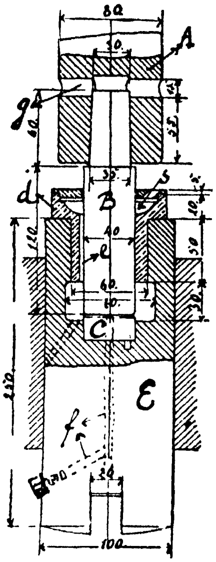

FIG. 161.

The driving iron.—By means of the driving iron the spindle is connected with the rotating stone. The plainest style of a driving iron (Fig. 163) is an iron cross-head which is hermetically set in the grinder, or a tripod driving iron (Fig. 164), also tightly fitted in the stone. But these designs should be avoided, for the proper balancing of a fast coupled runner in motion is an impossibility. A type of driving iron in vogue is shown in Figs. 165 and 166. In the stone there are set two cast-iron cups *N*, on which the journals *e* of the cross-head *b* rest. This cross-head likewise has sockets for journals *e* of a second cross-head *c*. The spindle is set with its conic end in the cross-head *c*, and fastened to it

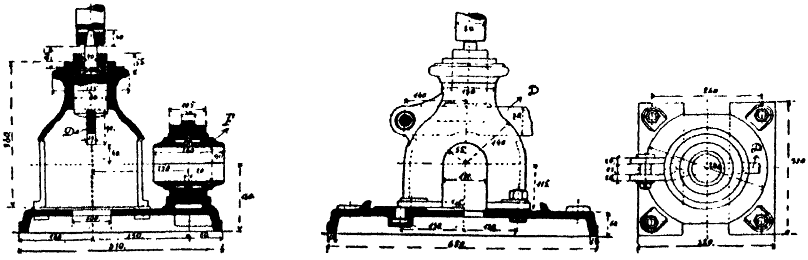

FIG. 162.

with one or two keys. This forms a flexible fastening on the principle of Hooke's joint.

Instead of cups *a* it is better to set (Fig. 167) a cylindric cast-iron ring *B* with ribs *P* for the journals of the cross-head. In that case the load chipping the stone is distributed over a larger area. The second cross-head *D* here, is coupled to the spindle by wedges *i*, though keys *t* may also be employed.

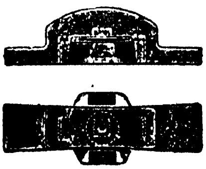
Fig 163.

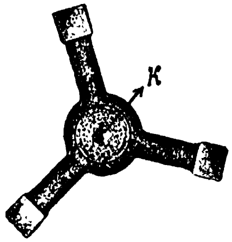

Fig. 164.

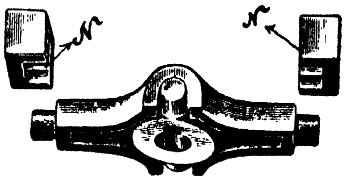

Fig. 165.

To prevent any curling up of the ring, it is provided with protruding ribs which are sunk into sockets hollowed out in the stone for that purpose, and fixed there with cement when the ring is laid on.

In the upper cross-head of the driving iron there is usually made a hole *K* for setting the plate *e* (Fig. 167) which receives and flings the grain by centrifugal force into the eye of the millstone. Sometimes a cup (Fig. 168) is set in the place of a flat plate. The advantages supposed to be afforded by this cup are that the heavy extraneous matter (stones, small pieces of iron, &c.) drop to its bottom and do not reach the milling area. This is, however, an unnecessary complication of the design, because previous to being milled, the grain has to be freed of all impurities. And if unclean grain is milled (as in primitive

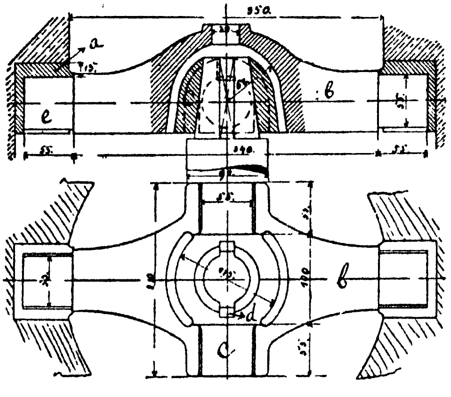

Fig. 166.

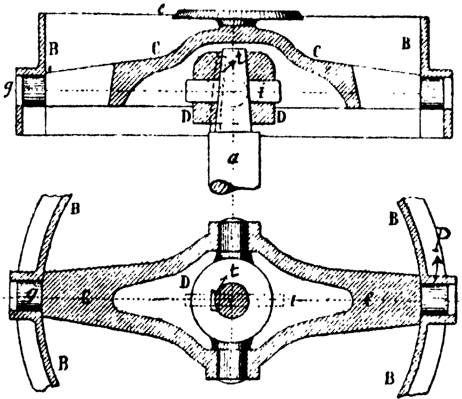

Fig. 167.

peasant mills), this cup is too small to serve as a heavy impurities collector.

The feeding of the millstones is done through feeding tubes or other more complicated mechanisms. Fig. 169 represents an iron feeding tube *B* with a hopper B_1. With a view to regulating the feed, the distance between the end of the tube and the plate is measured by means of a cast-iron sleeve *b* having a square thread, firmly joined to the tube, and a hand-wheel *T*, with an inversely threaded hub, which is held by the collars of the cast-iron cross-head *M*. By rotating the hand-wheel, the tube may be raised or lowered, thus regulating the diameter of the stream of product between the tube and the plate.

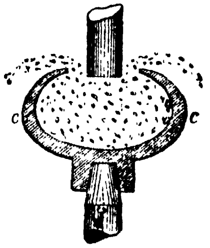

FIG. 168.

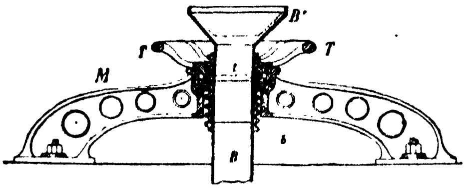

FIG. 169.

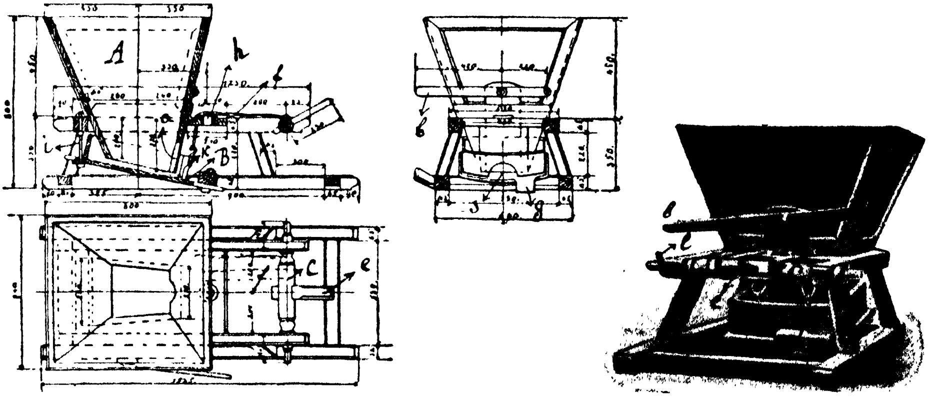

FIG. 170.

The ordinary feeding device employing a rocking shoe is shown in Fig. 170. The hopper *A* is set on a small timber frame which stands on the cover of the casting. Under the hopper, on three or four rods (bolts *i* and two rods *k*) the shoe *B* is suspended aslant. To the protruding plank of the shoe *g* is attached a square block *d*, which receives the blows from a cross-head set on an axle, which in its turn is set in a plate. In the cross bar of the frame, *h* serves as an upper bearing to the axle. A slide *a*, lowered or lifted with the aid of a hand-wheel *b*, regulates the flow of product. The inclination of the shoe is adjustable by means of belts *f*, which may be wound on and off the axle *c* by turning it with the hand-wheel *e* and keying on with wedges *l*.

Another feeding appliance we see in Fig. 171. Here we have a cast-iron trunk *A* mounted on the cover of the casing by its wall-brackets. The spout *T* is cast jointly with the trunk. Through the bottom of the trunk is let an axle *v* connected by sleeve *m* with an axle v_1 running from the driving iron. The sprocket *b* feeding the grain into the spout *T*,

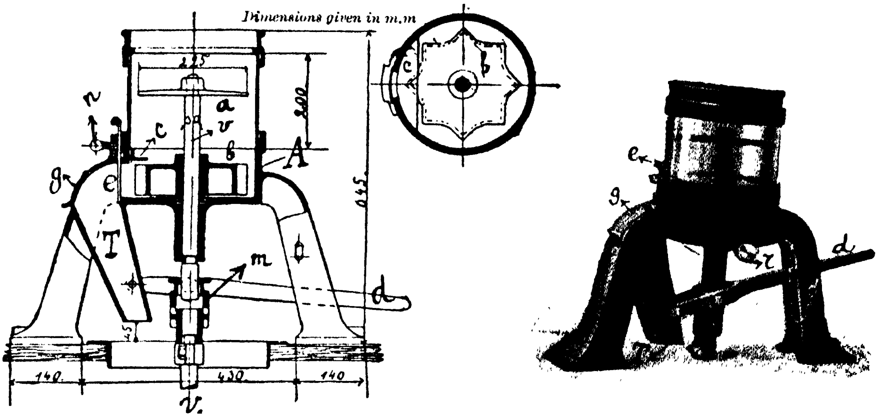

FIG. 171.

and the cross-head *a* which loosens the grain fed into the trunk, are both set on the axle *v*. By raising and lowering axle *v* with lever *d*, attached with its fork to the spout, the flow of product is regulated.

The gate valve *e* held by a screw *n* regulates the delivery of the grain into the spout; the lid *g* is an inspecting door, *r* the lubricator oiling the axle *v*.

3. *Under-Runner Millstones*

In studying designs of stone mills we saw that the product treated travels to the outlet from the working space under the action of the force of friction, if large enough and subjected to pressure between the stones, or travels down the furrows of the stone and the working surface of the bed-stone, driven by an air-current if it is so finely broken that the top runner cannot act upon it.

In the stone mills with an under runner, the delivery of the milled product takes place under much more favourable conditions, since its particles acquire a centrifugal force. As to the large stock to be milled, its treatment also obtains under better conditions, for, owing to the centrifugal force, the pressure being equal to that of the upper-runner mills, it is treated more vigorously, and the actual grinding takes less time.

In respect of under runners, the important question as to the outline of the furrows, and even their indispensability, arises. If in a mill with a fixed bed-stone the ventilating air carries the fine ground product out, in the case of a rotating under stone the unground particles of grain will be ejected by centrifugal force if the line of the furrows coincides with the direction of the product which is propelled by centrifugal force, and by the pressure of air. Owing to this, if the line of the furrow is badly chosen, the finished product will be unsatisfactory, *i.e.* it will be intermixed with unground particles of grain.

To solve the question of the pattern of the furrows we must know the direction in which the product travels, and then a design of furrows can be selected which will result in the crossing between the route of the grain and the direction of these furrows. Only in this way will the unground product be ejected from the furrows to be reduced to flour in the grinding area.

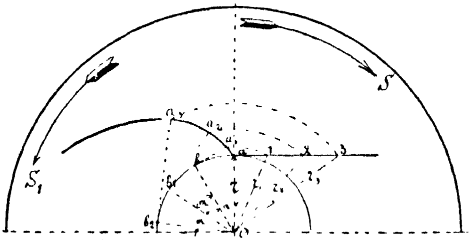

FIG. 172.

Professor Kick gives the following solution of the problem concerning the route of the stock.

Let us suppose that the under stone rotates with an angular velocity. If a particle of product at a distance r from the axis of rotation acquires a centrifugal force $m\omega^2 r$, equal to the friction force fmg, it is bound to slip off the stone at that moment, and move uniformly, *i.e.* as a free body, with a speed $r\omega$, so that its motion will be directed at a tangent to the circumference of the radius r. The denotations employed here are : m, the mass of particles ; g, the acceleration of gravity ; and f, the coefficient of friction between the product and the stone.

The free motion of the particle in respect to the uniformly rotating stone is an involute of circle, a fact easily grasped (Fig. 172).

The stone revolves as pointed by arrow S. The particle m having slipped off at point a_1, at a distance r from the axis of rotation, flies at a tangent a_3 in the direction the stone moves, with the speed $r\omega$. The motion of a_3 is absolute. To find the trajectory of motion in respect to the rotating runner, let us suppose that in a unit of time the runner has turned at an angle a, and the particle m has travelled the distance a_1. Then the resulting position m_1 of the particle will be at the intersecting point of the circle described with radius o_1 and the circle drawn from centre b of the radius of the straightened arc ba_1, corresponding to the angle a. A series of points a_1, a_2, a_3, &c. obtained in this manner, forms an involution of circle.

This opinion of Professor Kick's cannot be agreed with, for he has not taken into consideration the power of wind which will impart a uniformly accelerated motion to the particle m.

Besides that, taking for granted that the particle will slip off the surface of the stone (which is impossible, the gravity playing a part here), it will move in a parabola under the effect of the power of gravity and of wind and will certainly fall upon the stone.

Consequently we see that the trajectory of motion of the particle, influenced by its gravity, centrifugal force, and the power of wind, presents a very complicated curve, and in no case an involute of circle, as Professor Kick supposes. It is possible to construct this curve in theory for one particle. But if we consider that in the working area of the stones there is a large quantity of product undergoing friction in its mass, and that the rough surface of the millstone excludes the very idea of friction in the fine particles, for the cutting crystals of the stone impede the motion of the reduced particles, and, consequently, exclude the possibility of friction in the sliding motion over the surface of the stone (the motion must be performed in a zigzag line between the crystals), these circumstances make the problem insoluble.

As to general practice, it would have been possible to answer the question respecting the most advantageous tracing of furrows, had strictly scientific experiments been performed to that end. However, in our opinion, the furrows ought to be completely discarded on the lower runner, and retained only on the upper fixed stone for ventilating the working area: the shape of the furrows in the fixed upper stone, at the same time, being of no great importance, they may therefore be of the simplest kind, *i.e.* rectilinear.

Before proceeding to describe the designs of under-runner mills, we must mention the experiments performed by Buisson in connection with his observations concerning the influence of exhausting millstones.

All the three types of stone mills were driven by 6 h.p. each. The experiments were made on wheat grinding, and the stones employed were French, of equal diameter, and with similar furrows.

The results of an hour's grinding were as follows :

(1) An upper-runner mill without exhaust yielded 182 lb.

(2) An upper-runner mill with exhaust yielded 279 lb.

(3) An under-runner exhausted mill yielded 373 lb.

(4) The last mill, with both the upper and lower stones revolving in opposite directions, with ventilation, yielded 468 lb. per hour.

As regards the fourth case, the flour produced was of a worse quality than in the first three cases.

These experiments prove that stone mills with revolving upper and lower grinders ought not to be employed, because of the low quality of the grist. Besides, these mills are so complicated in design that in this respect, likewise, they may be regarded as unsatisfactory. At any rate they were rejected long since in general practice, and we shall pass them by.

In comparing the capacity of upper-runner and under-runner mills, we notice that the capacity of the latter exceeds the former by 33·5 per cent. Buisson's experiments are naturally insufficiently exact, for he used stones with uniform furrows, but undoubtedly under-runner mills grooved in the most advantageous manner would yield a larger quantity of product of a higher quality. But the comparatively great pressure of the spindle upon the vertical journal is a defect in the design of under-runner mills.

Indeed, if to a unit of working surface, the pressure of the upper runner necessary for grinding the product is p and the weight of the stone to the same surface P, then the pressure of the spindle upon the vertical journal, the common working area being w, will be $(P-p)w$, because p is the reaction of crushing of the bed-stone. If, on the other hand, we have an under runner, then the pressure upon the vertical journal may be expressed, employing the same denominations, by the formula $(P+p)w$, for the weight of the stone and the reaction of its pressure upon the grain both act in the same direction. Owing to this, the vertical journal becomes worn much faster in under-runner mills than in those with upper runners. However, this defect is reparable, as will be seen in the constructive description of stone mills.

An ordinary type of an under-runner mill is shown in Fig. 173. The stationary top stone B is encircled with an iron ring a (set on the stone hot) with three clutches q. The cast-iron casing c serves as frame to the upper stone ; the stone rests on the casing on bolts b, by means of which the working surface of the stone may be set horizontally. The chamber of the casing is closed by a timber ring d. The runner C is supported on an ordinary balancing driving iron *e*, the first cross-head of which rests on a disc *i*, furnished with a lid which serves at the same time as a plate supplying the grinding area. In its bottom surface the runner has boxes with weights for counterbalancing it. In the sides of the stones there are iron sockets *n* for lifting it. Every stone ought to be provided with such sockets, because in mounting or dismantling of the mills the stones must necessarily be lifted.

The feeding is performed by the tube *A* described earlier (Fig. 169). The side-travellings of the spindle *D* are arrested by an ordinary vertical bearing *k*. On the spindle is set a washer *l*, its turned down ends entering the ring reservoir *m*, which is filled with water (or empty) to prevent the meal-dust from penetrating into the bearing. As to the remaining details, the shafting of the rotation of the spindle, the step-bearing and the tram pot not given in the drawing, they are similar to those of the above examined upper-runner mills.

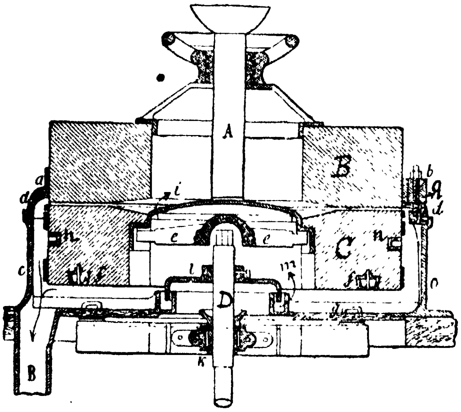

FIG. 173.

The constructive advantages of under-runner mills are the following :

(1) Simplicity of the bearing substituting the complicated mill-bush here, and its accessibility for inspection and lubrication.

(2) The driving iron does not impede the free passage of the product through the eye, and consequently the grinding surfaces are more evenly supplied with grain.

The heavy loading of the step-bearing is, as we have seen, an important defect more or less successfully combated almost exclusively by Russian engineers. To counteract the rapid wearing of the vertical journal and the step-bearing resulting from the heavy load, they replaced the sliding friction by a rolling friction, employing ball collar thrust-bearings of a corresponding design.

Fig. 174 represents an under-runner mill designed by Mr. Panshin. The revolving under stone *A* is fixed on a cast-iron frame *B* forming one block with the pulley *D*, which is set into motion from a belt drive. The whole system is mounted on a cast-iron frame *E* bolted to the foundation. The frame supporting the runner *A* rests on two ball collar thrust-bearings, the first one, *I*, being set below on the main frame, the second, *II*, on the vertical stationary cylindric steel column with a collar. The hardened steel balls receiving the pressure of the under runner, roll between the steel rings, likewise hardened. In this wise the pressure of the under runner is supported by two horizontal planes, which reduces the wear of the steel balls and rings. The third, upper, row of balls *III*, also rolling in steel washers, does duty for the mill-bush. The distance between the grinding surfaces is adjusted with the aid of a cogged hand-wheel *O*, having a long square-threaded hub. The hand-wheel is turned by a lever *H*. The lifting is done as follows: the tripod drop-hanger frame *K* supporting the fixed upper stone is screwed with its hub on the hub of the hand-wheel *O* and lifts the stone; with the retrograde motion of the hand-wheel, the drop-hanger frame is screwed off and the upper stone is lowered. The regulation of the flow of grain is performed by lowering or raising the feed-tube *L* with a hopper, which is done with a hand-wheel having a screw thread on the inside of its hub.

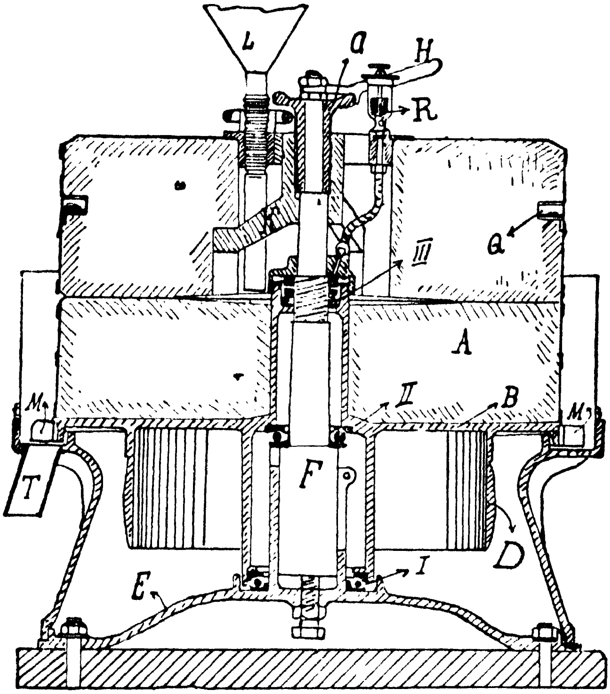

FIG. 174.

The lubrication of the mill-bush and step-bearings is sufficiently clearly depicted in the drawing. To the bottom of the frame on which the runner is mounted are riveted iron scrapers *M*, which convey the flour to the discharge spout *T*.

W. Joukovsky's stone mill (engineer Fuhrman's patent) has a fixed frame T carrying (Fig. 175) a step-bearing R with three rows of balls. The frame P is cast in a single block with the pulley S of pig iron; the cylindric rib U of the frame constitutes the mill-bush K. The steel shaft V, connected with the frame T by means of keys, is stationary, and has an axle V_1 inside, which, with the aid of a ratchet wheel gearing a and lever h, may rise and fall by being screwed into the screw hub b of the shaft V.

The shaft V_1 supports the fixed upper stone on a tripod drop-hanger frame, and thus affords the possibility of adjusting the distance between the grinding surfaces. The product is supplied by the hopper Q, and a tube r which may be raised and lowered by a crank mechanism po driven by a hand-wheel n. The oil is supplied from lubricator-box m through a copper pipe t, directed to the mill-bush. From the mill-bush it is conveyed to the step-bearing by a canal i. The step-bearing and the mill-bush are completely isolated from dust. The product is shovelled from the bottom of the casing into the spout Z by means of scrapers s.

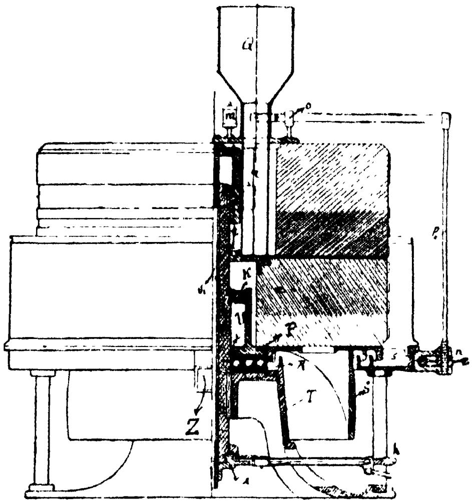

FIG. 175.

In comparing the two designs of stone mills and attaching supreme importance to ball bearings, we are inclined to favour engineer Fuhrman's design, for the assembling of a ball step-bearing in one plane presents no difficulties. In Mr. Panshin's design, the fitting up has to be done in two planes, and a slight inaccuracy in this case compels one to work but in one plane. At first sight the three rows of balls in Fuhrman's step-bearing also present inconveniences, namely, all the three rings of balls are evenly loaded, and therefore the balls of the outer ring, having a longer course to run, ought to wear out more rapidly. It has to be taken into consideration, however, that the number of balls in that ring is greater, and consequently the load per ball is less. Thus a judicious choice of diameters in the rings of the three rows of balls will equalise the wear of the balls.

The under-runner stone mills with ball-bearings have undoubtedly a good future, and will certainly supplant the mills of the ordinary style with an upper runner, as they require a smaller consumption of power, and have an equal capacity, and are more compact than the common mills. The problem of the rapid wearing of balls has now been completely solved, for the development of motor car production has furnished us with ball-bearings more durable than slide-bearings.

4. *Stone Mills—Vertical (Horizontal Axis of Rotation)*

While studying the question of setting the working surfaces (p. 99, Fig. 90), we pointed out some defects of the vertically set surfaces, and will therefore not discuss them now. In spite of those defects, the mills with vertically mounted stones, rationally designed, owing to the convenience and easiness in taking them to pieces, simplicity of attendance, and their compactness, fulfil their purpose successfully.

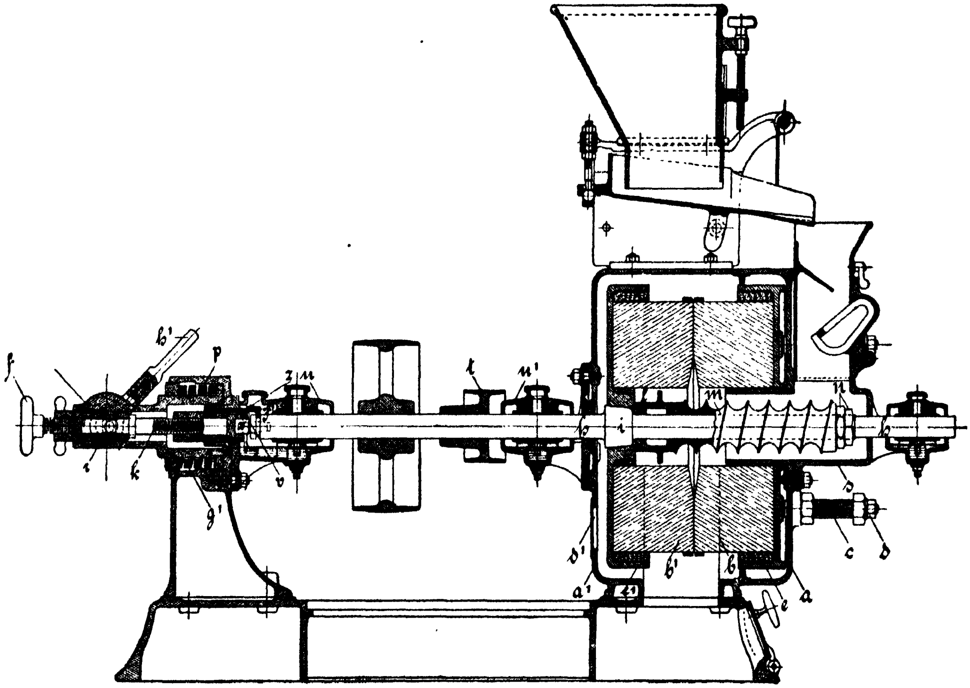

Fig 176.

"*Selecta*" *of the Works of form. Seck Bros.*—"Selecta" built by the Dresden works of Seck Bros., is a characteristic construction of stone mills having a horizontal axis of rotation, and is used for a single grinding, as well as for reducing the integuments (Fig. 176).

In a cast-iron casting *a*, easily removed, there is fixed the unmovable grinding stone *b*. The runner b_1 is set in the left section a_1 of the casing. The shaft *h* with the runner set on it by means of a cone and nut, rotates in three bearings with ring lubrications, two of which are attached to the parts *a* and a_1 of the box. The third bearing is set on a bracket.

The casing a–a_1 and the bracket are established on a cast-iron foundation-frame, and riveted to it by bolts. If the frame is correctly placed on the foundation or on the floor, the correctness of the position of the millstone is perfectly guaranteed, for the setting of the bracket and the casing aa_1 is done accurately at the works.

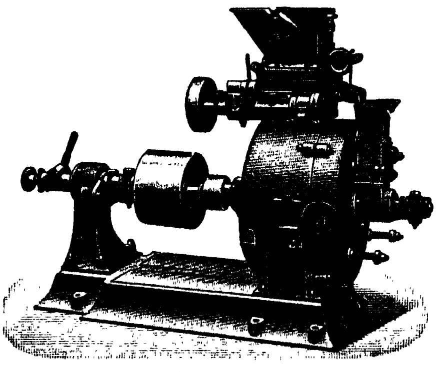

FIG. 177.

The throwing of the stones apart and together is performed by means of a lever h_1 connected by an eccentric with a screw ending in a hand-wheel *f*. This hand-wheel serves for a more accurate adjustment of the distance between the fixed stone *b* and the runner b_1. This is done in the following manner: the shaft *h* carrying the runner b_1 rests on a horizontal pivot-journal *z*, which is connected with the box *p*. Into this box enters a screw connected with a box g_1, which rests with its collars on a spring set in between the hub of the box and the casing of the bracket. The spring will resist a certain normal pressure. By turning the hand-wheel *f* to the right or to the left, one may accurately regulate the distance between the grinding surfaces. But when a big, hard object (nail, nut, &c.) is caught in between them, the runner presses hard upon the shaft *h*, which transmits the pressure to the box g_1. Then the spring contracts and the object leaves the working space having caused no breakage, while the runner acted upon by the spring returns to its former position.

The slight displacements of the bed-stone while being mounted are likewise provided for. This is done in the following way: in the right-hand bottom of the casing *a* containing the bed-stone, there are set four adjusting screws (only one is visible in the drawing, they are seen more clearly in the general view, Fig. 177). Through the bodies of the screws there pass bolts by means of which the casing of the bed-stone can be tightly pressed to the ends of the adjusting screws. At the beginning the grinders are adjusted in proportion to their wear, with the aid of the hand-wheel *f*. But once the wear of the working surface has reached the stage when the turning of the hand-wheel becomes purposeless, then, having freed the bolts and screws of their nuts, the fixed stone is pushed together with its casing in the direction of the runner, the hand-wheel *f* having previously been brought to its former position. The further adjustment is performed as far as circumstances permit, again by the hand-wheel, until the displacing of the adjusting screws has to be renewed. This manipulation is repeated so long as the length of the adjusting screws permits, *i.e.* until these screws completely sink into the hollow of the casing *a*.

When the fixed stone, in consequence of wear, has attained the last-mentioned position, the runner can be further transposed. To this end (Fig. 178), the adjusting screws *l* are screwed out of the casing and the runner, keyed on to the shaft, is pushed with the aid of a cone-shaped entasis *i* to the right towards the fixed stone. To assist in transposing the runner, a box *o* is set on the shaft and the runner with its casing is shifted more to the right. During the operation following the stones are adjusted in the manner explained above, until they are totally worn.

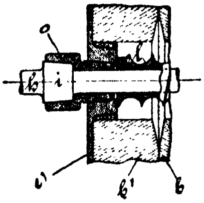

FIG. 178.

In dismounting the mill, special hoops are screwed on to the frame, and after the bolts coupling both halves a_1 and *a* have been loosened, with due precautions the frame is shifted with the aid of rollers over the hoops to the right.

This mill may be furnished with stones of various types. For the purposes of aspiration the machine is either included in the general aspiration, if there is a centrifugal appliance, or provided with a special dust-collector. During the ventilation the opening in the left-hand side section of the casing a_1, usually covered with wire cloth, is hermetically stopped up.

The feeding appliance consists of a hopper with an adjustable bottom, similar to the rocking shoe in the hopper of an ordinary stone mill. The hopper is driven by a pulley *t* which can be shifted along the shaft *h*. For regulating the feed there is a distributing slide valve by means of which the outlet in the adjustable bottom may be enlarged or made smaller. The product fed into the millstone slides over a magnet which extracts all pieces of iron, and is then conveyed by the worm *n* to the working space of the grinders.

When the mill is in operation and filled with product the lever h_1 set on the box g_1 is brought into a position defined by the pawl of the ratchet wheel, *i.e.* it is turned to an angle of 90° in respect to its former position. Then by means of the hand-wheel *f*, the runner is brought by the screw so close to the fixed stone as to produce a grist of the desirable fineness. If the process has to be quickly stopped, it is sufficient to turn the lever on box g_1 back the 90° and the stones acted upon by the spring will move apart. At the same time the movement of the rocking shoe must be stopped with the aid of a disengaging gear.

If any hard foreign object is fed into the mill together with the grain, the runner may be thrown out of action by pressing the spring, which forces back the box g_1 and the adjusting mechanism.

This set may be furnished with quartzose stones, but the artificial emery stones are preferable, as they require redressing much more rarely. There is no need to make slanting furrows here, it is sufficient to deepen the ventilatory furrows from time to time and smooth the spout for the ready product.

Of stone mills of this type Thos. Robinson's "Dreadnought," the "Monarch" of Dobrovy and Nabholtz, have a name, as have the mills of a similar type from many American works, whence the European engineers have borrowed the design.

Below are given the data of the capacities of all three types of stone mills obtained in general practice. In the second table, *D* denominates the diameters of the stones in quarters,[1] *n* the number of revolutions, *P* capacity per hour, *N* the number of effective horse-powers, and *Q* the weight of the mill without the stones.

TABLE XVII

THE CAPACITY OF STONE MILLS

(1) *Upper-Runner Mills*

Diameter of Stones, in Quarters.[1]	Number of Revolutions per Minute.	Number of H.P. required.	Capacity per Hour, in Bushels.	Weight of Mill without Stone, in Lbs.
$\frac{5}{4}$ (35 in.)	160–170	4–5	6–8	4140–4320
$\frac{6}{4}$ (42 in.)	145–155	5–6	8–10	4500–4680
$\frac{7}{4}$ (49 in.)	135–145	6–7	10–14	4860–5040
$\frac{8}{4}$ (56 in.)	120–130	7–8	14–16	5120–5300

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[1] Quarter = 7 in. "Quarter" is a Russian measure used in measuring millstones.

(2) *Under-Runner Mills on Balls*

D.	*n.*	*P.*	*N.*	*Q.*
4 quarters	180–200	6–10	3–5	900–1080
5 ,,	170–180	10–16	5–10	1260–1440
6 ,,	145–150	23–26	10–15	1730–1800
7 ,,	135–140	30–35	15–20	2050–2780
8 ,,	120–125	40–48	20–25	2780–2960

(3) *Stone Mills of the "Selecta" Type*

Diameter of Stones in Millimetres and Verschokes.	Number of Revolutions per Minute.	Capacity per Hour, in Bushels.		Number of H.P.	Full Weight of Mill, in Lbs.
		Coarse Flour.	Soft Flour.		
256 mm. = 5⅞ v.	1000–1200	6–10	2–6	2–4	396–432
400 ,, = 9 v.	900–1000	16–24	8–14	6–10	828–900
600 ,, = 13½ v.	750–800	45–60	20–25	15–20	1908–1980
711 ,, = 16 v.	700–750	60–75	25–32	20–25	2720–2512

The considerable difference in the weight of machinery given in this table should be taken notice of. The light weight of the under-runner mills on balls and sets of the "Selecta" type in comparison to the upper-runner mills does not speak in favour of mills of the old type, which are, in fact, losing ground to the new type of machinery, owing to their cheapness and satisfactory operation.

5. *The Capacity and Calculation of Stone Mills*

On examining the practical data of the capacity of stone mills with grinders of natural and artificial stone, we see that it does not exceed 1 to 2 bushels to an effective horse-power.

The data of capacity given here pertain to the single grinding, and have been obtained from the materials of large works, which give us no reason to doubt their veracity. Those data are confirmed, with insignificant reductions, by our immediate observations. The reduced capacity, however, results from the millstones being badly attended to by inexperienced millers rather than from any inaccuracy in the data given by the factories. For this reason, in calculating the capacity of stone mills it ought to be set at 5 to 10 per cent. lower than as per catalogues of large firms ; it is still better to employ an experienced miller able to handle the machinery well.

Detailed investigations of the capacity per horse-power per hour are published by Wiebe,[1] and are based upon his experiments on mills in Budapest (Pester Mühlen). These researches, in spite of their dating from so early a period, have not lost their value in a comparative sense, owing to the fact that the standard of millstone grinding was very high at the time mentioned. The stones, the capacity of which was investigated, were 5 feet in diameter, and ran at the rate of 120 r.p.m.

Those data relate to the plain and high grinding on stones. The first figures (belonging to plain grinding) approach our modern data. If they are rectified in proportion to the increased number of revolutions of the millstones and an improved ventilation, 108 lbs. per horse-power-hour will be a perfectly normal capacity for modern millstone sets.

TABLE XVIII

CAPACITY PER HORSE-POWER (STEAM) PER HOUR ACCORDING TO WIEBE.

WHEAT.	Without Ventilation, lbs.	With Ventilation, lbs.
(1) Single grinding with a regrinding of the rest . . .	59·4	79·6
(2) Grinding in two passages . .	50·4	67·3
(3) Grinding in three passages .	45·0	59·4
RYE.		
(1) Grinding in a single passage .	58·3	78·8
(2) Grinding in two passages . .	34·9	47·2
(3) Grinding in three passages .	28·4	37·1

In passing to the question of the design of stone mills, it must be pointed out that the calculation of exact details of this machinery depends on the weight of the stones, which, in its turn, is determined by the force necessary to crush the grain. The natural stone, being diverse and variable in its structure, does not allow of the evolution of any

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[1] Wiebe, *Die Mahlmühlen.*

analytical formula as regards the normal dimensions or for the velocity of rotation of the stones. Owing to this fact we must have recourse to the empiric data evolved by factories and mills in their long years of practical experience, according to which to one square metre of the working surface 700–1000 kilogrammes' weight of the runner is accepted. Availing himself of those data, Navier suggests the following formula for the weight P of the runner : $P = 668D^2$ kilogrammes, D being the diameter of the stone in metres. If the height h of the stone is to be determined, then, denominating the density of the stone as δ, the diameter of the stone D, the diameter of the eye d, we obtain the pressure to one square metre of the working surface :

$$p = \frac{\pi(D^2 - d^2)\delta h \,.\, 4}{4 \,.\, \pi(D^2 - d^2)} = \delta h,$$

for the weight of the millstone $P = \frac{\pi(D^2 - d^2)\delta h}{4}$ (the volume of the cylindric ring multiplied by the specific gravity of the stone), while $\frac{\pi(D^2 - d^2)}{4}$ is the area of the base of this ring. Seeing that the density δ of the natural stone is equal to 2000, and taking the average of p as 850 kilogrammes, we obtain $h = 0{\cdot}425$ metres, which closely approaches the dimensions of the stones made by French manufacturers.

Results of a greater accuracy may be obtained for artificial stones, as the uniformity in their structure enables us to find more accurate limits of weight.

As regards the circumferential velocity of the millstones, Wiebe proposes 9·42 metres per second for the utmost limits, Fairbairn 10 metres per second, and modern constructors place the highest limit at 16 metres per second for good French stones.

No scientific experimental operations with the view to calculating the power consumed in the working and the empty run of the stones have been made as yet, while the imperfect observations give the following general rule : it is considered that to move a grinding stone a force equal to $\frac{1}{20}$ to $\frac{1}{22}$ of the weight of the stone is required, applicable at the distance of $\frac{2}{3}$ from the axis of rotation. Then the work T per second will be expressed by the formula :

$$T = \frac{P}{20\text{–}22} \cdot \frac{2}{3}\frac{\pi D n}{60} = \frac{P \,.\, \pi D n}{1800\text{–}1980}$$

where D is the diameter of the stone, n the number of revolutions per minute. General practice in Russia has established a still more simple rule, according to which one H.P. is reckoned to each quarter, *i.e.* 28 inches require four H.P., 35 inches five H.P., 42 inches six, &c.

In calculating the consumption of power of the stone mills, it must be kept in mind that the power consumption depends on how the grinding is done. The numbers of horse-power given above are to be regarded as an average.

A stone mill running empty consumes 20 to 25 per cent. of power.

Wiebe offers the following inference for the definition of the relation between the velocity of rotation of the stone and the consumption of power:

Let us suppose that h is the distance between the working surfaces at the inflow of the product, u the speed at which the product is discharged in a radial direction. The volume of product V delivered per second will be equal to πDhu, D being the diameter of the stones. If we grant, with a great approximation, that the volume of the reduced product is proportionate to the volume Q flowing into the mill, then $V=aQ$, where a is the coefficient of proportionality. Reckoning that the speed of the product delivered is proportionate to the circumferential velocity of the grinder, we obtain $u=\beta v$, where v is the velocity of the stone, and β the coefficient of proportionality. Substituting those significations in the formula for V, we shall obtain for the bulk discharged per second :

$$V=aQ=\frac{\pi Dn\pi D\beta h}{60}, \text{ whence}$$

$$\frac{Q}{D^2n}=\frac{\pi^2\beta h}{60a}=\text{const.}$$

By substituting the mean values of n and Q in this formula, we shall define this constant quantity. The following problem may be solved as an example. Granted $D=1{\cdot}5$ metres. The number of revolutions $n=120$, 48 litres of wheat per one horse-power have been fed in per hour. Then per minute $Q=0{\cdot}8\ N$, N denominating the number of horse-power. Hence (reckoning Q per hour to be equal to 275 litres) :

$$\frac{Q}{D^2n}=\frac{0{\cdot}8\ N.}{D^2n}=0{\cdot}019.$$

Consequently, $N=D^2n\ .\ 0{\cdot}019$. The constant $\frac{Q}{D^2n}$ may be regarded as equal to 0·02, then the formula defining the number of powers will be

$$N=D^2n\ .\ 0{\cdot}02.$$

But seeing that the capacity of the stone mills in modern technics has risen, the coefficient 0·02 should be slightly increased.

6. *Mills with Metal Grinders*

Repeated attempts have been made in Europe to supplant the stone grinders by metal ones—cast iron or steel—but no satisfactory results have been obtained. In Europe, chiefly in Germany, up to this day such mills are made only for laboratory purposes. The American technical science, however, has evolved a series of splendid designs of mills with steel grinders for industrial purposes, mainly for grinding forage products —maize, barley, oats, cotton seeds, &c.

The Americans build mills of this style with a horizontal axis of rotation, and mostly with twin rotating grinders.

Figs. 179 and 180 represent a universal attrition mill "Scientific" built by "The Food Manufacturing Co.," Springfield, Ohio. The product is fed into hopper *A* with a feeding and crushing roller 4 with pulley 44 driven from a special shafting. The regulation of the feed is performed by a cast-iron valve 38 by means of a screw 39, which are set apart on *B*. If whole ears of maize are to be ground, a narrow passage is left open between the valve and the side of the hopper: should the product fed in be the grain of barley, oats, &c., the valve is kept almost quite open. From the hopper the product streams (arrows *s*) into the working space through the eye of the left-hand stone.

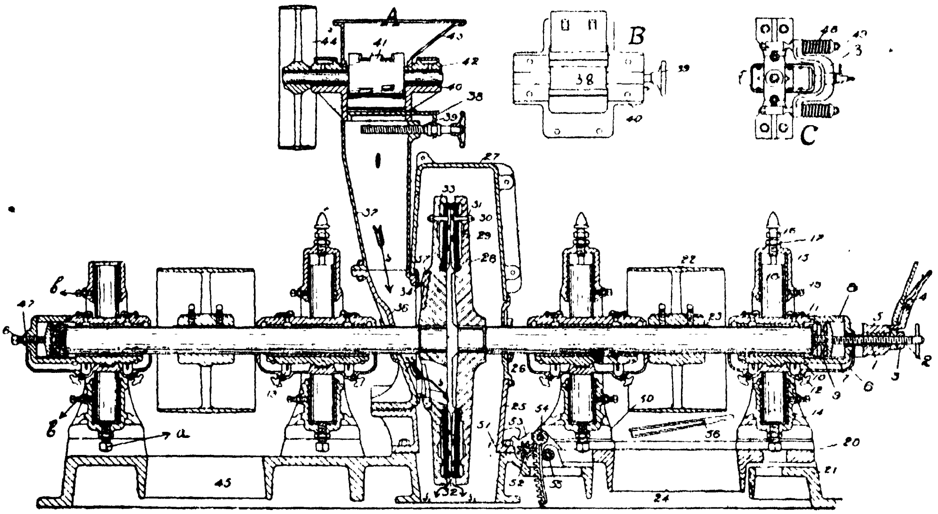

FIG. 179.

The grinders are cast-iron discs 28 and 33 with cover plates 32 of hard tempered steel with cutting edges (Fig. 180). The reduced product is discharged as pointed by arrows s_1. The grinders are enclosed in a cast-iron built-up casing 27. The shafts of the grinders are set each on two bearings with bronze bushes and ring lubrication and have ball step-bearings 9. The right-hand grinder has a tension adjustment drawn in detail on *C*, which is arranged as follows : the pivot journal of the shaft transmits the pressure to the bolt 2, which in its turn presses upon the cross-head 3 resting with its ends on springs 48 ; the spring and the ends of the cross-head are set on guides 49 fixed to the frame of the bearing. The bolts 2 and 47 of the end bearings also serve for the fitting up. For lifting and inspecting the grinding surfaces there is a rack and pinion 52 operated by a ratchet wheel with the aid of a lever 56. One end 54 of this rack is connected by a joint to the base plate on which the bearings are set. The bearings and the casing are set on the foundation frame. The accuracy in the setting of the shafts of the grinders is guaranteed by the construction of the bearings, which may be raised or lowered by bolts *a*, and pushed backwards or forwards by bolts *D* (see general view).

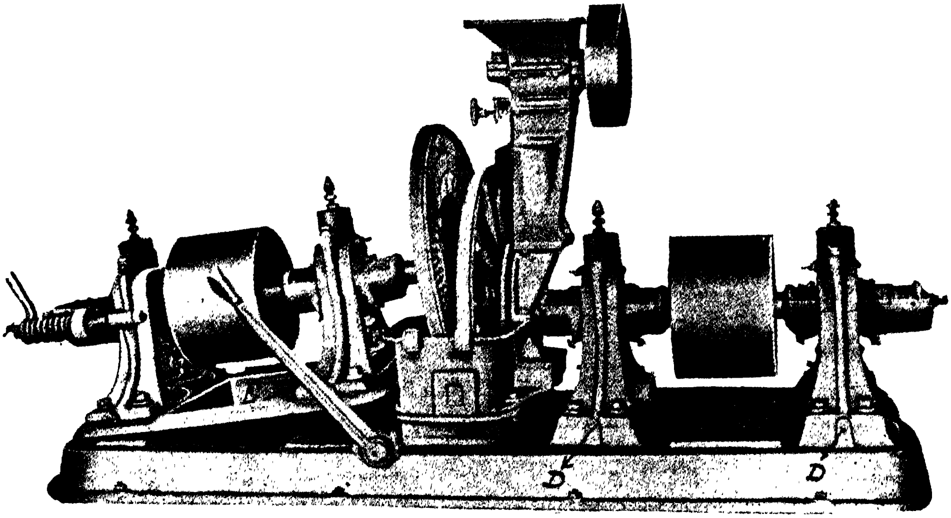

Fig. 180.

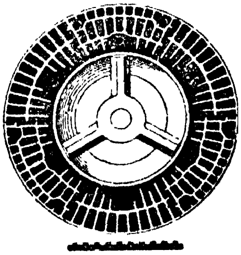

Fig. 181.

For the inspection and cleaning of the grinders the casing is broken off, the belt removed, and the whole side with the tension adjustment is lifted with the rack and pinion. The plate 20 of this side is placed on the base plate free and is not bolted to it; while the plate of the other side is cast in one block with the base plate.

By the first bearing on the left (section) a collar 63 is set, and the bush of the pulley 22 serves as guard for the shaft of right-hand grinder. The holes *E–E* in the frame are made for the belts to pass through.

This machine has been rationally designed, and its sole defect is the absence of ventilation, which is particularly important for cooling, when hard mineral substances are ground. The worn grinding steel discs (Fig. 181) are easily replaced by new ones. The capacity of the machines of this type and the power consumption are given in the following table:

TABLE XIX

CAPACITY OF MILLS WITH METAL GRINDING DISCS

Diameter of Grinding Discs.	Number of Revolutions.	Capacity per Hour, in Bushels.	Number of H.P.	General Weight, in Lbs.
16 inch.	2000	14–18	10–12	1800
19 ,,	1900	25–45	15–18	1800
22 ,,	1800	35–50	20–25	2100
24 ,,	1700	70–110	25–30	2100
26 ,,	1450	90–125	25–35	3950
30 ,,	1350	125–165	35–45	4740
36 ,,	1200	145–185	45–60	5950

This table gives us the produce of feed, this type of mills not being employed for milling flour for human consumption, because the energetic activity of the cutting discs reduces to powder the bran too, which cannot be extracted from the meal.

Lately in the West European countries the use of mills with steel grinding plates also for other kinds of grinding has begun rapidly to spread. These machines have also appeared in Russia. The absence of any definite data in general practice, however, allows us to utter no positive opinion concerning them. As to the firms selling them, they give but advertisements. At any rate, owing to the cheapness of these mills and the simplicity in attending to them, they may play a considerable rôle in supplanting the heavy machinery on the peasantry market.

The grinding discs constitute an essential detail of this machinery. Fig. 182 represents two kinds of those discs. One has the cutting facets arranged after the type of the circular furrows, the other is with figure rim collars A and radial edges B at the outlet of the product. Undoubtedly the first design of the facets is more rational than the second. In the discs, the heads of the bolts riveting them to the millstones rest in square sockets D of a sufficient depth for the heads to be sunk to a level with the working surface of the disc.

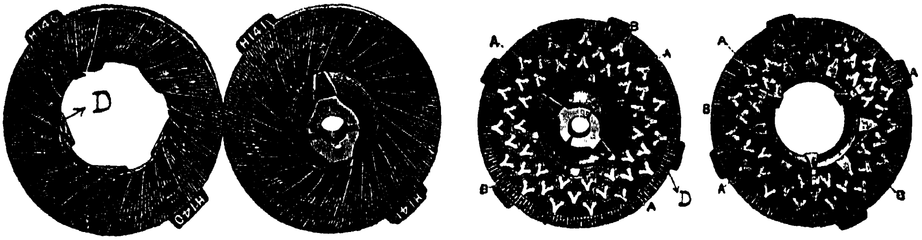

FIG. 182.

IV

MACHINES ACTING BY IMPACT

The machines acting by impact are constructed on the principle of transforming the kinetic energy into a crushing action, which is the result of pressing a body beyond the elastic limits.

Supposing we have a body weighing P kilogrammes for the crushing of which work equal to E kilogram meters is required. Then, reckoning the initial velocity of motion of the body to be equal to zero, we obtain the following formula for the destructive work :

$$E=\frac{Pv^2}{g\,.\,2}.$$

As $\frac{P}{g}=m$, herefrom is defined the velocity v of motion of the striking element or the velocity of the body, with which it must hit against an immobile object, to be destroyed :

$$v=\sqrt{\frac{2E}{m}}$$

If the hitting element and the body to be broken are moving towards each other and the velocities corresponding to their motions are V_1 and V_2 the resulting velocity will be V_1+V_2.

Disintegrators.—One of the first machines of this type (Fig. 183) was suggested by Carr. The working organs in this machine are iron discs A and B, with steel taper-pins a and b set in concentric circles. Both the discs are brought into rotatory motion in opposite directions by means of belt pulleys E and E_1. The disc A on the left-hand side is attached to the bush A_1 with taper-pins e. The cast-iron casting H encloses both discs. The tube G which conveys the grain to the working space on receiving it from the tank F and hopper N, likewise passes through that casing. Speaking generally, the design of this machine greatly reminds one of the American grinding machines of the "Scientific" type, differing from them in the character of action performed by the working surfaces.

The grain falling on the moving taper-pins receives an impact, is rejected, and meets the next pin, which again strikes it. In this manner the product travels in a zigzag line to the outlet, being gradually reduced.

Though the disintegrators are mentioned in catalogues of some factories, they cannot be recommended for milling, for they do not work economically, and require a great quantity of power. For instance, the disintegrator that worked at the exhibition in Paris (1878) expended some 30 horse-power yielding about 1800 lb. per hour, *i.e.* 60 lb. per hour power. This was on the average 15 to 20 per cent, below the capacity of the stone mills of the time.

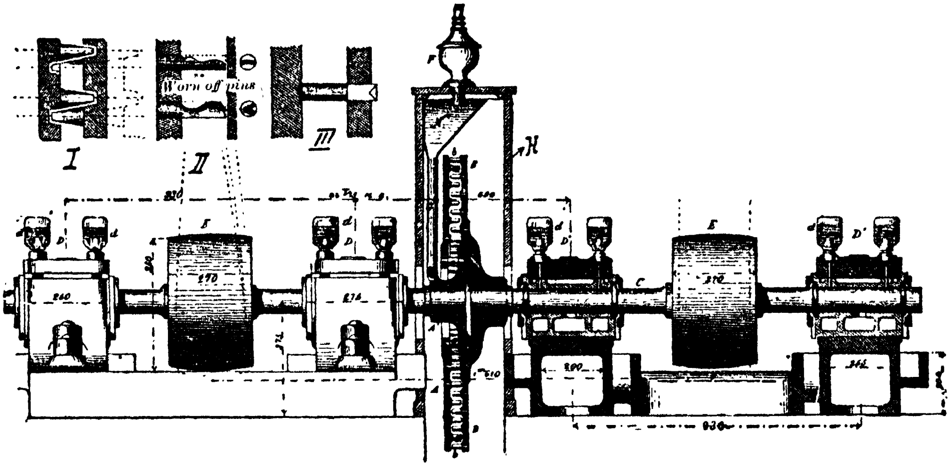

FIG. 183.

The dimensions of the working parts of those machines were generally the following: the diameters of the discs were 350 to 1800 mm., the diameters of the taper-pins 10 mm., their length and the distance between the discs almost the same, 230 to 280 mm., the number of revolutions 1200 to 400.

The Nagel and Kämp's disintegrator (Fig. 184) differs from the one preceding, one of its discs A being stationary. This machine serves for the further reduction of the product obtained after passing the grain once or twice through the roller mills. On leaving the roller mill the semolina passes into the hopper 1, whence by a feeding roller *H* it is delivered into the working space. In this machine the constructor tried

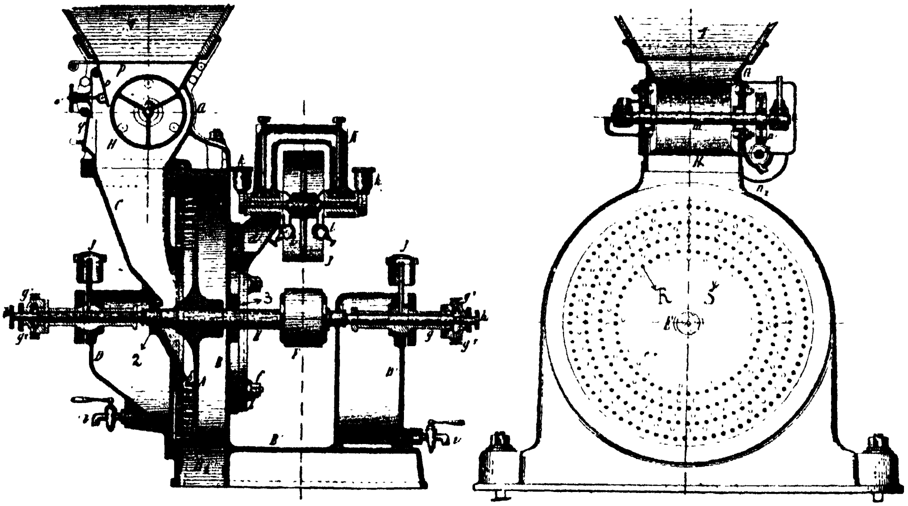

FIG. 184.

to obviate the ventilating effect of the disintegrator, which results in pulverisation of the meal; this explains the presence of the stuffing boxes 2 and 3.

The disproportionately large cisterns *D* and D_1 serve to collect the exhaust oil and drain it through cocks *i*. *T* is the driven belt-pulley, while the loose belt-pulley *J* is the tightener.

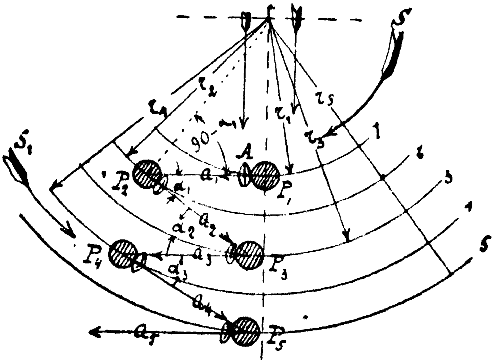

FIG. 185.

To get a clear idea of the process of movement of the product over the working area in a machine of the first type, let us suppose we have it (Fig. 185) in section over the taper-pins parallel to the discs. The pins P_1, P_3, and P_5 are moving in the direction *S*, and the direction of the pins P_2 and P_4 is pointed by the arrow S_1. The angular velocity of rotation of the two discs is ω, then the velocity of the pins is $r_1\omega$, $r_2\omega$, &c. The berry *A* falling through the eye of the disc encounters the pin P_1, which throws it with an impact at tangent a_1 with the speed $r_1\omega$. On its way the berry meets the pin P_2 of the second disc and is rejected at a tangent line a_2 to the pin P_3 moving in a contrary direction, with the velocity $r_2\omega$. At the moment the grain and the pin P_2 meet, the velocity of the impact is equal to $r_1\omega + r_2\omega \cos a_1$, for the velocity of the pin P_2 is projected upon the direction of the motion a_1, by the quantity $r_2\omega \cos a_1$. With a slight inaccuracy, however, we may mark $r_1 = r_2 \cos a_1$. Substituting the r_2 of this equation into the formula of the velocity of the impact, we obtain:

$$V_1 = 2r_1\omega.$$

By reasoning in the same manner with regard to the percussion of the grain or its particle by the taper-pins $P_3, P_4, P_5 \ldots$, we shall accordingly obtain the velocities:

$$V_2 = 2r_2\omega$$
$$V_3 = 2r_3\omega$$
$$V_4 = 2r_4\omega, \text{ \&c.}$$

If we mark the distance in a radial line between the pins P_1, P_2, P_3, &c., through n, the result will be:

$$V_1 = 2r_1\omega$$
$$V_2 = 2(r_1 + n)\omega$$
$$V_3 = 2(r_1 + 2n)\omega$$
$$V_4 = 2(r_1 + 3n)\omega$$
$$V_5 = 2(r_1 + 4n)\omega, \text{ \&c.,}$$

which means that the velocities of the impact accelerate in proportion to the product's approach to the outlet in arithmetic progression, the denominator of which is $2n\omega$. In accordance with it increases the force of the impact.

This conclusion is arrived at on the supposition that in every element of the route n to the outlet, the product encounters taper-pins of the forward and backward motion of the discs. Other, often occurring cases, when the product encounters the pins of the retrograde motion only on its $2n$ way, are also possible. Then the law of acceleration of the velocities in arithmetic progression is infringed.

If the law we deduced respecting velocities were not infringed through the blows of some of the pins being missed, then, the calculation of the number of revolutions of the discs being correct, and the distance n definite, the grain would gradually be reduced and leave the working space in the shape of a product uniform in size.

In reality, however, those omissions do occur, and Wyngaert's experiments have shown the following results of grinding on a disintegrator of Carr's type :

Flour	33 per cent.
Fine middlings	20 ,,
Semolina	14 ,,
Coarse middlings	31 ,,
Offal	2 ,,
Total	100 per cent.

Thus, after a passage through the disintegrator, 66 per cent, of the product needs further treatment.

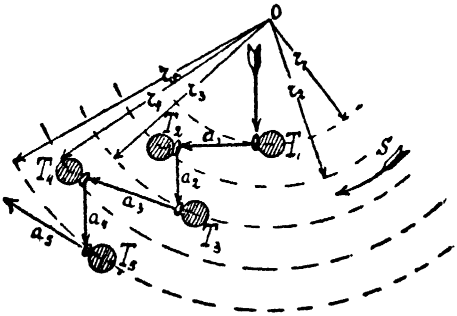

FIG. 186.

Before giving a definite estimation of this machine we shall examine the action of the Nagel and Kämp's type of disintegrator, *i.e.* with one rotating disc.

The disc with taper-pins T_1, T_2, T_3 . . . rotates as indicated by arrow S. The grain, struck by the pin T_1 (Fig. 186), moves in the direction a_1. On encountering on its way the fixed pin T_2, the grain is crushed and loses its velocity $r_1\omega$. If the grain does not break, still, owing to its insignificant elasticity when compared to the steel pin, it loses its velocity.

We suppose in the first, as well as in the second, case that it will not rebound from the fixed pin, having lost its velocity, and will drop in the direction a_2 influenced by its gravity. Therefore, the pin T_3 will give it the direction a_3. In this wise the way of the product will lie a_1, a_2, a_3, a_4, a_5, . . . Seeing that the speed of the free drop is quite insignificant in comparison to the velocity of the pins, we may ignore the item of the speed down a_2 to a_3. Consequently, the velocities of the impact T_1, T_2, &c., will accordingly be :

$$V_1=r_1\omega,\ V_3=r_3\omega,\ V_5=r_5\omega,\ \&c.$$

Let us compare these velocities with those of the first case :

$$\begin{array}{ll} V_1=r_1\omega & \qquad V_1=r_1\omega \\ V_3=2(r_1+2n)\omega & \qquad V_3=(r_1+2n)\omega \\ V_5=2(r_1+4n)\omega & \qquad V_5=(r_1+4n)\omega. \end{array}$$

Thence it is clear that the homonymous impacts in the first case have doubled the velocity of those of the second. This means that to attain the crushing effect it is necessary to double the speed of rotation of the discs in the disintegrators of the second type.

In drawing this inference, we rested upon the supposition that the grain or a particle of it loses its speed in striking the fixed taper-pins, thus simplifying the problem considerably. But it may be maintained that the product possesses a certain elasticity, and on striking the pin T_2 will rebound in compliance with the law of percussion of elastic bodies, the mass of one of which (the pin) is infinitely great. Then the resultant velocity of the impact of the pin T_3 and of the grain will be greater than in our preceding inference. The process, probably, is performed in this manner, because for crushing the product a velocity less than the double velocity required in the first case suffices, as we see in general practice and in the factory data. At any rate, the resultant velocity of the blow, conditionally denominated here as the total sum of velocities in the direction the grain is travelling, needed for breaking the grain, attains 150 metres per second.

Similarly to the first case, we have been examining the disintegrator of the second type operating in ideal conditions, supposing that the product is subjected to impacts from pins of each row. This is close to the fact ; however, gaps in the series of blows are possible. Altogether the phenomenon of the impacts here is extremely complicated, and the character of the process may be judged of only by the final product, as it is an absolute impossibility to observe its movements in the working space.

The grist from the disintegrator of the second type is likewise not uniform, and requires further treatment.

We shall now proceed to estimate these machines. First of all, the grist yielded not being uniform, these machines cannot be used independently, but only in a cycle of other grinding machinery. For a primary breaking of the grain also they cannot be employed, because the meal is rendered impure by an admixture of bran. It was attempted, therefore, to employ them for grinding the grain bruised along the crease and for semolina. But even here there is no reason to use them, for they are exceedingly uneconomical. Experiments have proved that the energy expended in an empty run amounts to 44 per cent. of the total power, whereas the millstones require a maximum of 25 per cent.

Attempts have been made lately to use the disintegrator for separating the particles of endosperm from the offal, after the third or fourth passage. However, these attempts we also consider to be useless, for the machine will grind the good semolina and admix bran to the meal obtained. These attempts have been made in high rye milling.

Lastly, if the disintegrators were to produce results of as high a quality as those obtained from other milling machines, even in that case they would not be worth employing, for the capacity of a disintegrator per horse-power per hour is considerably below that of other machines. Generally speaking, the machines acting on the principle of a blow consume a great quantity of kinetic energy unproductively, and if there is any possibility of replacing them by others, the use of them should be avoided. This question of disintegrators has been raised in our manual only with a view to making an end of them once and for ever, and to warn the engineers against losing time in perfecting the designs of machines of the impact type.

V

MILLING MACHINES HAVING THE AXIS OF ROTATION OF THE WORKING ORGANS IN DIFFERENT PLANES

Our examination of the machines of repeated action has shown that these machines have a common axis of rotation, if both the surfaces have a gyratory motion ; if, on the other hand, one of them is fixed, its axis of symmetry coincides with the axis of rotation of the other.

Passing now to machines in which the stock is treated by the working organs but once, it must be noted in the first place that their axes of rotation lie in different planes. Speaking, next, of the form of the working surfaces, we can accept only planes and cylinders, because other rotatory bodies (cone, hyperboloid, &c.) cannot produce equal circular velocities of rotation along the line of the treatment of the product ; under such conditions of work, therefore, the product ground will not be uniform and the wear of the working surfaces will be unequal.

Taking these circumstances into consideration, general practice and theory have produced three combinations of working surfaces (Fig. 187). The first of them (*I*) is a cylinder *A* and plane *B*. In practice we know but one type of machinery of the *I* combination, the runner (Fig. 188) employed in oil-manufacturing. The second combination (*II*) is two cylindric surfaces with an inner contact, and lastly, the third (*III*), two cylindric surfaces with an outer contact.

In all those combinations the working surface is theoretically defined as a straight line, and therefore the product is considered to be treated only once by the working surfaces. The machines of the runner type differ from the single action machines, for the rotating surface *B* carries the product under treatment several times to A. We shall not occupy our attention with machines of that type, as they are in no way connected with flour milling. The machines of the second type are used for grinding hard substances, for instance, gravel for artificial millstones. For this reason we shall later on give a description of a typical machine of that kind.

The third combination (III), two cylindric surfaces with an outer contact, revolving with different velocities, is the basis of construction of the roller mill, the most widely used grinding machine.

In studying the designs of machines subjecting the product to a simple treatment, we notice that their working organs, very rarely, have equal velocities (runner), or the speed of one of the surfaces equals zero (II). Usually, however, the velocities of rotation are different, as shown in combination III. In that case the surface B_2 brings the product up to the surface A_2, which performs the cutting or chipping action. Of the degrees of velocities we shall speak below, and point out now that, owing to their variety, the product undergoes several cutting or chipping operations before being discharged from the working space.

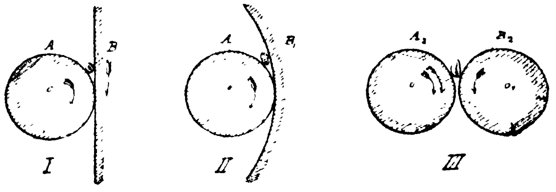

FIG. 187.

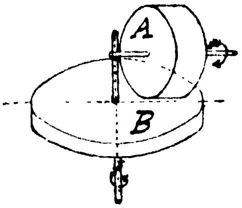

FIG. 188.

We shall now proceed to give a description of the designs of these machines, and commence with a type of the second (II) combination.

The Mill "Griffin."—The single roller mill "Griffin" (Bradley Pulveriser Co.) shown on Figs. 189 and 190 is an original type of a grinding apparatus for hard materials such as cement clinker, Thomas' scoria, superphosphates, &c.

Its principle of operation consists in crushing and grinding the material by a roller, which runs over the casing and thus acquires a centrifugal power.

This is attained by means of the following construction:

On a cast-iron base plate 24, in shoes 66, which rests on rubber buffers, there are set timber stands 23, supporting a belt-pulley frame 4.

This frame is of cast iron, and consists of two box-shaped parts riveted together by two bolts 63 below and joined by a cross-piece 22 at the top. By means of four iron rods 5 it is supported in a correct position in respect to the foundation. With their upper ends those rods are screwed into the frame 4, while the lower ends run through bolt-holes in the corners of the foundation and are screwed up by nuts, under which are laid two rubber buffers 64 apiece, separated by an iron lining.

The first machines of this type, however, were furnished with cast-iron stands, but the vibration of the casing during the grinding process was communicated, it appears, by the rigid stand to the frame, and had a detrimental effect upon the bearings. The necessity of obviating this vibration has led to the above-mentioned construction of an elastic junction between the frame and the foundation.

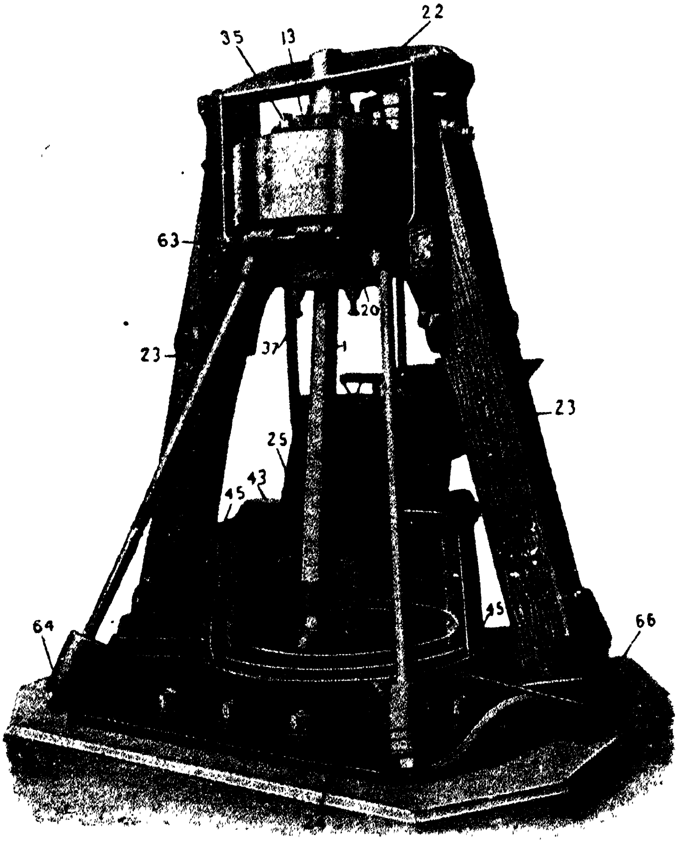

FIG. 189.

In the frame 4 there are set a fast belt-pulley 17 and an auxiliary one 14. The latter, by means of the belt-pulley 40 set on the axle 41 and carrying the gear 60, turns the worm 49 of the feeding apparatus with the aid of the worm wheel 61. The fast belt-pulley 17 rotates in the step-bearing 20 which is adjusted by means of bolts 37. On the inside of the fast belt-pulley the shaft of the roller 1 is suspended on a universal joint 9. The joint consists of a ball 9 provided with journals: the latter operate in bearings which slide in suitable slots of the belt-pulley coupling. On the lower end of the shaft 1 is set the roller 2 furnished with a change ring 31. Owing to a drop-hanger frame inside it, the joint can swing in the cup 24 in all directions. The cup or base 24 carries a casting 70 on which the roller runs; the grinding is thus performed between them. Owing to the difference in the diameter at the top and at the bottom of the ring, it velocities in relation to the casing in the generating circle are unequal which causes the reduction of the product under treatment.

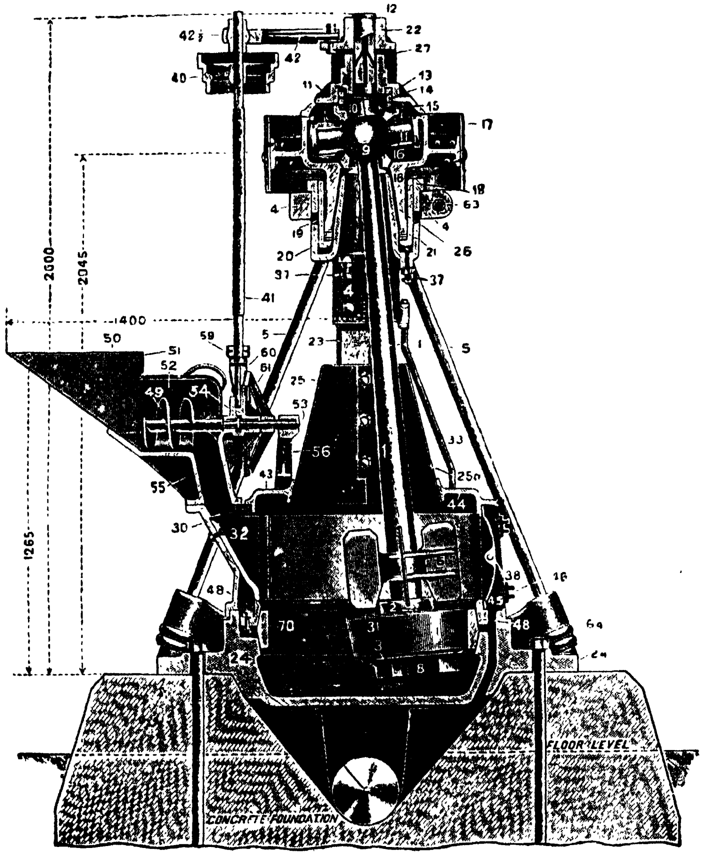

FIG. 190.

Round the casing outside there are several slightly oblong apertures.

through which the product falls into a funnel-shaped chamber under the cup, whence it is removed by a transporting appliance (a worm, in Fig. 190).

On the foundation is fixed a sieve 38, a cylindric cone 45 surrounds it covered with a lid 44 carrying a cone-shaped casing 25, through which the shaft 1 passes.

In Fig. 190, above the roller are seen the wings of the fan 6, which are designed to propel the triturated product through the sieve 38.

Under the roller, and attached to it by nuts, there are the wings 8 for stirring the product.

There are no moving parts in the dusty atmosphere of the cup. The joint in the belt-pulley is hermetically covered with a lid 13. The lubrication of all moving parts is done through the hole 12 drilled in the spindle fixed in the cross-piece 22.

The spindle centres the lid aided by cannon steel bush 27.

The dimensions of the machines are the following :

Height above the foundation	2600 mm.
Size of the base plate	2100 × 1600 mm.
Height of the middle of the belt-pulley above the foundation	2045 mm.
Diameter of the belt-pulley	760 mm.
Number of revolutions per minute . . .	200 mm.
Consumption of work . .	between 15 and 25 powers
Weight of the whole mill	10800 lb.
Diameter of the roller	460–470 mm.
Diameter of the casing	760 mm.
Length of the generating circle	150 mm.
Weight of the casing	285 lb.
Weight of the change ring of the roller . . .	145 lb.

According to the data of the factory, the mill reduces to fine meal from 264 to 6400 cells to a square centimetre of the sieve between 1·5 and 2 tons per hour of hard, up to 3.5 of soft phosphate, and from 1·5 to 2·5 tons of Portland cement, quartz, or ore, depending on the hardness and the largeness desired of the product.

The machine operates in the following manner : when brought into motion, the roller rotates in the same direction with the belt-pulley, and on reaching its normal number of revolutions is jerked out of its central position by hand.

The centrifugal force, which attains 3000 kilogrammes when at full speed, presses the roller to the casting.

Now the roller commences to revolve around the casing, moving in the direction opposite to the one it started with.

The product is poured into the hopper 50.

As soon as there has collected enough material in the cup to be scooped up by the wings 8, it is flung by them on the casing and the milling commences.

While in full operation the contents of the cup are stirred by the roller, and when reduced are bolted through the sieve by the paddles 6 which do the duty of a fan at the same time. The pieces remaining unsifted fall back under the roller.

The paddles on the axis of the roller in revolving draw the air in through the conic casing and impel it through the sieve, so that the dust does not escape outside.

The sieve chosen is slightly larger than the final product, to avoid choking up.

In spite of the ingenuity of the design described, its considerable complexity must be pointed out, as well as the circumstance that a large part of the work in grinding goes to overcome the resistance offered to the motion by the wings 8 and the continuous stirring of the heavy product.

The application of rubber buffers also cannot be regarded as a happy thought, for india-rubber exposed to the open air rapidly loses its elasticity and will do so the quicker because of the vibration. Steel plate springs would serve that purpose with success.

Then, if the action of the fan be regular, the dust may fly out of the hopper 50 if there is no product in it, and therefore a lid to the hopper would be an acceptable device.

Lastly, our attention is drawn to the unsheltered position of the feed-worm 49 set on the free end of the shaft, if anything large were to fall into it.

This defect could likewise be obviated by carrying the bearing 53 over to the left, behind the hoppers.

VI

ROLLER MILLS

1. *Conditions of Reduction of the Product*

Before we direct our attention to the construction of roller mills, it is necessary to become acquainted with the character of action of the working surfaces and the conditions under which the reduction of the stock is possible.

We have (Fig. 191) two cylindric surfaces O and O_1 rotating at different velocities in the directions S and S_1. At a certain moment there is a berry (or a particle of one) A in between them, which is to pass through the working space. The surfaces of the cylinders may be either smooth or consist of a series of chisels spoken of on p. 153, Fig. 135. In that case the rolls are said to be corrugated or grooved, and the product may be impelled into the working space by their corrugations in any combination of velocities and diameters of rollers. As to the operation of smooth rolls, the conditions of working will be deduced from the following considerations:

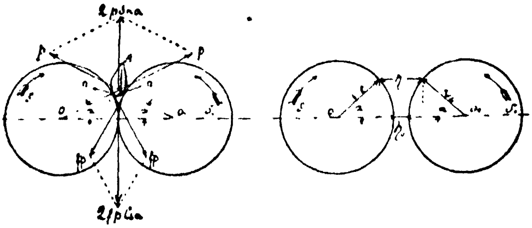

Fig. 191.

First, the working surfaces and the product under treatment must have a certain coefficient of friction f. If the material of the rolls gives a very small coefficient, the grain A will not be drawn into the working space, but will remain sliding above it. But, as the working surfaces are prepared of a definite kind of material (cast iron and porcelain), f is likewise a definite quantity. Therefore the definite f has to be combined with other elements characterising the working surfaces.

For the coefficients of friction f and the angle of friction φ Kick gives the following quantities:

TABLE XX

Material of Rollers.	For Fine Middlings.		For Semolina.	
	ϕ.	f.	ϕ.	f.
Cast iron smooth, polished .	12°	0·213	11°	0·194
Dead cast iron	16°	0·287	15°	0·268
Cast iron used	18°	0·325	17°	0·300
Porcelain	22°	0·404	20°	0·364

Let us examine now the conditions needed for the product to be drawn into the working space with the quantities φ and f given.

The rolls being in rotation, the grain A weighs upon their surfaces in the points of contact n. Suppose the reactions of that pressure to be p, their direction is evidently radial. Then the forces of friction, directed in tangents at the points of contact of the rolls and the product, will be fp. If the angle of direction of the reactions and of the centre lines, named the angle of grasping, is a, then the resultant of the two fp, which is the force drawing the product into the working space, will be $2fp \cos a$.

To bring about this drawing in of the product it is necessary that this resultant should be larger than the resultant of the reaction forces $2p \sin a$:

$$2fp \,.\, \cos a > 2p \sin a, \text{ or } f > tg\, a,\ tg\, \varphi > tg\, a, \text{ i.e. } a < \varphi.$$

Hence the condition allowing the product to be drawn into the working space may be formulated thus:

It is requisite that the angle of grasping a should be less than the angle of friction of the product and the working surface. Considering that, given one and the same size of product, the angle a depends on the radius of the rollers, by modifying this radius we are always able to select $a < \varphi$.

The dependence of the length of the radius on the size of the product may be deduced from the following considerations. Let us imagine we have two rolls of a radius r, the distance between them is η_0 (Fig. 191), the size of the product fed in η. After the product has passed between the rolls it is reduced to the size η_0. It is clear that

$$O\,O_1 = 2r \cos a + \eta = 2r + \eta_0\,;$$

by deducing herefrom the r, we obtain:

$$r = \frac{\eta - \eta_0}{4 \sin^2 \frac{a}{2}}.$$

Consequently, knowing the primary and the final size of the product, we can define the radius of the rolls, for a is known to us—it must in its limit be equal to φ. Generally speaking the angle a is comparatively small, and therefore with a more or less admissible approximation, we may accept $\sin \frac{a}{2} = \frac{a}{2}$. Then

$$r = \frac{\eta - \eta_0}{a^2}, \text{ or } r = \frac{\eta - \eta_0}{\varphi^2}.$$

Hence it follows, that the greater the angle of friction the less is the radius of the rolls for grasping the product of a given size. This means that the diameter of the porcelain rolls ought to be less than the diameter of the cast iron ones, for the coefficient of friction of porcelain and the product is greater than that of cast iron and the same product. Such material as porcelain, however, cannot always be successfully employed for making rolls, as the very great stresses set up in the process of reduction, which in such cases can have a detrimental effect upon the porcelain, must be taken into consideration.

The Materials and Design of Rolls.—The materials of which rolls are prepared must be hard and wear-resistant.

If the product is to be reduced by cutting, it is necessary that the coefficient of friction should be the least possible, as the force of friction is obnoxious here. But if the rolls operate on the principle of trituration (Fig. 136, p. 154), then the force of friction renders useful service; a high coefficient of friction, therefore, is desirable in that case. The choice of material, however, is determined by its durability, wear-resistancy, and mouldability. General practice has shown that cast iron, steel, and porcelain answer those requirements.

The iron rolls are cast so that their surface is hardened 5 to 10 mm. deep from the surface. The hardening of the surface of the rolls is brought about by casting them in metal fining-pots or by other means, which are the secrets of the factories.

The attempt to use steel was unsuccessful; it must be admitted, though, that this question has been but little treated by engineers. It is probable, however, that rolls of ingot iron with a cemented (hardened) surface would give better results than cast iron, and the engineering firms ought to work in that direction.

Porcelain rolls were first introduced by Wegmann's factory. The durability of porcelain rolls is not as great as that of cast iron, but for semolina-grinding they are indispensable. At first, some twenty years ago, the porcelain rolls were not quite satisfactory, often bursting on becoming heated, and they became rapidly and irregularly worn. Nowadays, however, the exhausting of roller mills having been improved and durable porcelain being available, they compete with cast-iron rolls quite successfully.

The composition of the roll-porcelain is approximately:

Pure china clay	61–62 per cent.
Fine quartz	16–17 ,,
Feldspar	16–17 ,,
Chalk	. 4 ,,

As regards the designs of rolls, those of cast iron are generally hollow cylinders *A* (Figs. 192 and 193) which are set on the shaft *B* hot, and are seldom keyed on. This construction (Fig. 193) is more convenient if cast; when at work the roll warms more evenly, and therefore its expansion evenly modifies the dimensions, leaving the cylindric shape unaltered.

The porcelain rolls (Fig. 194) consist of a full cylinder *A*, caught between cast-iron washers *C* by means of coupling bolts *d*. In the washers there are holes for the shaft *B*. A general view of a grooved roll is given in Fig. 195.

Position of the Rolls.—The position of the rolls in the frame materially influences the design of other parts of the machine, the degree of wear of the rolls themselves, and the compactness of the whole machine. In choosing a position for the rolls the constructor must be guided in the first place by considerations of a convenient supply of the product to the milling surfaces, and easy access for inspecting the operation. Modern practice allows eight different combinations of the rolls, which we shall examine now (Fig. 196).

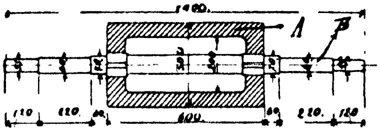

FIG. 192.

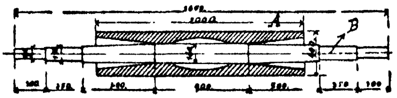

FIG. 193

The first three combinations—1, 2, and 3—relate to double roller mills. Combination 1 with the axes lying in a horizontal plane, in respect to the supply of the product and inspection of the work offers an undoubted advantage over the second, which was suggested with a view to reducing the breadth of the machine, which is important for mill-buildings deficient in space. But a material defect of the vertical position of the rolls is the more complicated feeding of them, *i.e.* the supplying of the product to the working surfaces. Combination 3 gives a diagonal disposition of the rolls, owing to which the complex construction of the feeding device is discarded, and at the same time the machine gains in compactness in comparison to combination 1. Combinations 4 and 5 are designed to afford the product two passages between three rollers. These combinations, however, should be most decidedly rejected, as the middle rolls are placed in working conditions different from those on either side. In doing double work, they wear out considerably faster than the outer rolls, owing to which the operation of the mill becomes irregular and inferior in quality. In addition, the feeding of the rolls requires

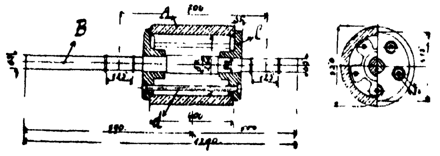

FIG. 194.

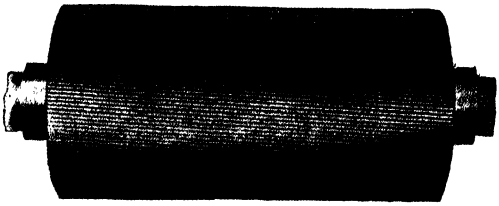

FIG. 195.

a complicated apparatus and the inspection of the work is difficult. Combination 8 offers a double passage of the product. The designs of machines of that combination, purporting to give two passages, one succeeding the other, are senseless, if only from the fact that they infringe the principle of a single treatment of the product. Machines of this type are offered for use in plain farm milling, which is quite successfully performed by stone mills.

The machines where the product after the first passage is delivered to be bolted, and the large product sifted off is then fed to the lower pair of rolls for further treatment, are complicated in construction and are now almost entirely discarded.

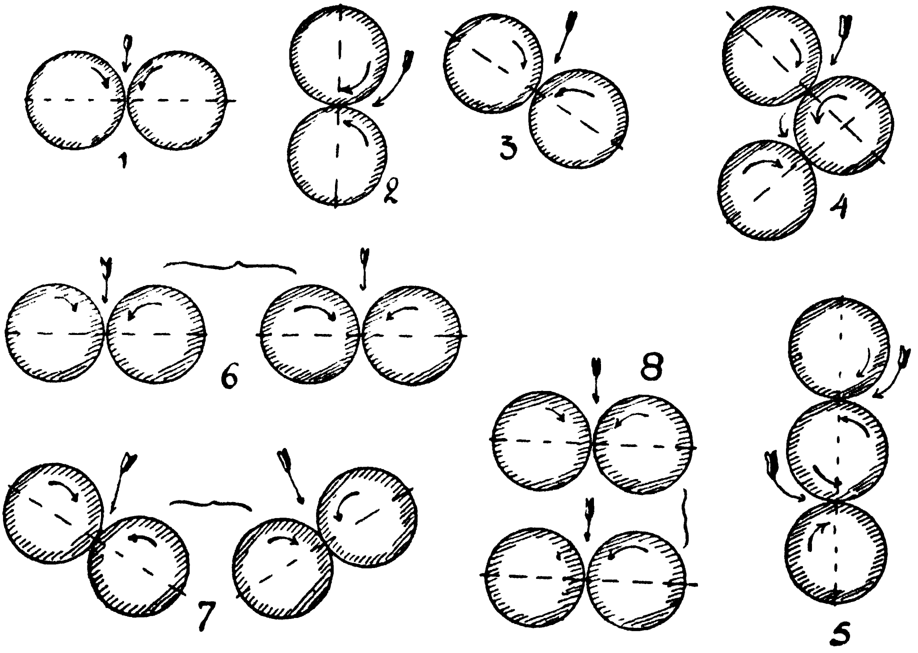

FIG. 196.

There remain but two combinations—6 and 7. The fact is that the four-roller machines are the usual modern type of the roller mill. Not only in industrial mills, but in small country mills also, two-roller mills are a rarity. This is easily understood since one four-roller mill is considerably cheaper than two mills with two rolls each.

Combination 6 is accepted by all American factories, and but at one, Hantz in Austria-Hungary, in Europe. Combination 7, with a diagonal disposition of the rolls, has been accepted by all European makers.

When studying the designs of mills with a horizontal and diagonal disposition of the rolls, we shall estimate the merits and point out the defects of those combinations.

The Character of the Surface and the Motion of the Rolls.—The process of reducing grain to flour in the form it exists in modern flour milling technics is divided into two parts. At first the grain is crushed into small particles (middlings and dunsts—very fine middlings), and then after the middlings and dunsts have been graded according to size (sifted) and quality, they are reduced to flour. The first operation is named breaking and the second is the reduction proper. At a comparatively recent date, there has been introduced into Russian milling plants another operation or second breaking of the cleaned middlings (called "Auflösung" in Germany) or the polishing of middlings, as we name it. The aim of breaking is, by only slightly crushing the integument, and obtaining as little flour as possible, to reduce the grain to middlings coarse and fine, from which it is easy to extract the particles containing bran and imparting a dark colouring to the flour.

These two fundamental operations determine the character of the working surfaces of the rolls. For breaking the rolls are covered with grooves, having an effect similar to the chipping (p. 154, Fig. 135) or cutting. The chisels on the surface of the roll are named[1] corrugations or grooves, and the rolls are said to be corrugated. In accordance with the size of the product, which is broken up into smaller particles by the corrugations, the size of the grooves, fluting or corrugations varies. The shape, size, and dispositions of the corrugations will be spoken of in a special chapter; at present the fact must be mentioned that the stock is passed through the corrugated rolls from two to nine times, depending on the kind of milling. Consequently the size of the corrugations as well as other elements, which define them, likewise are varied. But the general character of the break rolls remains the same, *i.e.* the surface is covered with grooves of a greater or smaller size. As there are coarse middlings yielded during the process of breaking, the treatment of which cannot be performed on break rolls, they are separated and conveyed to special machines, also with corrugated rolls, for further reduction. Such rolls are called rebreaks in Russia and are used almost exclusively in Russian mills (the Germans call them "Koppenstühle"). Thus both first and second break rolls have a corrugated surface.

For the reduction of cleaned coarse and fine middlings the surface of the rolls is smooth. Here the reduction is performed on the

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[1] Corrugations, grooves, flutes are all quite synonymous terms. "Grooves" are perhaps more commonly spoken of in England than either of the other terms.

principle of trituration (p. 154, Fig. 136). When studying the principles of reduction, we saw that the work of trituration is performed by the force of friction Nf, where N is the pressure of the working organ upon the product, and f the coefficient of friction of the product against the working surface. The greater f is, the less is the pressure of the rolls upon the stock, and the less will the wear of the working surface and of other parts of the machine be. Besides that, if the pressure of the rolls upon the product be heavy, the quality of the flour deteriorates; the flour is "dead," *i.e.* has a low baking quality, as proved by experiments. Great pressure produces bad results in the milling of flour of high quality, while the lower kinds are less influenced by it. For this reason the surface of the grinding rolls should have the largest possible coefficient of friction f. In this respect porcelain rolls or the dull surface of cast-iron rolls produce satisfactory results, though the dull surface of the cast iron becomes polished rapidly and requires frequent renovation.

To procure flour out of the branny particles (dark middlings), a heavy pressure has to be applied, which the porcelain cannot support. The dull surface of the cast-iron rolls is so rapidly worn, that there is no sense in using it. Therefore a polished cast-iron surface has to be used and a strong pressure given to the rolls, so as to obtain a sufficiently great force of friction Nf.

Thus we have three kinds of roller-surfaces: (1) corrugated for breaking, (2) rough surfaces with a large coefficient of friction (porcelain, dull cast iron) for reducing the middlings, and (3) the smooth-polished cast-iron surface for milling the lower kinds of flour.

Let us now turn to the character of motion of the rolls.

When studying the movement of the product in the working space of the rolls, we noticed that the rolls rotate in opposite directions, pushing the grain, or particles of it, in the direction of the line of grinding. The greater the revolving speeds of the rolls, the higher is their capacity. But this velocity has a limiting signification, which is determined by the degree of heating of the product, which must not exceed 30° to 40°, otherwise the flour may likewise become deadened. The limiting signification of the circumferential velocities of the rolls will be given later, while it must be pointed out now that their magnitudes are different for each roll.

This is indispensable to obtain a cutting effect on the corrugated rolls and trituration on smooth rolls. If the velocities of both the rolls were equal, the stock would be chipped radially on the corrugated rolls, and would blind the space between the corrugations by a radial pressure.

A continued operation of the rolls would lead to a crushing of the product to cake, if the grain were sufficiently soft, or to flour, if it were very hard. Consequently, there could be no idea of breaking in the sense we understand it. The same kind of crushing the product to cakes would take place on the smooth rolls too.

Our aim, however, in the breaking process is to obtain a uniform product approximately corresponding to half the size of the least distance between the working surfaces. For this reason different velocities are imparted to the rolls.[1] Then the slowly rotating roll carries the product to the one revolving rapidly, which cuts off part of the product with the chisel of the corrugation in the breaking process and chips it off by the force of friction in grinding. Only under such conditions does the direction of the active force coincide with the route of the product, and part of it, the size of which is determined by the distance between the working surfaces, is separated off. It is important to note that even if it were possible to avoid crushing the product to cakes by rolls rotating with equal velocities, the pressing forces, acting perpendicularly to the direction in which the product travels, would crush it to particles of various sizes, depending but little on the least distance between the working surfaces.

The circumferential velocity of the rolls is determined according to their diameter and number of revolutions, the relation of velocity of the slowly and the rapidly revolving rolls varying between 1·1 : 1 and 5 : 1. The following table gives a clear idea of the limits of the sizes of the diameters, number of revolutions, and velocities of the rolls. In this table D denotes the greatest and the least diameters of the rolls, N the number of revolutions of the fast roll, V their circumferential velocities in metres per second, $V : V_1$ the differential velocities of the fast and slow rolls.

TABLE XXI

Rolls.	D mm.	N.	V mt. per sec	$V : V_1$
6–9 breaks	150–350	225–480	3·0–4·7	2·5 : 1–5 : 1
2–5 breaks	220–380	250–600	3·0–6·0	2 : 1–3 : 1
1–3 rebreaks	220–350	250–400	2·5–3·5	1·2 : 1–1·5 : 1
Grinding cast iron . .	150–400	180–380	3·0–3·6	1·1 : 1–1·3 : 1
Grinding porcelain . .	220–350	150–180	2·0–2·75	1·1 : 1–1·5 : 1

The factories in Europe, England excepted, generally give the averages of those quantities, namely, D of the corrugated rolls 220–300 mm.,

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[1] This is known as the "Differential."

sharp angles, characterising it only by the size of the angle of the corrugation itself. Fig. 197 shows us the angle of 50°, established by practice for corrugations in high milling of wheat, and Fig. 198 reproduces the shape of the corrugation with an angle of 75° employed in the simplified wheat and high rye milling.

The drawings of Figs. 197 and 198 prove that those angles of corrugations are easily obtained. The front facet of the corrugation (Fig. 197) forms a diametrical plane of the rolls for an angle of 50°, and a segmental plane (Fig. 198) for an angle of 70°–75°, the *r* in the second case being equal to $\frac{2}{7}-\frac{1}{3}$ *R*.

It is not difficult to show (Fig. 197) that given such angles and a certain number of corrugations, their height is a quite definite quantity. Indeed, if we denote through *n* the number of corrugations to a centimetre of circumference of the roll, *t* their height, and $h=\frac{10 \text{ mm.}}{n}$ the circular pitch of the corrugations,[1] then from the triangle *ABC* we shall obtain for *t* in millimetres :

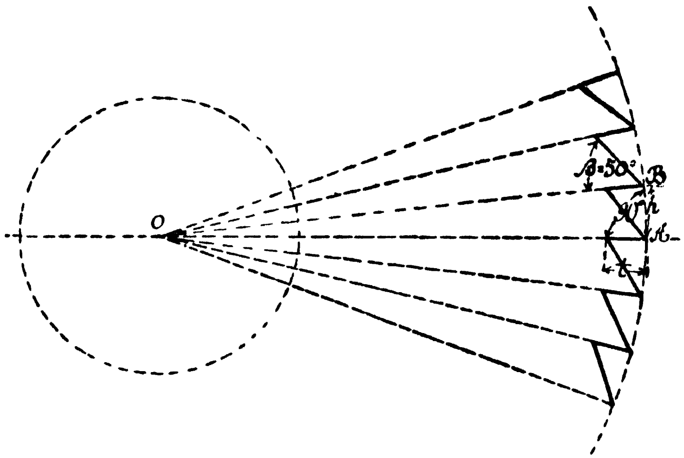

FIG. 197.

$$t=h\times tg(90-\beta) \quad . \; . \; . \; . \; . \; . \; . \; . \quad (1),$$

supposing, with a slight error, that the tangent passing through the point *A* of the corrugation passes at the same time through its point *B*. Hence it is clear that with an increased number of corrugations to a centimetre their *t* decreases. If we take the number of corrugations *n*

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[1] The circular pitch of the corrugations is the part of the area between two points of the corrugations, but for the simplicity of the inference *h* may denote a chord of this arc or a tangent, as the mistake occurring from this inference is insignificant.

equal to 5 and 10, and $\beta = 50°$, then, according to formula (1) we obtain corresponding t's in millimetres :

$$t = \frac{10}{5} tg 40° = 1{\cdot}68 \text{ mm., and } t = \frac{10}{10} tg 40° = 0{\cdot}84 \text{ mm.}$$

The shape of the corrugations, having an angle of 50°, defined by the construction derived from Fig. 197, is generally used in high grinding. For the medium, low, and rye grinding general practice has established the shape of corrugations given in the design on Fig. 198, the radius r accepted for the medium grinding being less than the one used in low and rye grinding.

Let us see how the height of the corrugation will be defined in this case, the number of corrugations to a centimetre being given.

Having denoted the angle of the corrugation β, the angle formed by the radius R passing through the point of the corrugation and its lower facet γ, the circular pitch of the corrugation h, and its height through t, we can define the height t of the corrugation.

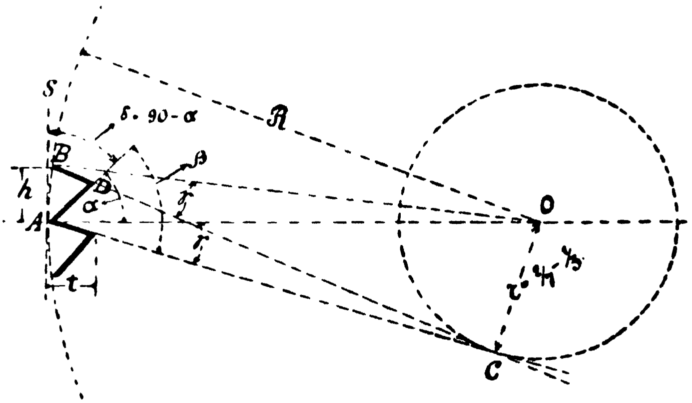

FIG. 198.

The angle γ, usually equal to 75°, and the radius of the roll R and r being given, previously to defining t the angle γ and the circular pitch of the corrugation h have to be defined in accordance with the quantities given.

The angle γ is deduced from ΔAOC by sin γ,

$$r = R \sin \gamma, \text{ hence } \sin \gamma = \frac{r}{R}.$$

The circular pitch of the corrugation h may be easily defined, with a slight error, either as an arc AB, taken as a straight line, or as its chord. In the latter case the circular pitch h is defined as the side of an oblique-angled triangle ABD.

We shall take the second case, it being more simple and giving an insignificant error. Granted that the tangent AS passes through the top of the second corrugation B, *i.e.* coincides with the chord, and forms likewise with the radius OB a right angle. Then we obtain $\angle BAD = 90 - \alpha$, $\angle ABD = 90 - \gamma$, and, consequently, $\angle ABD = 180 - (90 - \alpha) - (90 - \gamma) = 180 - (\alpha - \gamma) = 180 - \beta$.

The triangle ABD gives:

$$\frac{AB}{\sin\,(180-\beta)} = \frac{BD}{\sin\,(90-\alpha)};\quad AB = h.$$

If t is the height of the triangle ABD dropped on to AB, *i.e.* the height sought for of the corrugation, we obtain $t = BD \sin\,(90-\gamma)$. Hence, by substituting the signification in the place of BD and performing the simplifications $(\alpha = \beta - \gamma)$, we obtain the t sought for:

$$t = gh\frac{\cos\,(\beta-\gamma)\,\cos\gamma}{\sin\beta} \quad . \; . \; . \; . \; . \; . \; . \quad (2).$$

In this formula all the quantities are known, for h is defined in accordance with the number of corrugations per centimetre, the angle β is given, and the angle γ is defined, as explained above.

If we take the diameter of the roll to be 250 mm., *i.e.* $R = 125$ mm., $r = 40$ mm., $\beta = 75°$, and, having defined γ out of the formula $\sin\gamma = \frac{r}{R} = \frac{40'}{125}(\gamma = 18°40')$, substitute them into the formula (2) then, the number of corrugations being 5 and 10 to 1 centimetre, we obtain after a calculation:

$$t = \frac{10}{5} \cdot \frac{0{\cdot}949\,.\,0{\cdot}554}{0{\cdot}970} = 1{\cdot}08 \text{ mm.}$$

$$t = \frac{10}{10} \cdot \frac{0{\cdot}949\,.\,0{\cdot}554}{0{\cdot}790} = 0{\cdot}54 \text{ mm.}$$

Having reckoned out and compared the signification t of the corrugations for high milling, with the same number of them 10 per 1 cm., and an angle of 75°, we obtain $t = 0{\cdot}76$ mm. This shows that the height of the corrugations in the second case is considerably less—0·54 mm., *i.e.* by 0·22 mm.

Besides the corrugations of a triangular shape just examined, the use of corrugations with rounded cutting edges has been suggested. But this form is justified neither by theory nor by practice, whence the theoretical premises are deduced. The third shape of corrugations, trapezoidal in section, as shown on Figs. 199 and 200, is still recommended by some factories and specialists,[1] who maintain that the cutting of the grain, or

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[1] Fr. Kettenbach, *Der Müller und Mühlenbauer*, 1907.

particles of it, is more perfect in that case, for the integument of the grain remains whole. There is no logical justification for this, however, for in the breaking process the cutting up of the bran is unavoidable. Further, the cutting of such corrugations is undoubtedly in worse condition even by the type itself of the cutting operation, not to mention the fact that the friction of the flat part of the corrugations against the product generates superfluous work.

The French factory, Teisset, Chapron & Brault Fr., very seriously recommends corrugations, shown on Fig. 201 with a large circular pitch for the main corrugation, and small intermediate corrugations, maintaining that such an arrangement increases the yield of semolina, and consequently the number of breaks may be reduced. The utility of this arrangement, however, is doubtful, for the inner corrugations will not work. In addition, the corrugating of the rolls has to be performed either with a forming tool or in two turns, which presents great difficulties.

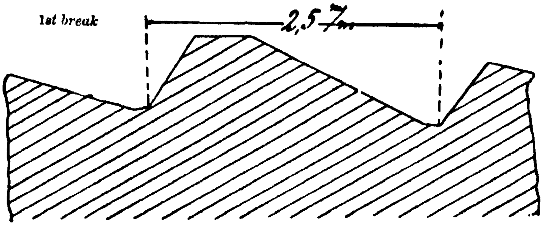

FIG. 199

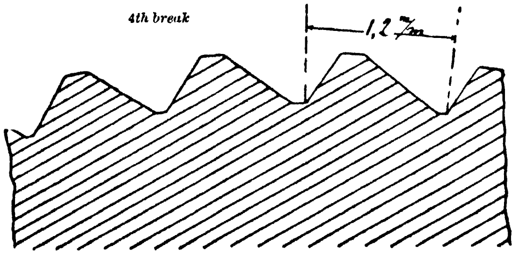

FIG. 200.

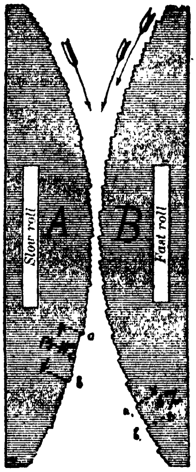

FIG. 201.

For feed milling, G. Barat (France) has lately suggested the use of pyramidal corrugations obtained by cross-corrugating at a right (Fig. 202) and a sharp (Fig. 203) angle, but up to the present corrugations of this shape have been used in America only for stone-crushing and compressing refuse in the production of oil from cotton seeds.

This is all that has been evolved by practice and theory regarding the shape of corrugations.

Let us see now what requirements the shape of corrugations should answer, from the point of view of the least expenditure of energy in the breaking process.

The aim of the breaks is to obtain as many middlings as possible with the least possible breaking of the bran coverings. The ideal position of the grain in first break rolls is shown in Fig. 204. In this case the grain would be broken through its crease. The transversal position given on Fig. 205 is less favourable for the first breaking.

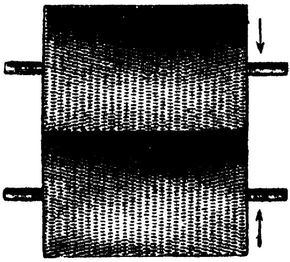

FIG. 202.

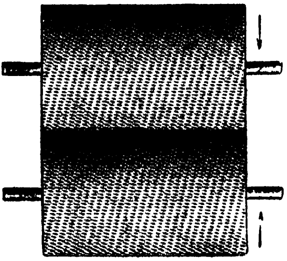

FIG. 203.

From the point of view of the theory of cutting, the shapes of corrugations examined exclude all possibility of cutting. Indeed, the shape of corrugations, defined by Fig. 197, gives a cutting angle of 90°, for this angle is defined by the front edge of the chisel (Fig. 204) and the direction of its motion, which may, with an insignificant error, be regarded as straight. The cutting force[1] $P = P_3 tg a$, for P_2, the force of pressure, is perpendicular to the front edge of the chisel A; P_3, the chipping force, is perpendicular to the direction in which the chisel moves, and a is the cutting angle. If $a = 90°$, then $P = \infty$. That is to say, the grain is not cut, but broken. Should the shape of the corrugation be as defined by Fig. 198, $a > 90°$. Then P is a negative quantity, which means that the breaking of grain is performed under worse conditions than in the first case (Fig. 206). In the so-called "Hochschrot,"

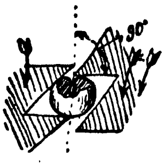

FIG. 204.

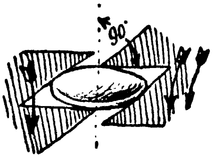

FIG. 205.

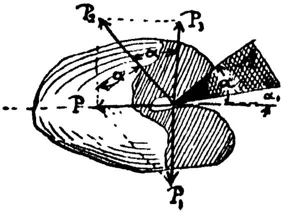

FIG. 206.

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[1] See Prof. I. Time's theory of cutting.

when the slowly-rotating roll is smooth (Fig. 207) or has fine corrugations (Fig. 208), it is quite plain that the grain is broken and that part of the bran, coming in contact with the smooth or finely-cut surface of the slowly revolving roll, is ground. That is the reason why "Hochschrot" produces the so-called "blue flour," which is generally extracted on the brush machine.

Now, if we set before ourselves the problem of obtaining a perfect cutting of grain or particles of it in the breaking process and leaving the integument whole, with the view of obtaining a greater amount of broad bran, then the fast roll has to be supplied with corrugations having cutting angles of 45°, as shown on Fig. 209, which proves that the feeding roll may have ordinary corrugations. The cutting of corrugations of that shape on cast iron, however, would present some difficulty by reason of its brittleness. Therefore, taking into consideration the incline of the corrugation in regard to the generating circle of the roll, this angle may be accepted as exceeding 45°, namely 60–65°, which has a small cutting effect.

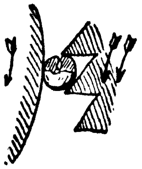

FIG. 207.

FIG. 208.

FIG. 209.

A solution of this question is likewise possible if the rolls are made of ingot iron, and not of cast iron with a hardened surface. It is quite possible to use ingot iron (open-hearth steel). The rolls may be considerably lighter, and a cementation of the corrugations which would guarantee their wear to be less than that of the corrugations on cast-iron rolls is attainable, as proved by Professor Zworykin's experiments.[1]

The question of the preparation of rolls of ingot steel is very important. Serious attention ought to be paid to it by engineers, because a satisfactory solution of that question would cause a revolution in respect to the shape of the corrugations, resulting in a more perfect breaking process, owing to the sharper angle of the corrugations.

Incline of the Corrugations.—Two directions for the cutting edges of the corrugations were suggested at the beginning of the development of

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[1] See "Cementation of Iron by Gas," by Prof. Zworykin, *Russian Miller*, 1911, No. 2

roller-milling; down the circumference of the roll and along its generating circle. But this produced unsatisfactory results. For this reason general practice in the end adopted the direction of the corrugations at an angle to the generating circle of the roll.

In their attempt to give a theoretical explanation of the results obtained in practice, some of the German authors (Fr. Kettenbach and F. Baumgartner) regard the breaking down of grain or particles of it as a process of shearing. Fig. 210 represents the edges of two corrugations: N of a slowly rotating roll and N_1 of a rapidly revolving one. The cutting of the grain takes place when the corrugations cross at the point O. For the sake of clearness we shall carry this point out to O_1. When the edge of the corrugation N_1 presses upon the berry, the direction of the cutting force P is perpendicular to the direction of the corrugation. If the inclinations α (the angle α in respect to the generating circle) of the corrugations of both rolls are equal in size, but opposite in their directions, the angle between them is 2α. Let us divide the active power P according to the law of parallelograms into Z horizontal and S vertical. The cutting forces will be $S-S$. The force Z tends to push the product in a horizontal direction, and if this force exceeds the force of friction of the product against the surface of the corrugation, it will drive the product to the end of the rolls, having annulled the cutting force S. The forces P and Z depending on $\angle\,\alpha$ will be formulated thus:

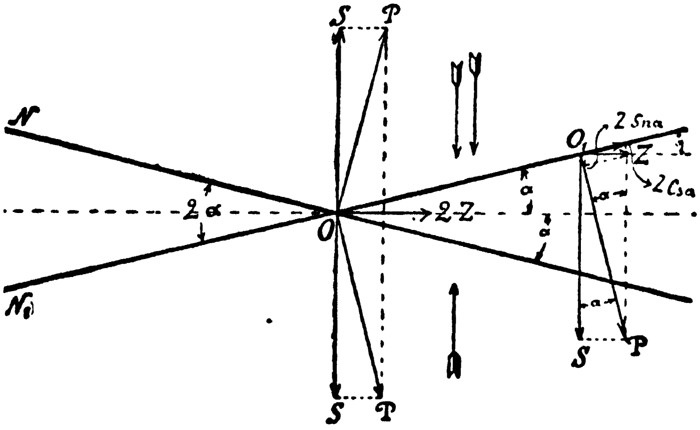

FIG. 210.

$$S = P\cos\alpha\,;\quad Z = P\sin\alpha.$$

It is evident that the power Z must not exceed Pf, *i.e.* the force of friction of the product on the cast iron, where P is the normal pressure and f the coefficient of this friction. The highest and the limit signification of Z is when it equals Pf. Hence it is clear that $\angle a$ depends on f, which may be defined by experiment.[1]

The coefficient of friction $f = tg\varphi$, φ being $= 16$–$18°$ for cast iron, and up to 22° for porcelain. But if $Z = Pf = P \sin a$, the result is:

$$\operatorname{Sin} a = f = tg\varphi,$$

i.e. $\angle a$ is defined as an angle, the sine of which is equal to the tangent of the angle of friction.

Coming to a critical estimation of F. Baumgartner's theory, we must say, that the comparison of the action of corrugations to that of shears is not accurate enough.

In the cutting with ordinary shears the $\angle a$ is variable, its limit being zero, whereas in the operation of the rolls $\angle a$ is a constant quantity. Consequently, in the present case the cutting action is performed by non-parallel edges, in opposition to the normal case, when the edges of the cutting instrument are parallel to each other. In regard to the expenditure of cutting force, the cutting with slanting corrugations is disadvantageous, as it leads to the loss of force spent in pushing out the product (force Z).

How is, then, the fact to be explained that general practice has evolved the slanting corrugations ?

If the sides of the cutting corrugations were parallel to the generating circle, the cutting would be effected periodically. But if an inclination be imparted to the corrugations, *i.e.* the cutting edges are cut on the curved surface of the roll-cylinder, then the product is subjected to an uninterrupted cutting action. In the second case a steady cutting force is attained, and consequently a steady load, which is very important in the work of every machine.

The idea may be elucidated by drawing an analogy between a rapidly rotating roll and a milling cutter for metal or wood, where the cutting edges are directed along a curve of the cylinder. Still, we must say that this is of no importance in the operation of planing machines, for they run with great rapidity (2500–6000 revolutions per minute), owing to which the intervals parallel to the generating circle are quite insignificant (0·006–0·002 of a second), and when four knives are in operation, scarcely influence at all the steadiness of the load.

The small number of revolutions of the rolls, which is accepted now, makes an inclination of the corrugations indispensable. But this generates the Z forces, which tend to a one-sided pressure of the axis upon

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[1] Prof. Kick, *Mehlfabrikation*, 1894.

the bearing, which, in its turn, results in the wear of only one collar of the bush of the bearing, the right or left hand one—this depends on the direction in which the corrugations are inclined—and the wear of one shoulder of the axis of the roll. It is obvious that there will be no pressure upon the axis only in case $a=0$ ($Z=P \sin a=0$), *i.e.* if the corrrugations are cut in a generating circle.

Tending to discard the inclination of the corrugations, which causes the injurious pressure upon the axis, we must increase the number of revolutions of the rolls. If we were to bring the speed of the fast roll to 1000 revolutions per minute, with a corresponding increase in the speed of the slower roll, the direction of the corrugations might be laid in the generating circle, and the shape adopted, that in Fig. 209. In this manner we should obtain a steady load, annul the pressure against the axis, and considerably raise the capacity of the mills. That is the reason why the question concerning the preparation of cemented iron rolls should receive earnest consideration.

In closing the chapter on the inclination of the corrugations, we must remark that it depends entirely upon the coefficient of friction of the product upon the material of the rolls. If experiments prove that f for the grain is smaller and increases for semolina in accordance with the diminution of its size, then the $\angle a$ must likewise gradually increase, as it clearly follows from the formula $\sin a=tg\varphi$ (for the limit of signification $Z=Pf$), because the $\angle \varphi$ modifies within the limits of 12° and 25° maximum. The inclination of the corrugations, therefore, has to be accepted at 10 to 16 per cent., *i.e.* at 10 mm. to 16 mm. to 100 mm. of length of the roll.

Position of the Cutting Edges of the Corrugations.—The position of the cutting angles of the corrugations in respect to the product treated plays no small part in the process of breaking the berry. The practice of this process in Russia generally recognises but one position of corrugations, viz. the product is fed in by the sharp edges of the slowly revolving roll and is subjected to the cutting effect of the likewise sharp edge of the fast roll. The general practice partly of the West and chiefly of America has evolved four types of position for corrugations.

Those types are to be seen on Fig. 211. Here *a* shows a sharp edge opposite to a sharp one, *b* sharp to dull, *c* dull to sharp, and lastly, *d* dull to dull.

The Germans recognise only three types of position of the corrugations, namely, *a*, *b*, and *d*, while in America also the type *c* is used. In F. Baumgartner's opinion the type *a* is to be employed for breaking, type *b* for loosening the bran, and type *d* for rebreaking of pure middlings (" Auflösing " named " Polishing " in Russian milling).

The well-known German factory form. Seck Bros. and the Austrian firm of Selmar Hecht (Vienna), apply the one type *a* for the whole breaking process.

Let us examine every one of those types apart.

Undoubtedly in high milling the type *a* should be used only while the break semolina is sufficiently large and sharp. But beginning with the fifth break, it ought to be replaced by the type *b*, because only in that case can a large quantity of broad bran be obtained and the coarse meal and middlings be less dirtied by the small particles of reduced bran.

It is evident that if the product is fed in by the dull edges, the sharp edges of the fast roll will scrape out the middlings without breaking up the covers, which offer greater resistance to the cutting force.

When we turn to the last break, the purpose of which is to clean the bran and separate from it the mealy particles of endosperm lying immediately beneath the integument, then, to avoid the reduction of bran, it is reasonable to use the type *d*. The opinion expressed by Baumgartner, who recommends the type *b* for the loosening process, is to be regarded as erroneous, for the cutting of the bran is inevitable in that case.

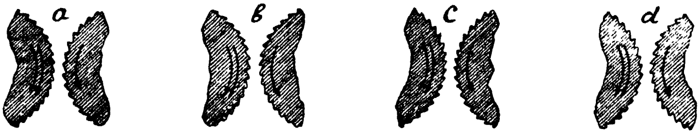

FIG. 211.

The type *d* must be employed for polishing the middlings (Auflösung), *i.e.* the scratch rolls, and for the passages following after the first one in rye milling.

As to the type *c*, it is used only in America partly in the rye, partly in maize milling, mostly for the first passage. In several American mills, however, we had the occasion to see the type *c* applied to the grinding of very hard wheats. One of the oldest American firms, Nordyke & Marmon Co., in Indianapolis, also mentions the use of type *c* for very hard wheats, commencing with the third break, though it gives no definite considerations in favour of that type.

The Number of Corrugations.—The number of corrugations in the breaking passages depends on the degree of perfection of the milling. In high, protracted milling the number of corrugations increases more slowly than in the semi-high. In the cases where one is obliged to use the same pair of rolls for two passages (as in the sack milling or in the semi-automaton), an intermediate number of corrugations is taken.

The number of corrugations is generally defined to a centimetre of the circumference of the roll; in Russia, however, the number of corrugations is generally given per inch.

The table adduced below gives a general view of the number of corrugations for breaking and cleaning of the bran (the last passage) in different kinds of milling. There the average numbers, evolved by practice, are given. In the same table will be pointed out the desirable inclination of the corrugations and the position of their cutting edges according to the above-mentioned types.

This table must be regarded as giving the normal quantity of corrugations to a given number of breaks. As the number of breaking passages fluctuates, according to the type of the grinding or the hardness of the wheat, the number of corrugations on the intermediate breaks may vary. The first and the last breaks, however, have to retain the mentioned numbers of corrugations, if it is desirable to obtain broad bran. For the first break (if there is no "Hochschrot," *i.e.* breaking of grain along the crease) there remain three to four corrugations to a centimetre, and for the last twelve corrugations.

It must be noted that we considered the number of corrugations in connection with the generally accepted differential velocity of rolls, and with the normal number of revolutions for the fast roll, established by German and English factories and based on the normal productivity of the breaking process. For this reason we give tables of different types of grinding here, which also characterise the definite productivity of the breaking process in connection with the accepted corrugating.

From this table we learn that for high grinding (eight breaks without "Hochschrot") with a normal number of corrugations and spiral, the joint working length of the break rolls to one sack of grist per day is defined to be 21–24·7 mm. To obtain the length of the first break rolls for a mill of, for instance, 300 sacks capacity of high grinding per twenty-four hours, we must evidently multiply 2·7–3 mm. by 300. That will give us the length of the rolls for the first break, which will be 810 to 900 mm. in eight breaking passages. This being the length, the general incline of the corrugations is 120 mm.

For medium grinding, with a normal number of corrugations and their incline, the joint working length of the break rolls to one sack of grist per day is 19·8–22·3 mm., for low grinding 17·9–20 mm., and lastly 23·3–24·5 mm. for English grinding.

TABLE XXII

NUMBER OF CORRUGATIONS, THEIR INCLINATION AND POSITION

The Order or Name of Passages or Breaks.	High Russian or Hungarian Grinding.		Common High German Grinding.		Semi-high Grinding.		English Grinding.		German Rye Grinding.		Hungarian Maize Grinding.		Incline of Corrugations in mm. per 100 mm.	Type of position of Corrugations
	NUMBER OF CORRUGATIONS TO A CM. AND TO AN INCH.												For High Russian or Hungarian Grinding.	
	Per cm.	Per inch.	Per cm.	Per inch.	Per cm.	Per inch.	Per cm.	Per inch.	Per cm.	Per inch.	Per cm.	Per inch		
The breaking of grain along the crease (Hochschrot) . .	4	10·0	...	...	...	...	...	...	...	...	...	...	10 mm.	...
1st break . . .	3–4	10·0	4·0	10·0	5·5	14	4·5	11·0	6·0	15·0	3	7·5	10 ,,	*a*
2nd ,, . . .	5	12·5	5·0	12·5	6·5	16	6·5	16·0	6·5	16·0	7	17·5	11 ,,	*a*
3rd ,, . . .	6	15·0	6·5	16·0	8·0	20	7·5	18·0	6·75	17·0	9	22·5	11 ,,	*a*
4th ,, . . .	7	17·5	7·5	18·0	12·0	30	11·0	27·5	7·0	17·5	11	27·5	12 ,,	*a*
5th ,, . . .	8	20·0	9·5	23·0	...	...	...	...	7·5	18·75	...	...	12 ,,	*b*
6th ,, . . .	9	22·5	12·0	30·0	...	...	...	...	8·5	21·0	...	...	13 ,,	*b*
7th ,, . . .	10	25·0	...	...	...	...	...	...	9·55	24·0	...	...	14 ,,	*b*
8th ,, . . .	12	30·0	...	...	...	...	...	...	...	...	...	...	15 ,,	*d*
1st rebreak or scratch	6	15·0	...	...	...	...	...	...	...	...	...	...	11 ,,	*a*
2nd ,, . . .	8	20·0	...	...	...	...	...	...	...	...	...	...	12 ,,	*a*
3rd ,, . . .	10	25·0	...	...	...	...	...	...	...	...	...	...	13 ,,	*b*
4th ,, . . .	12	30·0	...	...	...	...	...	...	...	...	...	...	15 ,,	*d*

TABLE XXIII

The Number of Corrugations, their Inclination, and the Length of the Rolls in each Break per One Sack of the Treated Product per Day (24 Hours)

High Grinding.				Medium Grinding.[1]				Low Grinding.				English Grinding.			
Break.	Number of Corrugations to 1 cm.	Incline of Corrugations in per cent.	Length of Rolls in mm. per Sack.	Break.	Number of Corrugations to 1 cm.	Incline of Corrugations in per cent.	Length of Rolls in mm. per Sack.	Break.	Number of Corrugations to 1 cm.	Incline of Corrugations in per cent.	Length of Rolls in mm. per Sack.	Break.	Number of Corrugations to 1 cm.	Incline of Corrugations in per cent.	Length of Rolls in mm. per Sack.
I	3–4	10	2·62–3·0	I	4·0	10	3·0–3·15	I	5·5	11	6·0–7·5	I	4·5	10	4·87–5·25
II	5	11	3·75–4·12	II	5·0	10	4·5–4·87	II	6·5	12	4·87–5·25	II	6·5	10	6·75–7·5
III	6	11	3·75–4·12	III	6·5	12	4·5–4·87	III	8·0	13	3·37–3·75	III	7·5	12	6·75–7·5
IV	7	12	2·55–3·37	IV	7·5	12	3·0–3·75	IV	11·0	15	3·37–3·75	IV	11·0	14	4·87–5·25
V	8	12	2·62–3·0	V	9·5	12	2·62–3·0								
VI	9	13	2·25–2·62	VI	12·0	14	2·25–2·62								
VII	10	14	2·25–2·62												
VIII	12	15	1·87–2·25												

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[1] Common high grinding in Germany.

Consequently, with a normal number of inclined corrugations, the following capacity is defined for four kinds of grist (in lbs.) to a centimetre or an inch of the working length of all the breaking passages per twenty-four hours :

TABLE XXIV

CAPACITY OF THE ROLLS PER TWENTY-FOUR HOURS TO 1 CM. OR 1 INCH IN LBS.

Kind of Grinding.	Per 1 cm. of Length of the Roll.	Per 1 inch of Length of the Roll.
	lbs.	lbs.
High grinding . . .	107–125	268–313
Medium „ . .	122–135	302–336
Low „ . . .	134–153	333–382
English „ . . .	97–117	243–302

But as the capacity of the breaking process is defined by the absolute and differential velocity of the rolls, the number of corrugations and the other elements characterising the corrugating (their inclination and position) were dealt with in connection with the generally accepted velocities of the rolls : the absolute velocity of rotation of the rolls is 3·5–4·5 metres per second, and the ratio of velocity of the slow and fast rolls is 1 : 2·5–1 : 3.

Here we may close our investigation of the question concerning the corrugating of rolls. All that has been said proves that this question, which opens out a new line of thought, as, for instance, of the shape of the grooves in connection with the investigation of the process of breaking, demands serious experimental treatment.

Since the time of Professor F. Kick and K. A. Zworykin—in the course of almost twenty years—this question has not stirred from its place, whereas in other regions of mechanical technology we witness gigantic progress.

3. *Adjustment of the Distance between the Working Surfaces*

The degree of reduction of the product depends not only on the form (corrugated or smooth) but also on the distance between the working surfaces. In accordance with the size and the hardness of the product, it is necessary to alter the distance between the break rolls with the view of obtaining the quantity of coarse and fine middlings given in the plan, as the machines, which divide the product according to its quality (purifiers), are calculated for a certain quantity and size of this product. For this reason every roller-mill must be furnished with a mechanism which will afford the possibility of adjusting the distance between the rolls at any moment. The necessity of adjusting the distance is likewise evident in the case of smooth rolls, on which coarse and fine middlings of various sizes have to be reduced, and meal of different fineness obtained. The possibility of adjusting the distance between the rolls can be attained by making only one of them adjustable, so as not to complicate the construction of the machine.

The adjusting mechanisms are named "brakes."[1] As it is impossible to reckon upon an ideal freeing of the grain of metal admixtures before milling, and there is also the possibility of their dropping in out of the machinery during grinding, the construction of the brake must be such, that in case of a nail or any other metal object falling in, the surface of the rolls shall not become spoilt, or the driving organs of the machine break. The brakes satisfying those requirements are called tension brakes.

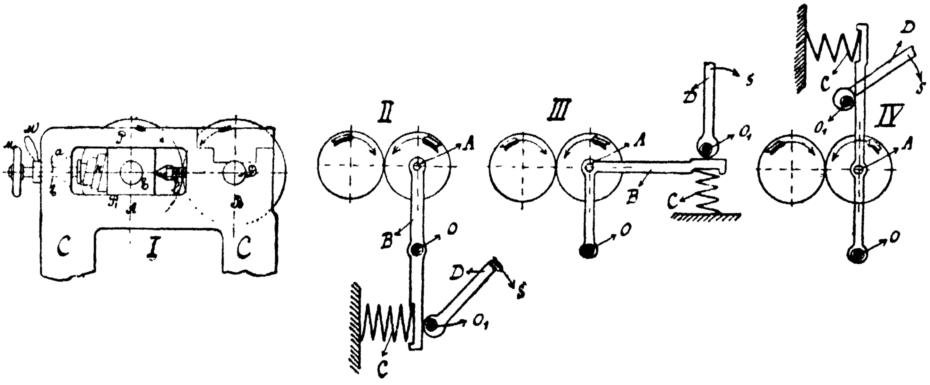

FIG. 212.

We shall explain the idea of the tension brake on schematic constructions.

On Fig. 212 we have four sketches of tension brakes. Sketch 1 exhibits the form of the simplest brake. The roll *B* is set in stationary bearings *D* fixed in the frame *C* of the mill. The roll *A* lies in bearings *E*, which may be displaced to the right and to the left within the slippers *P*–P_1 of the frame. If the rolls are to be set at a certain distance, the bolts *l*, screwed into the frame with their threaded part and their conic heads resting against the adjustable bearing *E*, are turned. With the aid of these bolts also the evenness of the axes of the rolls may be adjusted. From the opposite side, the bearings are pressed by the springs *k*, resting

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[1] This term is used throughout the work to denote what is now generally termed in England "adjustment mechanism" or "adjustments." It is short, and correctly expresses what otherwise entails needless circumlocution.

on the collars of the bolt *a* screwed into the hub *b* with a corresponding thread. In this manner we have obtained the desired distance between the rolls and a definite grade of pressure upon it by the spring *k*. If a piece of iron that the rolls cannot break down passes in between them, the pressure is communicated to the journals of the rolls. Now, as the spring is calculated to withstand a certain utmost strain for the reduction of the product, whereas the pressure of the metal particle exceeds it, the springs acted upon by this pressure will contract and the bearings *E* move to the left. The widened space between the rolls allows the metal particle to pass through without damaging the machine, after which the spring pushes the bearings back into their former position.

To adjust the tension of the springs the bolts *a* are screwed in or out by means of a hand-wheel *M*. To prevent the screwing out of the bolts *a*, there are nuts with wings M_1 on the outside, serving as lock-nuts.

The type of brake just examined has the defect, that it requires a complicated mechanism for the throwing out of the rolls, as the adjustable bearings move rectilinearly. Therefore the brakes shown on sketches *II*, *III*, and *IV* are more rational types of construction. The right-hand roll of all those constructions is adjustable. Its adjustable bearing *A* is set in a movable arm *B*, which has a stationary axis of rotation *O*. The other end of the arm rests on the spring *C*, which may be adjusted as in the first case. On the side opposite to the spring there is set a lever *D* with an eccentric on a stationary axis O_1. The springs in the *II* and *III* plans are compressed by the end of the arms *B*, and stretched in the *IV*th. Plan *II* represents a lever of the first order, and the plans *III* and *IV* levers of the second order. The advantage of these three designs lies in the fact that owing to the pressure being transmitted through levers, there is no need of a spring so strong as in plan *I*.

To throw out the rolls it is sufficient to turn the lever *D* as pointed by the arrow *S*. During the run of the rolls "in gear" the lever *D* is fastened by various means, to be examined later. The construction of the brakes on these plans may be infinitely varied according to the type of mills.

Besides the spring brakes there have been suggested constructions where the spring is replaced by a weight. The plan of one of such brakes, corresponding to the second spring plan, is shown in Fig. 213. The spring is replaced here by a crank mechanism with a weight *G*, rotating on a rigid axle d_2. The setting of the rolls at the distance required, and the dressing of the parallelity of their axes, is done by means of the bolts s and s_1. When the pressure upon the adjustable roll *b* exceeds the normal, the deflecting tail n of the lever transmits the pressure to the crank mechanism through the bolt s_1, and after the hard particle has passed between the rolls the weight G brings the roll to its established position.

From time to time the inventors patent such weight brakes. But we must say that this bulky appliance offers no advantages in comparison to the spring brake and at the same time complicates the construction of the roller mill ; for this reason such makes ought to be rejected.

As regards the first design, it is to be met with in the simplest American mills for crushing hard materials (quartz, &c.). Of the roll sets for mills there is known only one American construction of Noye's in Buffalo, who very unsuccessfully adapted the principle of direct action of the pressure of the spring (Fig. 214). The resistance of the spring here is placed below the axes, therefore the pressing force P gives a vertical component F_1 and a couple Th, which causes friction of the bearings in the guide parallels. It is only the component F, directed to the left, that transmits the pressure to the spring. For this reason the mechanism must be less sensitive.

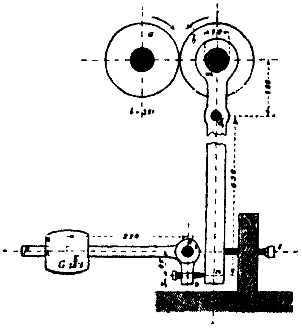

Fig. 213.

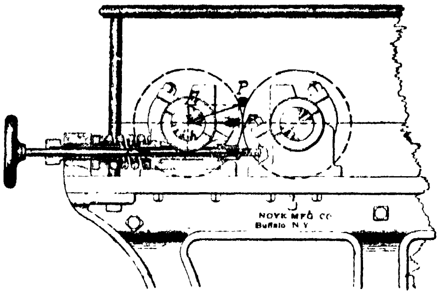

Fig. 214.

4. *A General Survey of the Roller Mill*

To understand the meaning and importance of the details of the roller mill one ought previously to become acquainted with the general character of its construction, where those details may be seen and their purpose understood. For this purpose we shall inspect the construction of the four-roller mills, for those mills represent double two-roller mills and constructionally in no way differ from the twin rollers set in separate frames.

Roller Mill of Ganz & Co. in Budapest.—Fig. 215 illustrates Ganz's roller mill in section. Let us examine the right-hand half of this mill. The product flows into the hopper *b* of the mill, with its weight presses open the gate *w*, and falls upon the feeding rolls which are rotating in the direction of the clock hand. With the view of letting through these rolls a stream of product of the desired thickness there is a gate down the whole length of the hopper, which may be opened more or less by means of a hand-wheel *h*. From the feeding rolls the stock runs to the reduction rolls, and on passing between them falls through the hopper *a* into the spout. During the milling of a moist product there is the possibility of its sticking to the surface and blinding the corrugations, and therefore, under the rolls down their full length there are scrapers set (knives for the smooth, brushes for the corrugated rolls) to free them of the adhering particles.

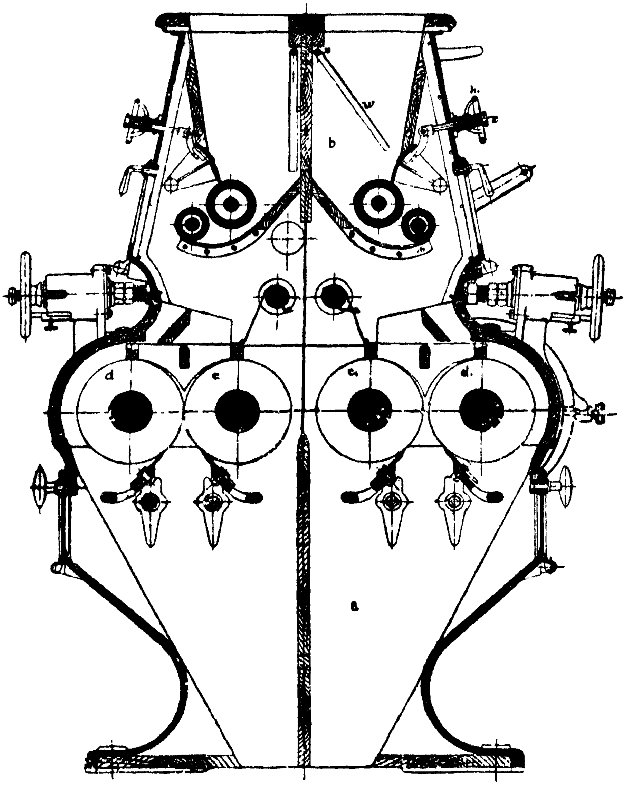

FIG. 215.

For the inspection of the feed there is a gate opposite to the feed rolls, and another one, for inspecting the operation of the rolls, is set in the frame below the rolls. Through both of them at any moment the stock may be seen and reached with the hand on opening the gate.

Let us see now how the problem of adjusting the distance between the working surfaces is solved here.

In modern mills the regulation of the working distance and the mechanism for throwing the rolls out of gear are joined in one common construction. When the mill is in working order the gate *w* is either in a vertical position or inclined to a certain degree, which depends on the quantity of the product fed. The gate *w* rotates on an axis, which has a lever on the outside (Fig. 217) with a weight *z* counterbalancing the pressure of the grain upon the gate *w*. This lever is joined by means of a finger with another lever *y* with the axis of rotation at the side of the feed-hopper.

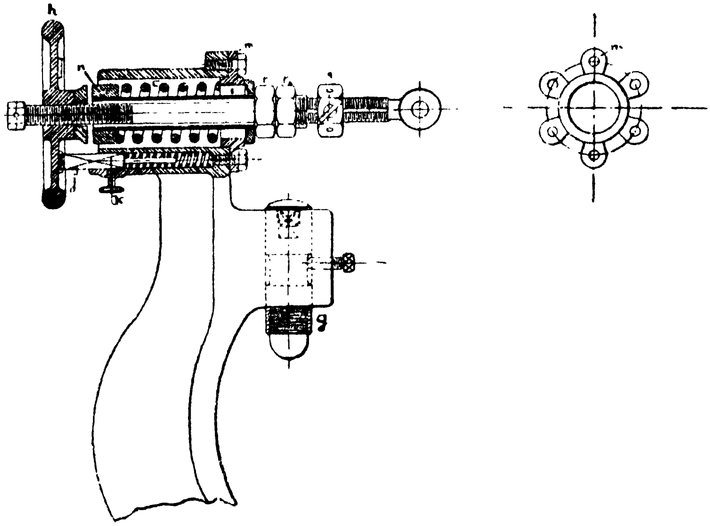

FIG. 216.

On the right-hand side of the lever *y* there is a cavity for the finger of the handle of the lever *x* (Fig. 218) leading to the rod *r* of the brake *M* (Fig. 217). The lever *x* is set on the roll *u* which runs through the whole length of the mill. The end of the lever *x* is connected by a rod *r* with the brake or adjustment mechanism proper, the joint being of the ball and socket kind.

The brake corresponds to our fourth plan. Its construction is as follows. In the levers *M* which have their axis of rotation in *N*, there are held by means of screws *g* the bearings of the slowly revolving side rolls *d* and d_1. These same bolts afford the possibility of setting the axes

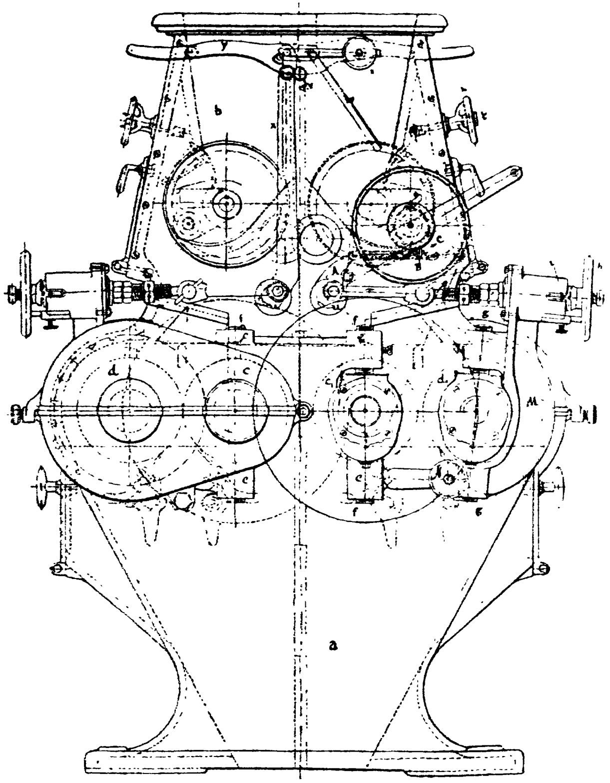

FIG. 217.

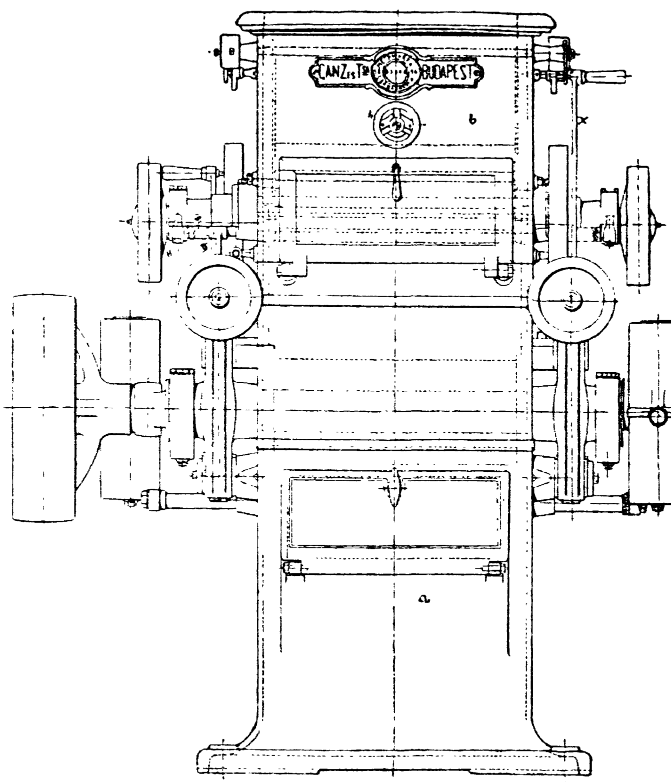

FIG. 218.

of the rolls horizontally. The top end of the lever *M* (Fig. 219) is a tension brake of the following construction. The hub of the lever contains a spring *c*, resting on the right-hand side against the washer *m* which is screwed to the hub, and on the left against the ring *n*. Through the hub there freely runs the bolt *o* joined with the rod *r*. If a hard object is caught in between the rolls and the pressure exceeds the normal, the hub of the lever transmits the pressure through the washer *m* to the spring *c*, and, compressing the spring, moves to the left, and when the hard object has passed the working area of the rolls, the spring compels the lever to return to its former position. The tension of the spring is increased by turning the hand-wheel *h*, the square pin *j* having been previously pressed in and stopped by screw *k*.

We shall now examine the operation of the whole mechanism. To bring the rolls into working position, we must lift the lever *x*, which with its pin raises the lever *y* and the lever with a weight *z* (Figs. 217 and 218). Then the gate *w* drops and the product flows to the feed rolls. With its weight the product keeps back the gate and prevents the weight *z* from disjoining the levers *x* and *y*. As soon as the flow of the product into the hopper is stopped, the pressure upon the gate *w* is removed, and the weight *z* will drop down, lift the lever *y*, and disengage it with *x*. Then, acted upon by the springs of the brake, the levers *M* will force the bearings apart. But as there is the possibility of the grain recommencing to flow from the hopper, there must be arranged an adjustment to retain it there. For this purpose each mill is supplied with a mechanism stopping the action of the feed rolls, which in Ganz's mill is effected in the following manner. The axle *u*, connecting the brakes of the roll, carries on a key a hub with the lever *A* (Fig. 219) which is connected by means of

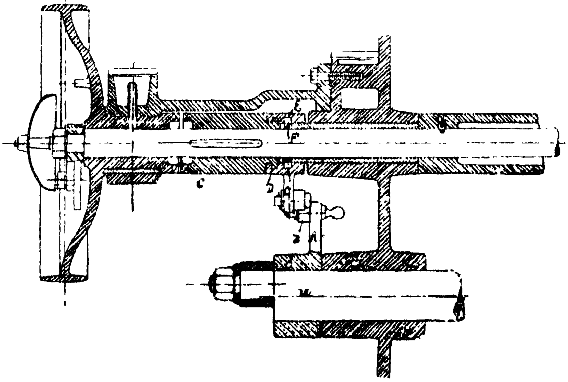

FIG. 219.

levers *B* and *C* with the hub *c*, freely running on a key of the axle *F* of the bottom feed roll. The left-hand part of the coupling is furnished with cross-heads. On the end of that same roll there is a freely rotating belt-pulley with a jutting out pin and a hub which also ends in cross-heads corresponding to those of the hub *c*. A bell is attached to the end of the roll *F*. When the machine is set operating the axle *u* turns so that the levers *A*, *B* and *C* push the hub *c* to the left and bring it with its cross-head end into connection with the hub of the belt-pulley. Then the feed-roll also commences rotating. As soon as the mill runs empty, the hub *c* becomes disengaged with the hub of the belt-pulley, which from this moment freely rotates on the now stationary roll *F*. The pin of the belt-pulley hits the spring with the small hammer, which having got loose at a certain part of the turn, hits the bell. This serves as a signal that there is no stock in the machine. The spring is attached on the hub, which is pressed to the shoulder on the end of the axle.

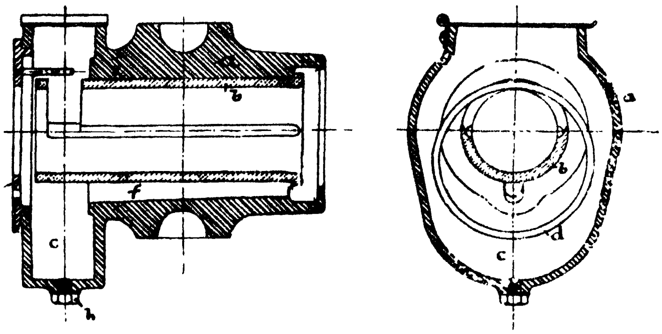

FIG. 220.

A detail of the adjustable bearing is illustrated on Fig. 220. Here the box *a* of the bearing has a cavity for the stopping and adjusting bolts *g*, *b* is a bronze bush, *c* the oil chamber, and *f* the canal for the exhausted oil to *c*. The bearing has ring lubrication.

The Seck Bros. Roller Mill.—Let us examine the Seck Bros. mill, which has diagonally placed rolls (Fig. 221). The product is fed into the box *V*, divided into two parts by a timber partition.

As in the preceding machine, both parts of this mill can reduce the same or a different kind of product, as each pair of rolls constitutes an independent machine. The axis of rotation *w* of the lever of the upper bearing is at the top. The adjustable top roll is put in gear by hand with the aid of a lever *B*, which is brought to its highest position

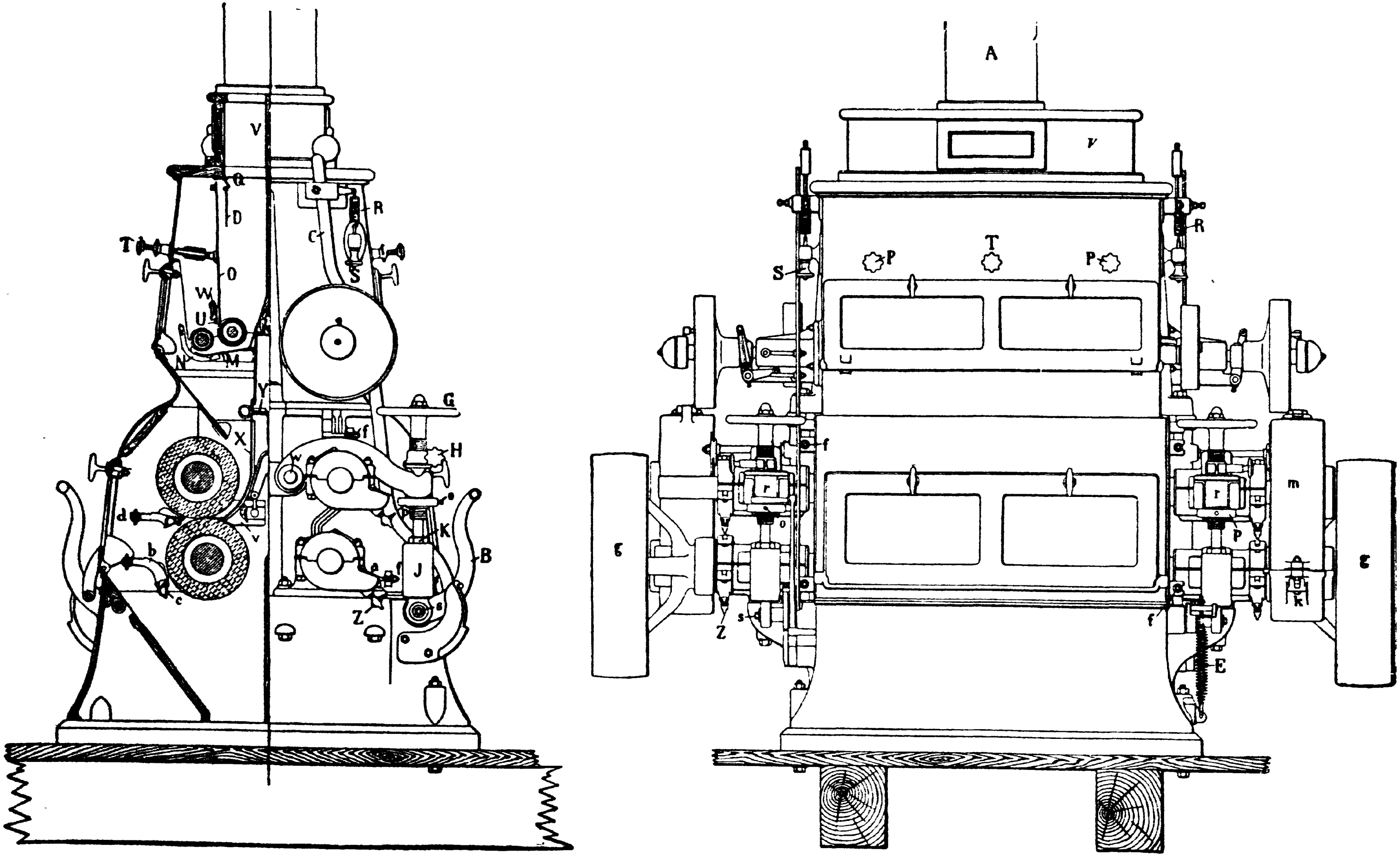

Fig. 221.

for that purpose, and raises the flat lever *C*, which drops the gate *D* for the inflow of the product. By means of an automatic displacement of the cross-head coupling, the feed rolls are simultaneously brought into motion. The throwing out of the roll is performed automatically, as soon as the flow of the grain into the hopper is discontinued. Meeting no resisting pressure of the stock, the gate *D*, owing to the counterbalance, assumes a horizontal position, freeing the engagement of the lever *C*, and through the action of the spring *E* (Fig. 221) the simultaneous disjunction of the reduction and of the feeding rolls is brought about.

The mechanism for the adjustment of the distance between the rolls is operated by a hand wheel *G*. For setting the spring brake encased in a box *J*, there is the nut *K*. For balancing the counterweight of the gate *D* the screw rod *S* is connected by a spring *R* with the lever of the counterweight.

When in working position the gate *D* is dropped. The product flows into the roller-feeder. The gate *O* gives a wider or narrower passage, being removed from the top roll or approached to it by the screw-rods *T* and *P*. Under the rolls there is placed a plate *M* on which the heavy (metal) particles collect. The stock thrown from the first roll on to the second falls from the latter on the inclined plate *X* and is passed to the working space of the rolls. For removing the particles of product sticking to the rolls and blinding the corrugations, there are brushes fitted, or, as in this case, for smooth rolls, scrapers *d* and *b*.

The perspective view of the Seck Bros. mill is shown on Fig. 222.

5. *The Feeding of the Rolls*

An examination of these two mills gives us an idea as to the characteristic details pertaining to such machines in regard to the feed and the brake or adjustment mechanism. The quality of the work of the machine depends on the successful construction of those mechanisms, and therefore it is necessary attentively to study the various types of the feed and the brake devices existing.

The working surfaces will yield a uniform grist only if the stock flows to the rolls in a continuous sheet of equal thickness down the full length of the working surfaces. If the product runs not in a continuous film but in separate streams, firstly a part of the working surface will be in disuse, and secondly the thick streams of grain, not calculated to answer the definite space between the working surfaces, will cause a strong pressure, and widen this space, thus allowing the product to pass through partly unreduced. In the process of reducing the semolinas and middlings

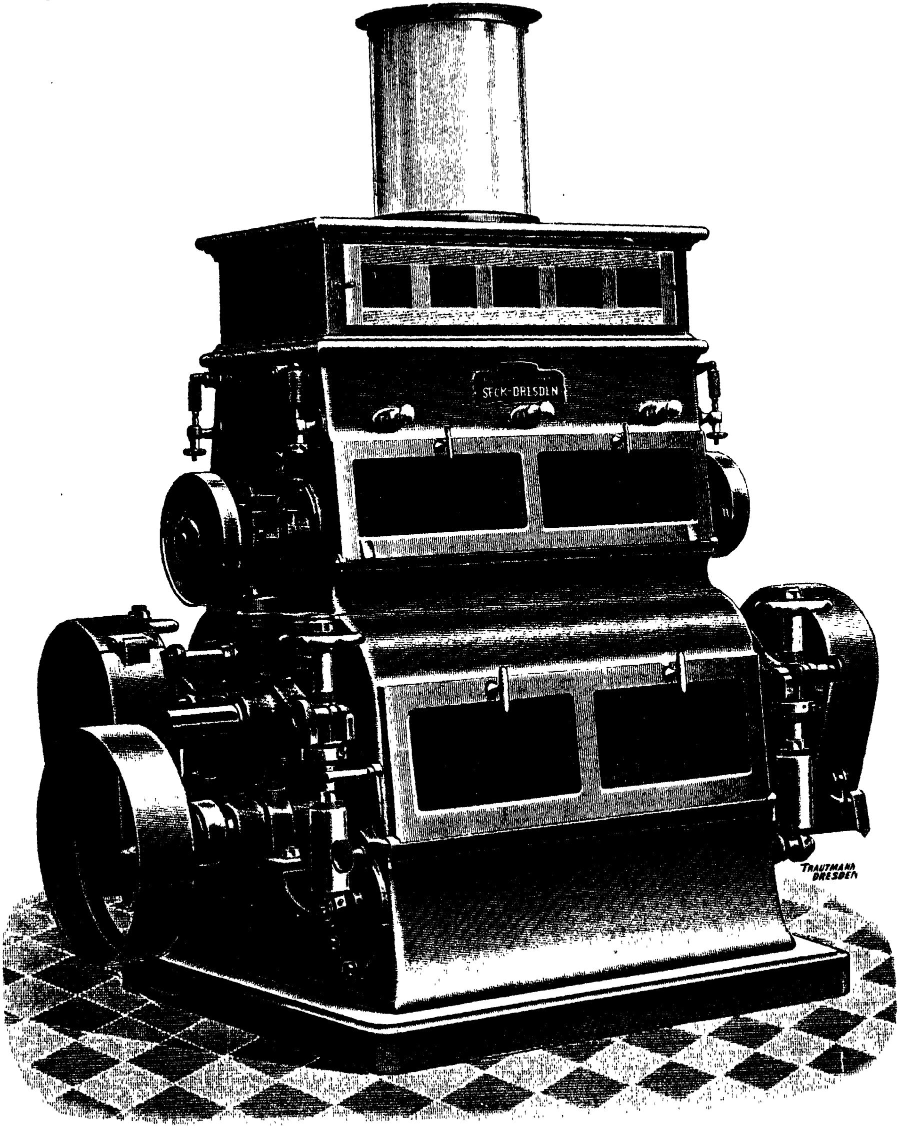

FIG. 222.

the feeding of the product in streams results in a great quantity of flakes, and makes the flour dead.

The feeding mechanism will perform its work correctly if the following requirements are satisfied :

(1) An even and continuous flow of the product.

(2) Automatic regulation of the flow.

(3) The shortest way from the feeding mechanism to the rolls.

(4) Absence of any obstructions to the flow of the product.

Let us examine now all the existing types of feeding devices and give an estimation of them from the point of view of the stated requirements.

Fig. 223 represents a mill with diagonally set rolls. The product flows into the feeder *A* and with its weight presses upon the gate *n*, holding the counterweight *f* off (on the other side of the machine). The gate *t* is set at the greatest desired opening between its edge and the feed roll 4 with the aid of screws 1 and stops 3. Sometimes spring stops are employed, and their number is from two to four, according to the size of the machine. The gate *t* is fixed to a square stem 6 with journals, one of which protrudes out of the box and carries on a key a lever 7 held back by screw rod 2 with a spring. The feed rolls are covered from below by a screen 9 to catch up the product accidentally passing between them. When the inflow of the stock to *A* diminishes, the spring 8 pulls the lever

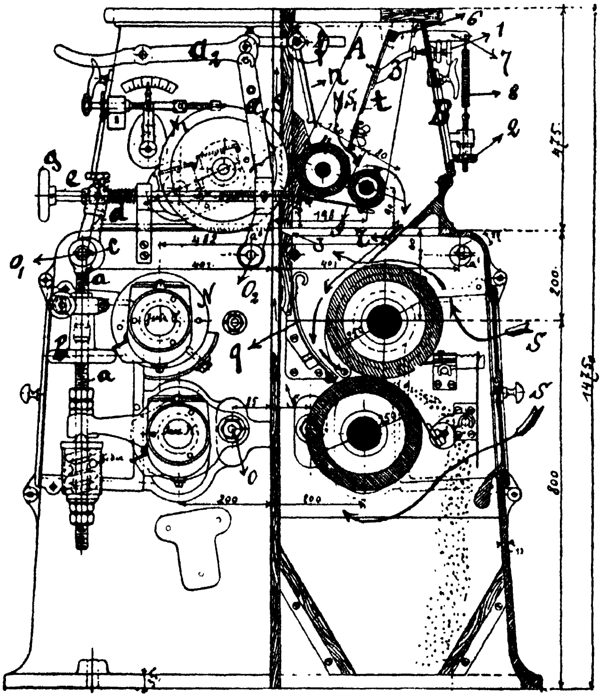

FIG. 223.

6 and turns the gate *t* to the left, owing to which the space between the feeding roll 4 and its edge diminishes. The degree of stability of the gate *t* is regulated by the greater or smaller tension of the spring 8, which is obtained by means of a nut 2, which may be screwed up more or less. The product passed from the roll 4 to 5 along the arrow S_1 falls on the screen *r*, then on the top roll and the screen *q*, which carries it to the slowly rotating bottom roll.

When the stock ceases to flow into the feeder *A* the weight *f* drops down and closes the gate *n*. In this manner, as it is in Ganz's mill, the rotation of the feed-rolls is discontinued and the adjustable roll is thrown apart from the top one. It may be noticed, by the way, that the brake device here is based on the same principle as that of Ganz's, but slightly complicated by a third axis of bearing O_1.

Before proceeding to the estimation of roller feeding, we shall examine a series of analogous constructions, but for the moment we must direct our attention to the main detail of the mechanism, the feed-rolls. We have seen two feeding rolls in the construction examined. The first one, 4, is named the supplier, the second, 5, the feeder. They are brought into rotation by belt-gearing from the belt-pulleys *N* on the axes of the rolls with stationary bearings. The number of revolutions of the supplying roll 4 generally varies between thirty and forty-five per minute, and that of the feeder 5 is three to four times greater. Their diameters are: 120–160 mm. of the larger roll, and 60–80 mm. of the smaller, which corresponds to the circumferential velocities up to 0·33 metres per second for the first, and up to 0·75 metres per second for the second. The European factories maintain that the flow of stock is less even when supplied by one feed roll only, especially when the product is soft, and at the same time most of the factories recommend feed rolls of different diameters, as in the case just dealt with. The Americans are of a different opinion, and prefer the use of one feed roll, or even totally avoid roller-feeding, as we shall see later.

In our turn we must remark that both the European and the American methods of feeding give very satisfactory results. Everything depends, as observations prove, on the choice of a suitable velocity of rotation of the feed rolls or the number of vibrations of the American feeding plates, and upon the loading of the feeder *A* also.

Returning to the roller-feeding, we must give an idea as to the construction of the rolls.

The feeding rolls are hollow, cast-iron cylinders with corrugations cut parallel or perpendicularly to their axis. There are three shapes of corrugations used : (1) with sharp angles (Fig. 224), (2) of a semicircular shape in section (Fig. 225), and (3) the shape of an isosceles triangle in section, when the corrugations are cut along the circumference of the roll (Fig. 227).

The corrugations shown in Figs. 224 and 225 of the given dimensions are cut on the first feed rolls, and those of the dimensions shown on Figs. 226 and 227 on the second, if two rolls are employed for the feeding. The axes of the rolls are set diagonally, and the angle of inclination depends on their circumferential velocities and distance from the grinding rolls. The distance between the axes of the rolls is generally less than the semi-total of their diameters, but in some mills, as will be seen later, it considerably exceeds that quantity.

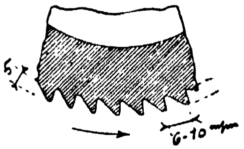

FIG. 224

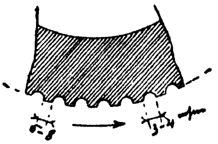

FIG 225

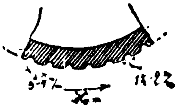

FIG. 226.

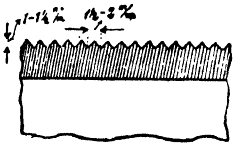

FIG. 227.

In giving an estimate of the shape and position of the corrugations, it will be as well to say that the transversal corrugations lately suggested by the firm of H. Simon in Manchester must certainly not be used, as they break up the solid sheet of product into streams.

Fig. 228 illustrates a single roll feeding,[1] to which we shall direct our attention with the view to explaining several details of the setting of rolls.

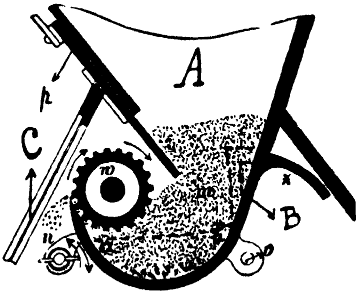

FIG. 228.

The feed-hopper *A* of the mill ends in a trough-shaped shoe *B* which can turn on the axis *o*. The feed of the stock is regulated by a sliding gate *p*. The distance between the feeding roll *w* and the shoe is adjusted by means of cross-heads *n*, by turning them to the right or to the left. To prevent the product from passing between the wall of the feeder and the shoe, the latter is furnished with a flange *z*. For inspecting the feeding operation there is a door *C*. The main point of this construction lies in the trough-like form of the shoe, which is designed to collect the heavy, mostly metal, extraneous matter fallen to the bottom owing to its weight, which exceeds the weight of the grain.

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[1] German patent, No. 38,184, of Engineer Kaufmann, 1885.

This idea has been utilised in many modern makes, but is erroneous in its principle, for the mass of the product below the plane *ab* becomes rapidly compact, and therefore the heavy particles are caught up by the feeding roll. Besides that the feeding mechanism ought not to be forced to fulfil the duties of a magnet apparatus, as all universality complicates the construction to the disadvantage of its prime intention.

We shall now proceed to consider further makes of feeding devices.

Two-roller Feeding.—The English machine-building factory of E. R. and F. Turner in Ipswich was one of the first to invent a rational construction of a diagonal mill. Fig. 229 illustrates the feeding of the "Diagonal" mill in its modern form.[1]

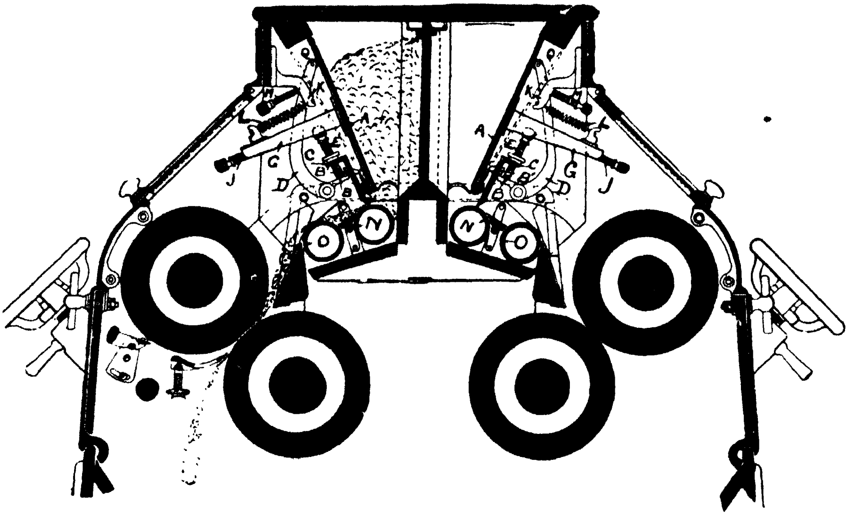

Fig. 229.

The grain or the grist flows into the hopper, in which there is freely suspended on ball-and-socket joints an iron gate *A*, as a second longitudinal wall of the feed. A second gate *B* directs the product to the first feed-roll *N*. This gate may be approached to or removed from the feeding roll with the aid of a screw *E* and nut *C* by pressing *E* upon the lever *D*, owing to which the flow of grain increases or decreases.

In the lever *G* there is a cross-head and guide which changes the position of the gate *A* within the space marked *K* and *Q*, when the spring *L* is pressed by the nut *J*.

The first feed roll *N* up to 100 mm. in diameter runs at about fourteen revolutions per minute; it is provided with longitudinal corrugations

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[1] English patent, Nos. 6501 and 11,992.

of different sizes, to answer the definite purpose of the roller mill for breaking, the grinding of middlings, or cleaning the bran.

The duty of the second feeding roll, making 150 revolutions per minute, is to supply the stock to the grinding rolls, which is done by means of a plate between the roll *O* and the bottom slowly rotating roll.

The second feeding roll is brought into motion from a belt-pulley on the axis of the bottom roll, by transmitting the motion to the roll *N* through toothed wheels. Both the rolls are of the same diameter.

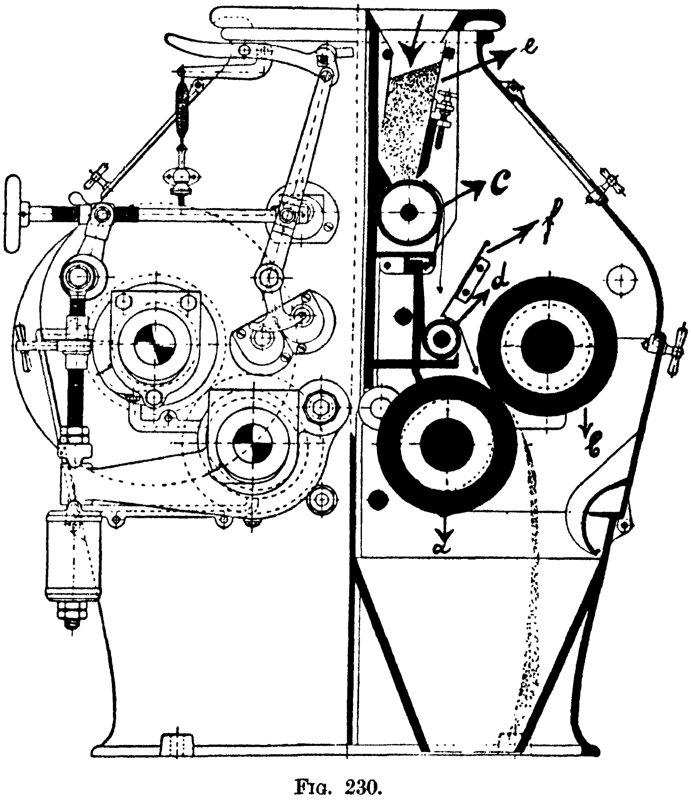

FIG. 230.

G. Luther's factory in Brunswick gives a construction of the feeding device (Fig. 230) totally different from the ordinary type, in that the supplying and the feeding rolls are removed from each other by a considerable distance.

The feed is thrown out of the hopper by the roll *C* on to the plate *f*, which together with the vertical partition forms a kind of second hopper. From this second hopper the roll *d* carries the stock to the slowly rotating bottom roll *a*. Thus the characteristic peculiarity of this construction is the division of one hopper into two parts and the absence of the supplying plate between the feeding roll *d* and the reduction rolls. The adjustment of the feeding by means of the gate *e* is a very common combined construction of the feeding mechanisms already examined.

The European constructors have lately begun to attach great importance to improvements in the regulation of the flow of the stock by means of a gate in the hopper, and have a tendency to discard the supplying plates. This is of great consequence, and we shall speak of it when giving an estimate of the various types of feeding.

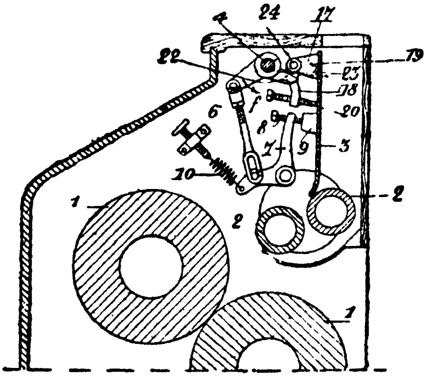

Fig. 231.

On Fig. 231 we have H. Bruner's feeding construction without a supplying plate, which operates as follows.[1] The feed rolls 2–2 have the same diameter, 90 to 100 mm. The top roll rotates with the speed of 40–50 revolutions per minute, and the one at the bottom 90–150, which depends on the product (grain, semolina, middlings, or bran) for which the mill has been fitted. Under the rolls there is a trough for collecting the heavy and hard extraneous matter. The gate 3 is adjusted with the aid of crank mechanisms and a spring 10. The axis of rotation of the gate is marked 24. The crank lever 7 revolving round its axis, when drawn off by the spring 10 presses the gate with its screw 8, which rests upon the support 9 screwed on. When the stock flows into the hopper and presses the gate 3, the pressure is communicated to the upper part of the crank lever 7, which stretching the spring inclines to the left. With the view to give the greatest declination desired to the gate there is set a screw 20, with the aid of which the limit declinations may be adjusted. The connecting rod 6 in its lower end has an oblong hole for the pin of the lever 7. The length of this connecting rod 6 may be adjusted by means of a nut connected with the joint part of the connecting rod and set on the screw part of the coupling rod. The pressure of the levers 7 upon the gate is adjusted by tightening the spring with the screw to which it is joined. To open the gate the axis 4 is turned with a handle on the outside (not shown in the drawing) in the direction opposite to that of

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[1] French patent, No. 429,736, of 1911.

the clock hand. The finger 22 lifts the axis 24, together with the gate connected with this axis, by a wall bracket 17. When the axis 4 is turned back, the gate 3 drops under the influence of its proper weight and is pressed to by the screw 8, as the connecting rod 6 turns the crank lever 7 round its axis in the direction of the clock hands. Simultaneously with the closing of the gate 3 the feeding rolls come to a standstill, which is effected with the aid of an ordinary appliance of cross-head couplings set in the same manner as in Ganz's mill.

Single-roll Feeding.—The single-roll feeding of the factory of Thos. Robinson in Rochdale is shown in Fig. 232. The stock flows into the hopper *A* and presses with its weight upon the gate 23 connected by a joint 24 with the fixed wall 7 of the hopper. The pressure is transmitted through a joint-stop 26 to the crank lever 20 set fast on the axis 13.

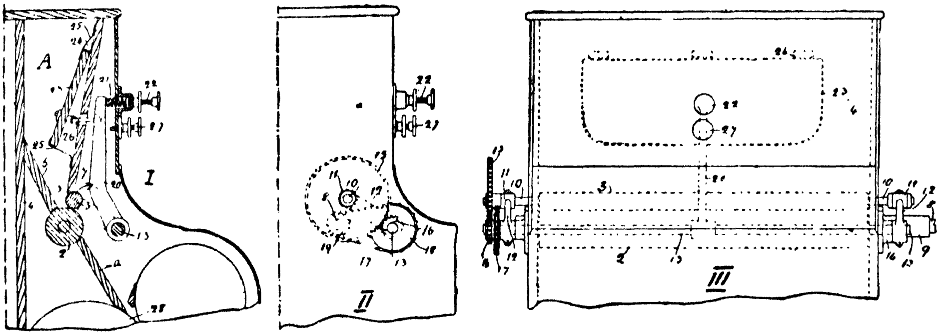

FIG. 232.

On the same axis there are set, also fast, the levers 12 with bearings 11 for the roll 3 (Fig. 232, *III*). When the lever moves to the right and turns the axis 13 the roll 3 likewise moves to the right (arrows) and opens the passage for the product between itself and the feeding roll 2. Though the roll 3 also rotates, the feeding is performed by the roll 2, while the first one only closes the passage of the product conveyed to the rolls 28 down the plate *a*. The pressure upon the gate 23 is adjusted by the spring 21 by means of the screw 22, and the widest opening is set by the spring 27. The feed-rolls are brought into motion in the following manner (Fig. 232, *II* and *III*); the roll 2 is revolved by a flexible gearing from a pulley set on the axis of the grinding roll and a belt-pulley on the axis 8 of the feed-roll 2. On the left-hand side (*II* and *III*) of the axis 13 there is shown a chain gear to the loose-toothed wheel 18 on the axis 13. The chain wheel 16 is made in one piece with 18. From 16 the rotation is transmitted to the roll 3 by a chain wheel 15. When the axis 13 is turned by a handle or by the pressure of the productupon the lever 20 through the gate 23, the chain wheel 15 rolls over the ch wheel 16 but is not disengaged from it. To prevent the dirt in product from penetrating in the joints 24 and those of th stop 26, the ends of the gate 23 are covered over with a leather lining 25.

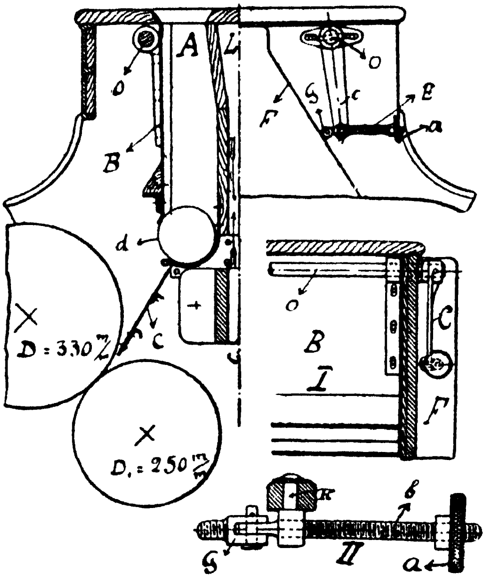

Fig. 233.

The roll 2 is 90 mm. in diameter and runs at fifty revolutions per minute, while the diameter of the roll 3 is 25 mm. and its velocity eight to ten revolutions.

A more simple single-roll feeding mechanism, evolved also by Thos. Robinson, is shown on Fig. 233. From the hopper *A* the stock flows on to the roll *d* and is thrown upon the supplying plate *c* by pressing off the gate *B* rotating on the axis *o*. The pressure of the gate is adjusted by a spring *E* which transmits the pressure by levers *C*, while the tension of the spring is varied by a nut *a* running on the screw *b*. The left-hand end of the screw is joined by the fork *G* screwed into an arm on the frame *F*. The details are given in the drawings *I* and *II*. The diameter of the roll is 100 mm. and its speed reaches up to forty revolutions.

In this mill the different velocities of the rolls performing an equal number of revolutions is obtained owing to their diameters being different. The channel *Z* serves for ventilating the mill.

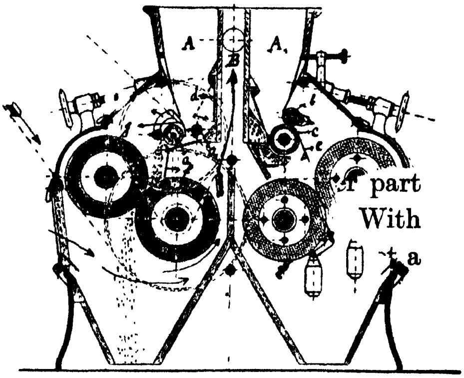

Fig. 234.

On Fig. 234 the single-roll feeding of the mill from G. Wegmann's factory is shown. The left half of the mill is for breaking, the other one —with porcelain rolls—for the reduction of middlings. Let us examine the feeding process in the former section of the mill. The stock flows oe) the hopper A, presses open with its weight the gate d, and is stirred oose if it is in lumps (this happens when the grain is moist) by a paddle bar a_1. By turning the gate g, as indicated by the arrow, the passage is opened to the feed roll a from which the product runs to the grinding rolls. The plate f isolates the product from the space between the partitions of the mill and of the bottom roll, where it might fall in accidentally. The number of revolutions of the feeding roll is about sixty, and the diameter is 40 to 50 mm.

The feeding of the porcelain rolls is similar to the system of Thomas Robinson's examined above. Both the halves of the mill are ventilated on the principle of counter currents through the channel B.

American Feeding Mechanisms.—Just as complicated as are the feeding mechanisms of the European constructors, so simple are those of the Americans. Very many American factories prefer a type of feeding device analogous to the intermittently shaken shoe for feeding millstones or a single-roll system, but in none of the American constructions do we find a two-roll feed. Further, in the American feeding mechanisms, the plates supplying the stock to the grinding rolls are totally absent.

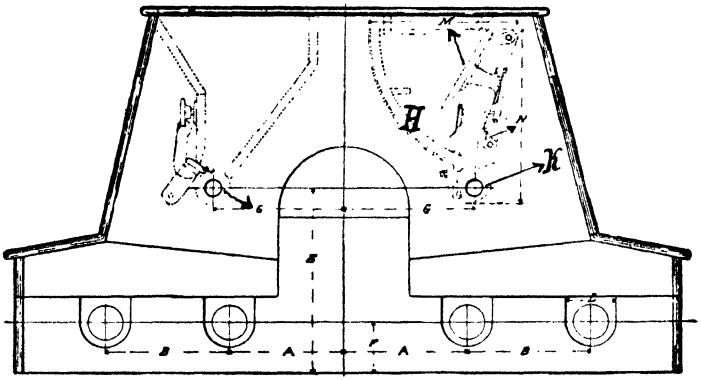

FIG. 235.

On Fig. 235 may be seen both the types of American feeding mechanisms, from the factory of Nordyke & Marmon Co. On the right-hand side of the mill we have two gates N and M which form the hopper. Influenced by the weight of the product the gate M turns round the axis of the fastening and the stock falls on the gate N, which is kept vibrating by cross-heads k. The cross-heads run at the rate of up to 250 revolutions per minute. Fig. 236 shows a section in perspective of this feeding mechanism. Both the receiving and the feeding gates are furnished with taper pins set in chess-board order, the purpose of which is to break up any lumps in the product.

Receiving a large number of oscillations, the gate *B* loosens the product well and feeds it in an even sheet to the grinding rolls.

On Fig. 237 is shown a perspective section of the roller-feed. The gate *B* is suspended on an axis to the ends of which on the outside the counterweights *C* are fixed for regulating automatically the passage of the stock between *B* and the feeding roll.

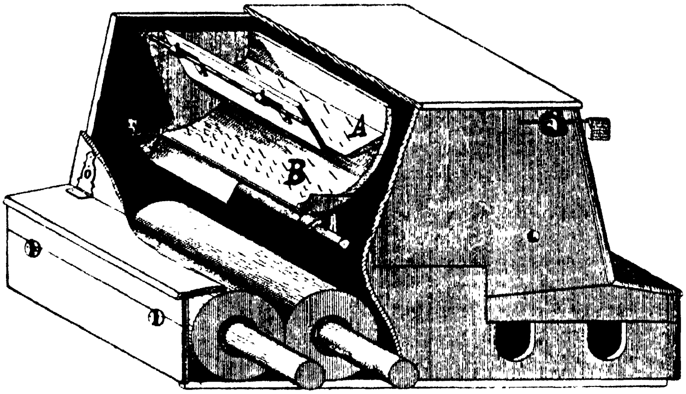

Fig. 236

Fig. 238 represents the feeding device of the factory of Allis-Chalmers Co. in Milwaukee. The stock runs into the distributing box *A* divided by an adjustable partition *B*, with the aid of which the quantity of product flowing into the right- and the left-hand section of the mill may be regulated.

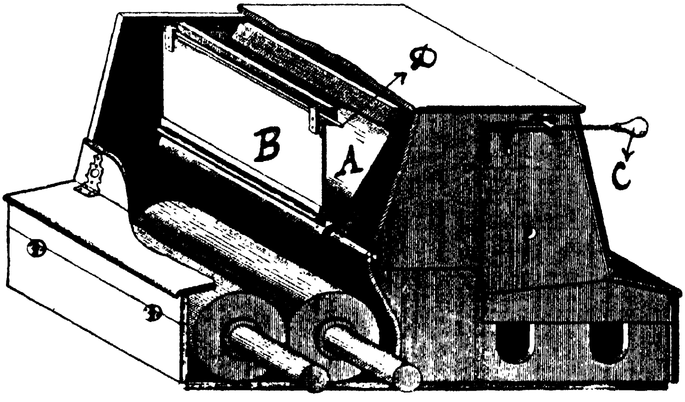

Fig. 237.

The feeder *C* is formed of a fixed plank *h* and a gate *a* suspended on two bolts *i* passing through holes in the lid of the feeder. The clearances in the lid and the ball-washer *e* allow the gate *a* to swing to the left under the pressure of the product. The gate *a* may be drawn up with the aid of the nuts *g*. The automatic adjustment of the flow is performed by means of fingers *c* and counterweights *d*. The largest desired opening is set by the stopbolts *k*. For ventilating both the pairs of rolls there is a channel *D* wherefrom the air is exhausted through the side holes *E*. The channel down the full length of the box *A* is covered over by an iron lid *F*.

Besides vibrations by cross-heads some factories make connecting-rod gears. Fig. 239 illustrates such a feeding mechanism from the factory of Noye Manufacturing Co. From the hopper *A* the product falls into the shoe *B* suspended on springs *a* by an eccentric connecting-rod *C*. The flow is regulated by the gate *b* with counterweights *c*.

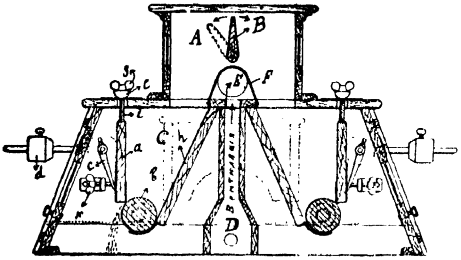

FIG. 238.

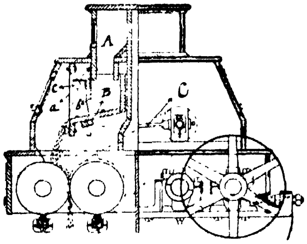

FIG. 239

From the shoe *B* the product passes directly to the slowly rotating roll. The number of vibrations of the shoe reaches up to 200 per minute.

The results of feeding with an American mechanism, as was said above, are quite satisfactory. Still the reciprocating motions of the working organs ought to be avoided, even though the inertia of the masses, as it is in the present case, be insignificant.

Estimation of the Feeding Mechanisms.—The types of feeding mechanisms examined may be divided into two principal groups : those where, after the feed rolls, the stock is passed to the grinding rolls down a plate, we shall name mechanisms with compulsory feeding ; while those in which the stock falls free upon the working surfaces of the rolls will be called mechanisms with free feeding.

In the beginning of the preceding chapter, the requirements which the feeding mechanism should satisfy were mentioned. Basing our estimate of the mechanisms with compulsory and free feeding upon the third and fourth requirements, *i.e.* the shortest route from the feeding mechanism to the rolls and absence of injurious resistances on the way of the stock, we must give preference to the mechanisms with free feeding.

If we turn to the constructions of compulsory feeding we shall see that in the most favourable case the supplying plates offer an inclined plane, and often a rather long way over a curved surface. In the first and in the second case, this way is longer than the falling of the product from the feed roll straight upon the rolls (the line of fall will lie in a parabola, for the stock is under the influence of its weight, and is flung off the roll with the initial velocity at an angle to the vertical). Spending more time on its way the product becomes heated to a greater extent before reaching the rolls. But if the ventilation is good, this circumstance is of little consequence. The chief point is that in travelling over the plate, the product has to overcome the power of friction, owing to which its velocity, and consequently the capacity of the mill, diminishes.

Another very injurious circumstance lies in the fact that on the plates, especially when a moist product is being reduced, knots are formed which break up the solid sheet of stock into separate streams. This disorder in feeding is particularly noticeable if semolina and middlings are the products treated.

The formation of the streams, or the so-called paths, is brought about in the following manner. When different kinds of product, besides the grain, run down the plate, the soft, mealy, glutinous particles stick to its surface. Around them fresh particles collect and stick to them, thus forming a knot, and the path is ready. The stock running in is turned aside by those bunches, and the sheet of product consists of separate thick streams. The feeding is uneven; one part of the working length of the rolls remains unused, while the other is overloaded and crushes the stock to flakes. The capacity of the mill decreases.

The supporters of compulsory feeding adduce in its defence the consideration that, if the process of reduction on rolls is correctly performed, the necessary movement and a rationally arranged ventilation will prevent the mealy, glutinous particles, which cause the formation of the paths, from falling upon the feed rolls.

However, these arguments are feeble. It should be noted that there is no idea of supplying the grinding rolls with a product totally free of moist, glutinous particles, however perfectly the movement might be arranged. When the middlings are ground those particles are nearly always present. The miller attending the operation can easily obtain proofs of it. A constant flaking of the meal, and an excessive heating of the product discharged, very often points to an unevenness in the feeding, caused by the paths formed on the plate. An inspection of the feeding appliance, and putting the plate in order, is of great assistance in the process. This inspection should be performed every four to six hours.

In the breaking process the paths are found more seldom; the rough break stock cuts the knots off as soon as they appear.

The danger of the mealy particles sticking to the plate and gathering into knots is considerably alleviated if a perfectly dry stock is fed in. This is attained by the arrangement of ventilation, the main purpose of which in a roller mill is to exhaust the warm, moist air. The fact must be kept in mind, however, that a perfect ventilation in this respect appears only as a palliative, which impedes but does not obviate the formation of knots on the surface of the plate. We must also not forget that so fine and tender a product as the fine middlings are to be dealt with. The very least obstacle is sufficient to build a path. The slightest traces of moisture would suffice for the exceedingly small hygroscopic particles of meal to form a knot. But moisture is always present even with the best of ventilation.

The following proves this statement to be true. With a rational ventilation the particles of meal reach the feed rolls in a state of normal moisture, but on their way from the feed to the grinding rolls they may undergo a change in that respect. In fact, with the passage of the product, both the product itself and the working rolls become heated. Owing to this, a part of the moisture contained in the product passes into air, which will be slightly warmer than the product. This air enriched with moisture, in spite of a perfect ventilation, will have time to return this moisture to a cooler hygroscopic product—the gluten; the moisture will precipitate upon the product. It will be absorbed by the finest hygroscopic particles of the meal, rich in gluten, which will settle in the lower end of the plate. To this we must add that the air impregnated with moisture settles immediately on the cold plate, which facilitates the formation of paths. This latter remark, however, is applicable only to the beginning of the operation, for the plate also becomes heated soon. It goes without saying that we have in view formations of dew (both on the product and on the plate) imperceptible to the eye and the hand, and such formations are possible even if the mill is ventilated, which is proved by experiment, for the plates of the ventilated mills have to be cleaned just as those of the non-ventilated mills, though more rarely. The harmfulness of the use of plates, even if used with the best modern ventilation, is perceptible.

In appraising the feeding mechanisms, the accessibility of their parts and operation for inspecting purposes must be considered. In this respect the compulsory feeding almost in all makes is placed in an unfavourable light. This defect in feeding is particularly noticeable on Fig. 223, p. 245. Here the product may be seen through the inspection window *B* only at the moment it leaves the feeding-roll 5 and partly when on the plate *r*. The plate *r* itself is quite inaccessible to inspection, and so far removed from *B* that its extraction with the view to freeing it of the knots is extremely difficult. The constructors upholding the compulsory feeding ought to accept it as a rule, that the supplying plates should be easy of access and loosely suspended, as this will facilitate the removal of the adhering product from them.

Whatever be the kind of feeding, forced or free, the stock must be delivered to the slow roll; it is required by the very idea of the process of reduction, that the slowly rotating roll should hold back the product. If the stock falls on the fast roll, it will be thrown against the slow one, rebound from it again, and hinder the other particles from reaching the grinding surfaces, thus lowering the quality of the work.

6. *Types of Roller Mills*

(i.) *Two-roller Mills*

Having become acquainted with the principal details of roller mills, we can formulate the requirements which must be satisfied by a rationally constructed machine. Those requirements are as follows :

(1) An even feeding of the grinding surfaces, automatic adjustment and stoppage of the feeding mechanism.

(2) A tension brake for the adjustable roll.

(3) The tramming of the parallelity of the rolls.

(4) The ventilation of the working chamber of the mill, for cooling the product and the working parts, and for removing the meal-dust.

(5) The work of the mill easy of inspection ; ease in the observation of the feeding process and in taking samples of the grist while the mill is in operation without any danger of mutilation.

(6) Removal of the adhering product from the working surfaces.

(7) Simple dismantling of the frame for removing the rolls.

(8) Economical transmission of power to the working organs.

Let us now examine the European and American types of mills, and see how far they satisfy the above requirements.

Mills of Amme, Giesecke, and Konegen.—Fig. 240 represents a two-roller mill with the lever for the brake, to which we shall return later, taken off. To understand its construction better, let us watch the dismantling and fitting up of this mill. The frames of the bottom adjustable bearings *b* are supported by timber blocks to shield them from the blow of the axles when lowered against the frame of the roll. Next with the aid of ratchet-braces *d* the lifting lever *c* connected with the bushes of those ratchet-braces by a screw (Fig. 243) is lowered. This is accomplished by turning the ratchet-braces *d* in the direction opposite to the movement of the clock hand. Further, the nuts and lock-nuts *e* are screwed off up to the plugs *f*. Then the whole system on which the adjustable bearings are suspended becomes free, and is easily deflected by the rotation round the axis of its eccentric fastening, as the fork-shaped tail of the bearing frame (Fig. 244) rests free on the cup of the brake. The lever *c* assumes the position shown on Fig. 241, after which the upper part of the frame is removed. On taking away

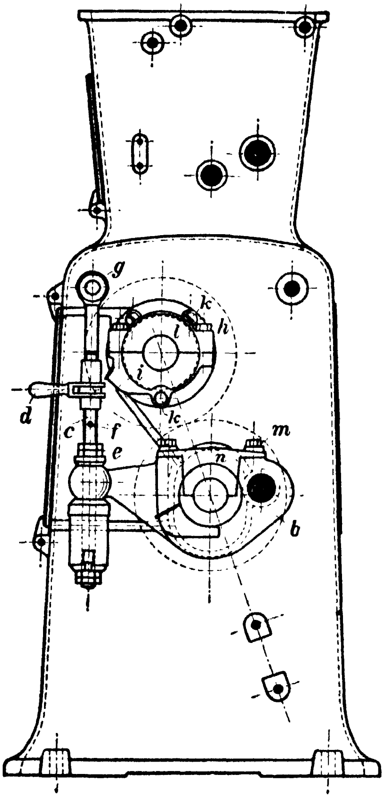

FIG. 240.

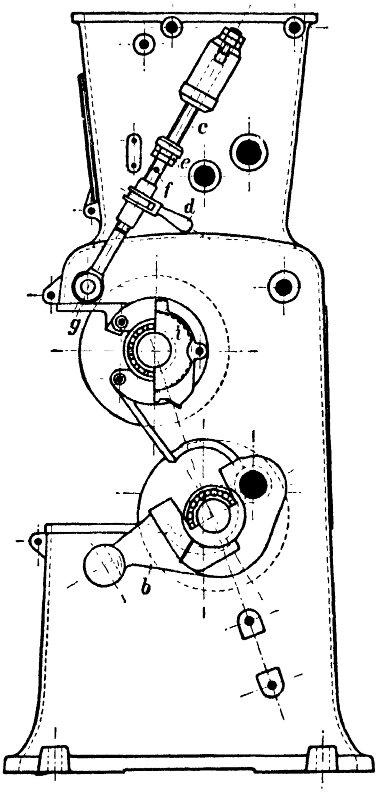

FIG. 241.

the timber blocks the adjustable bearings are carefully lowered, until the axles of the rolls are lying in the cavity in the casing of the frame. The lids *e* of the stationary bearing and *i* of the adjustable bearing are removed; it is then easy to take out first the upper then the bottom roll. The construction of the ball-bearings will be examined below, while for the present we shall occupy our attention with a four-roller mill

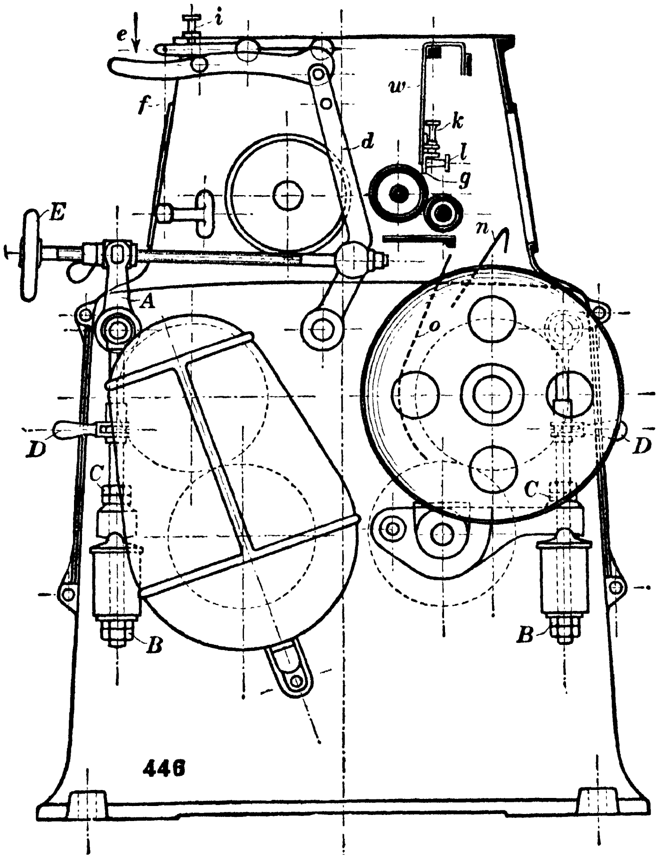

Fig. 242.

(Fig. 242), where the feeding mechanism and the brake may be inspected.

The feeding is performed in the following manner: a loosely suspended gate *w* has an adjusting valve *g*, which may be lowered and raised by means of screws *k*, increasing and reducing the passage of stock. By the pressure of the product the gate declines to the right and is retained in the position of the largest desired opening by a stop-screw *e*, with the aid of which the width of that opening may be altered. On the outside, the gate *w* has a counterweight running along the lever *e*, or, in other makes of the same factory, pushed by a spring, as in G. Luther's mill already examined. From the fast feeding roll the stock flows down the plate *n* to the fast grinding roll, which passes it to the plate *o*; the plate *o* directs the stock to the slowly revolving bottom roll. Both the plates are suspended, and may easily be removed through the doors in the hopper of the mills.

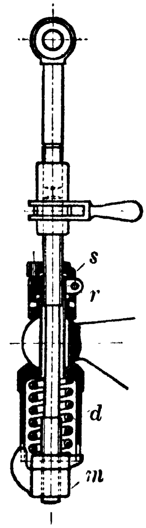

FIG. 243.

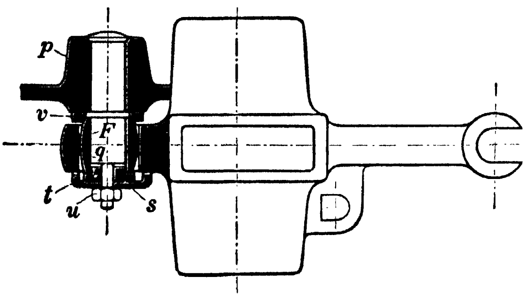

FIG. 244

The adjusting mechanism has the following arrangement: the frame of the adjustable bearing has two arms (Fig. 243), of which the right-hand one with a fork-shaped tail rests on the cup *d* with a spring, while the left-hand one is set on an axis of rotation fixed in the frame of the mill. The finger set in the hub *p* of the frame has an end *F* of a hexahedral section (Fig. 244). On *F* there is set an eccentric ball hub *q* fastened to the collar of the finger by a bolt *s*, the nut of which is covered by the washer *t*, held by a nut *u*. Between the hubs *p* and *q* there is a washer *v*. Turning the nut *s*, after having previously removed the nut *u* and the washer *t*, we turn the hub *q* together with the finger *F*, thus setting the axis of the adjustable bearing in a position parallel to the axis of the fixed bearing. This fitting up is generally performed accurately in the factory. A more simple truing up is performed with the aid of a spring brake already examined. In Fig. 243 is shown this brake for porcelain rolls. The same fork-shaped tail rests upon the cup *d*, in which there is a spring resting with its lower end upon a nut *m*, its tail entering into the aperture of the cup. The top end of the brake rod is set on a finger eccentrically positioned in respect to the axis of rotation of the lever *A* (Fig. 242). The raising or lowering of the bearing is performed roughly by turning the nut *m*, and more accurately by a ratchet-wheel nut connecting the top and the bottom part of the rod. Over the roundly ground fork of the lever there is set a washer with a ball-shaped cavity, held by a nut *r* and a lock-nut *s*. When the pressure upon the rolls exceeds the set limit, the fork of the tail presses upon the cup and, compressing the spring, drops down. If the bearing is to be lowered and the rolls put out of gear, the lever *d* is disengaged from the lever *f*, and then the fork, pressed by the weight of the roll, lowers the whole rod. A more accurate adjustment of the distance is attained with the aid of a hand-wheel *E* which, when turned, pushes forward the lever *A* and lifts the front and the back rods *t*, since the roll with eccentric fingers is let through the box of the frame.

The motion is communicated to the feed rolls from the fast grinding roll by belting to the larger and by a gear drive from the larger to the smaller roll. The feeding rolls rotate with the ordinary velocities. The throwing off and in of the feed rolls is performed by a cross-head coupling on the axis of the large roll, as in Ganz's mill.

The rotation is transmitted from the fast to the slow grinding roll also by means of a gear drive. The mills in question have ordinary ring lubricating- or ball-bearings.

The fitting of the gear-wheels, belt-pulleys and ball-bearings on these mills is of some interest, and we shall therefore direct our attention to those details.

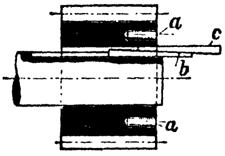

FIG. 245.

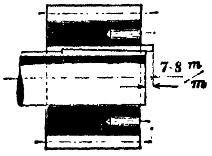

FIG. 246.

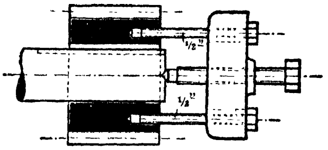

FIG. 247.

Figs. 245 and 246 illustrate the keying on of the gear-wheels or belt-pulleys by means of two wedge-shaped keys *b* and *c*. The chain-wheel is set on the shaft so as to allow easy access to the screw-threaded holes *a*, made for taking the chain-wheels off. Then the key *b* is set in first, the key *c* laid on it, and both are hammered in with the calculation that the end of the key *c* should protrude not more than 7 to 8 mm. outside the hub of the gear-wheel. When the pulley is to be taken off the key *b* is knocked aside a little to the left, which causes the key *c* to become loosened and easy to extract. The gear-wheel is taken off with the aid of a cross-head (Fig. 247) with bolts running freely through it and screwed into the holes *a*. The middle bolt, entering into the thread of the cross-head, rests against the centre of the shaft. In screwing the middle bolt into the cross-head, we obtain a tension in the side bolts, which evenly, without any crookedness, draw off the chain-wheel or the belt-pulley.

The essential part of the ball-bearing is the steel rings with balls between them, of which one is set fast on the journal of the shaft, while the other one is held in the frame of the bearing. The rings with balls fitted in beforehand are warmed during a period of about half an hour in machine oil of 40° C. and set on the journal (Fig. 248). To bring them up to the collar of the journal a free cast-iron hub *f* is set on the journal, and a piece of wood having been placed under the right-hand end, it is knocked with a lead hammer until the hub pushes the rings to the collar. For taking the bearings off there is also a cross-head (Figs. 249 and 250) with bolts *d* and a flange *b*. On the journal between the bottom ring of the bearing and the flange a built-up bush *a* is placed so that its section lies on a plane with the axes of the bolts *d*. Then the bolt *e* resting against the centre of the journal is screwed into the cross-heads, and in this manner tightens the rings with the balls without damaging the journal.

The feeding mechanism of the Amme, Gieseke, and Konegen's mill we have examined has the defects common to all inaccessible feed plates. In attempting to avoid these defects the factory has evolved a new design for setting the plates, the aim of which is to curtail the route of supply and make the removal of the knots from off the feed plate more easy. This construction was patented only in the end of 1911, and has not made its appearance on the market yet. Here (Fig. 251) we have already only one supplying plate *a* connected by a joint rod *b* with the controlling door *c*. The axis of rotation of the plate below is *a*. Another plate is set to prevent the product from accidentally slipping through on to the bottom roll. This position of the plate *a* allows any knots to be removed without taking it out.

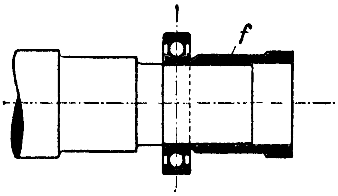

FIG. 248.

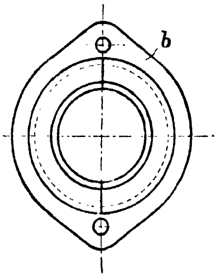

FIG. 249.

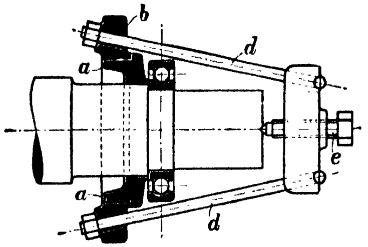

FIG. 250.

The "Diagonal" from the works of Dobrovy and Nabholtz.—As in the case of the preceding mill too, both the halves of the Dobrovy and Nabholtz mill operate quite independently of each other, having only a common ventilation chamber (Fig. 252).

From the hopper *A* the product runs to the two feeding rolls *aa*: the slowly rotating top roll passes the stock to the fast bottom one, which in its turn throws it upon the nickel-plated feed plate *b*. This plate delivers the product to the grinding rolls in a tangential direction. The distance between the feed-hopper and the grinding surface of the rolls has been reduced to a minimum, in comparison to the preceding mill.

The rolls are put in gear by means of a rod *c* with a handle *d*, which when pressed is caught by the lever *e*. At the same time a system of levers *f* and *g* turns the axis *o*, which with the aid of the lever *h* eccentrically set on it, raises the bottom grinding roll. The feeding device is thrown in by a lever *c* with an inclined segment *k* acting upon the fork-shaped rod *i*.

The parallelism of the grinding rolls is set by means of hand-wheels *m*. By turning the levers *q* with the screws *r*, the gate *t* may be set in any position, in which it will be retained by the springs *s*.

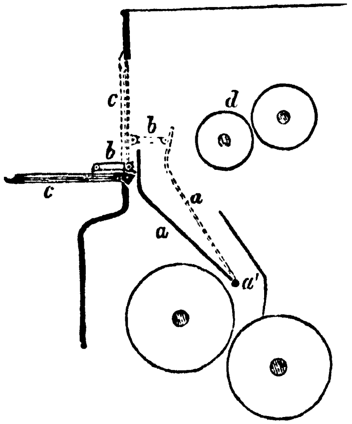

Fig. 251.

The automatic throwing out of the rolls and the stoppage of the feed are effected by the action of the weight *g* upon the levers *c* and *p* in a manner already known.

The grinding rolls are aspirated in the direction indicated by the arrows 1, 3, and 4 in the drawing, and the air on entering the chamber of the mill through the fissures under the lid exhausts the grinding rolls from below and then passes up.

The bearings of the rolls are made of phosphor-bronze and furnished with ring lubrication.

The gear-wheels for transmitting the motion to the rolls with double helical-like teeth are set in special cases serving them as oil boxes.

The slow feed roll is turned by a belt-drive from the belt-pulley on the axis of the fast grinding roll, and from the slow feeding roll to the fast by toothed gearing. The built cross-head coupling is set on the axis of the slow feeding roll.

French Roller Mill.—On Fig. 253 may be seen the mill of one of the largest French milling machinery works, Teisset, Chapron & Brault Frères, in Paris and Chartres.

The section illustrates the position of the feeding mechanism and grinding rolls, showing the fast grinding roll with fixed bearings to be at the top, and the slow roll with the brake below. The incline of the plane of the axes forms an angle of 50° with the horizontal plane.

The feeding is performed by two rolls *a* and *b* with corresponding differential velocities and an adjustable gate *c* discharged by means of a spring set on the outside of the mill. The stream of product observed through the glass door *d* in the upper part of the frame glides down two inclined plates. From those plates the stock falls upon the slow grinding roll *A*, which carries it to the fast roll *B*.

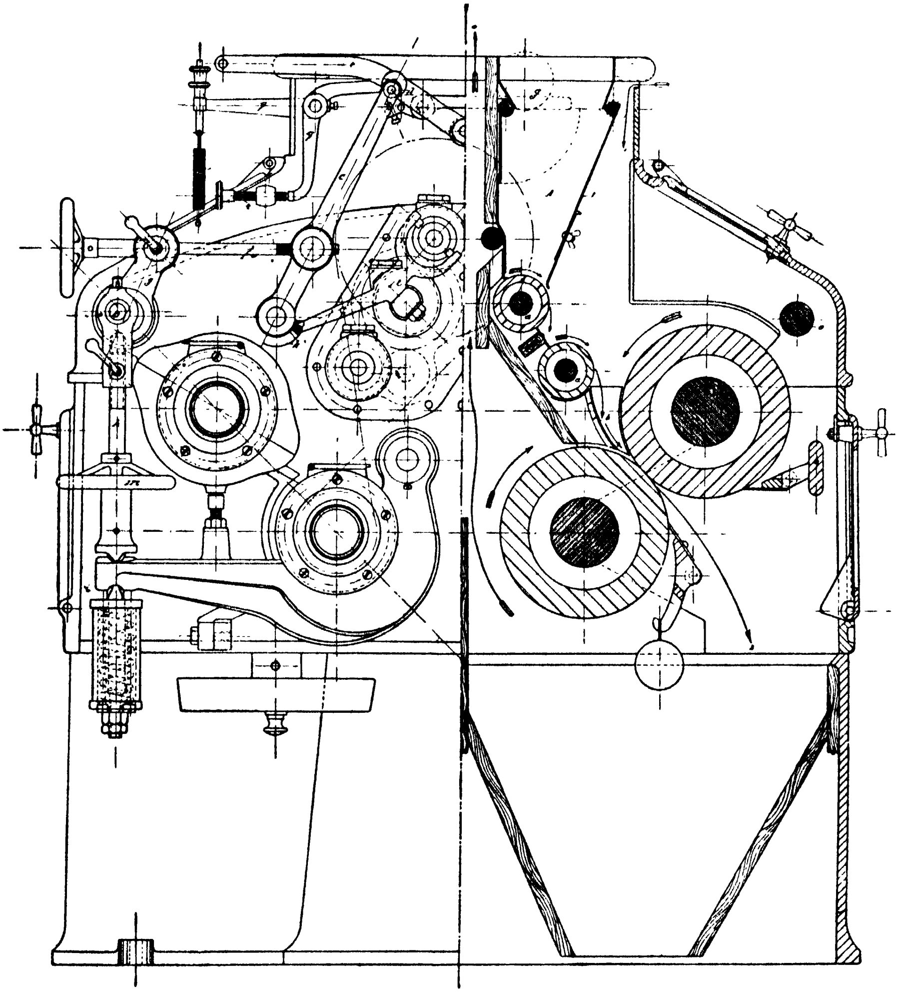

Fig. 252.

On opening the door *D* in the mill, the delivery of the milled product may be watched and samples obtained without any difficulty.

From the feeding rolls and on leaving the grinding rolls the product may be taken by hand without fear of any danger.

The exhaust air enters through the top part of the hopper, follows the stock all along its route, and is exhausted by the aspirator after the stock passes through the grinding rolls.

The cast-iron frame, judging by the outward appearance of its construction, is rigid, and vibration apparently obviated. The frame is lined with timber on the inside to prevent the walls from becoming cooled, in which case the moisture is deposited and settles on them and the meal turns to a paste.

The adjustment of the grinding rolls here, as in other types of mills too, consists of two separate processes: (1) tramming the adjustable roll in respect to the fixed one, and (2) setting the adjustable roll nearer to or farther from the fixed.

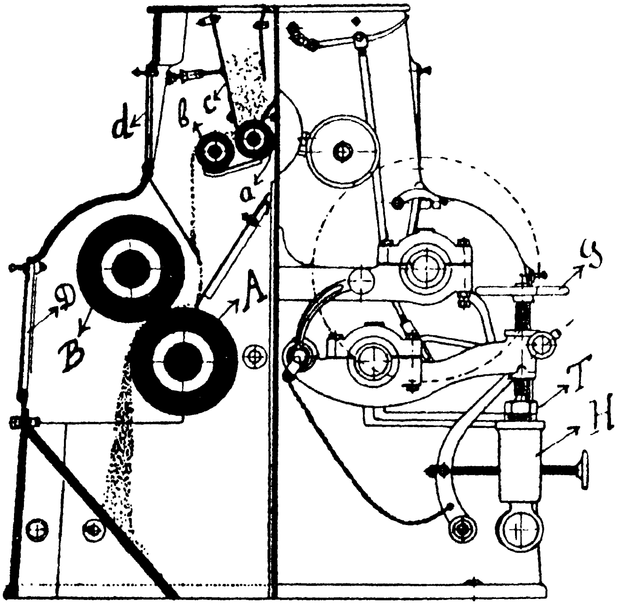

FIG. 253.

The tramming in respect to the fixed roll in every bearing is performed by means of a hand-wheel *G* resting upon a spring encased in a box *H*.

The brake-mechanism, as well as the automatic stoppage of the feed, in construction is similar to those of Seck, with the sole difference that the brake is fitted to the bottom roll, while in Seck's mill it is applied to the top roll.

G. Daverio's Mill.—The Swiss works of G. Daverio (Zurich) was the first to adapt the vertical position of rolls and very soon began to set them diagonally, convinced by experience of the inconvenience of the plates supplying the stock to rolls so positioned. Simultaneously with the English works of Turner, Daverio patented mills with a diagonal disposition of rolls, in which the operation of the feed plates is placed in more favourable circumstances. At last, for the first time in Europe, the Daverio works launched on the market in 1908 a model of a mill without any feed plates, and this was soon imitated by other works.

Fig. 254 shows a Daverio mill of the latest model. The grain runs into the hopper and with its weight presses open the feed gate adjusted by a counterweight *b*. The utmost opening of the feed gate is set by means of a screw *c*. The adjustment of the feed gate by hand is performed with the lever *d* set on the axis *r* of the flap. The slowly rotating top feed roll carries the stock to the fast roll, which throws it directly on the slow grinding roll. Under the frames there is placed a plate, the duty of which is to collect the heavy extraneous matter.

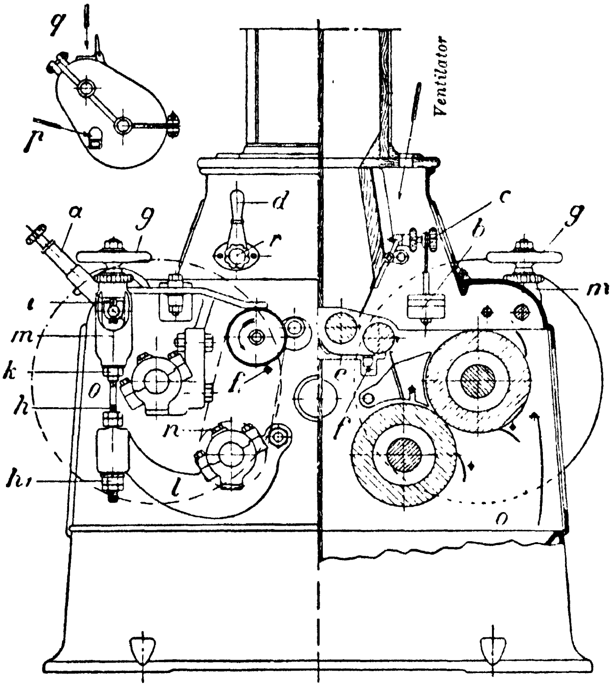

FIG. 254.

The tension brake in general is the same as in other mills, with this difference only, that the cup with the spring forms one single piece with the tail *l* of the adjustable bearing. With the aid of the lever *a*, connected by an ordinary distance eccentric with the tail *l* of the adjustable bearing, the grinding rolls may be either thrown out of gear or thrown in for ordinary work. In throwing out the bottom roll the lever *a* at the same time turns a horizontal crooked lever round its axis, which by means of a cross-head coupling throws the rapidly rotating bottom feeding roll out of motion. The spring of the brake is adjusted by means of nuts h_1–h. An accurate tramming of the axes of the grinding rolls is performed with a hand-wheel *g*. The dismantling of the frame and extraction of the grinding rolls is performed in the following manner. The removable parts *o* on either side of the frame are taken off. Then the cotters *i* are taken out and the nut *k* loosened, which allows the cup *m* to be lifted off, when the lids of the bearings are removed and the grinding rolls may be lifted out.

The ventilating air enters through the holes in the lid of the hopper covered over with a dense sieve, exhausts the rolls from below, and escapes through the side openings.

The transmission of motion from the fast top roll to the bottom one is done by means of toothed wheels enclosed in cast-iron casings filled with oil through the inlet *q* up to the level *p*.

(ii.) *American Roller Mills*

Not only in Russian literature but in Western Europe as well a total absence of descriptions of American milling machinery in general, respecting roller mills, is observable. Even so eminent an author as Professor Kick speaks only of Howes' scouring machine. This circumstance is all the more striking, since the first teachers of the European automatic milling engineers were Americans. One could learn a good deal from them even now. However, not only in monographs and lectures, but even in the periodical literature of Europe, we find no material dealing with the American construction of milling machinery. Is this the usual conservatism of Europe, or the patriotism of the Old World ? We cannot undertake to judge, but the fact is, that the European constructors have been deprived of rich material in the possession of their transatlantic colleagues.

The American roller mills are so different and original in their constructive ideas, and besides that so little known to us, that we have deemed it expedient to dedicate a whole chapter to their description.

We are already acquainted with the feeding devices of the American mills, and shall now examine the brakes and the mill in their full outfit.

Fig. 255 represents J. Stevens' two-roller mill with a brake of direct action. The bearings *a* are fixed, the adjustable ones a_1 run in the parallel guides of the frame. The brake has the following arrangement. The screw *F* freely passes through the screw 1–2, entering the box of the bearing and its end protruding out of it. The screw 1–2 is screwed into the arm *G* of the frame. On this screw a spring is set which presses upon the bearing. The grinding rolls are thrown apart by pressing the lever *D* down with the handle *d*, when the cross-heads *C* (on Fig. 1, with another curve of the lever *D*, it is more clearly seen) press upon the protruding parts of the screw *F* and draw the bearings and the grinding roll with them, to the left. When the lever is turned back, the spring brings the bearings to their former position. The distance of the working surfaces is defined by the size of the protruding ends of the screws F. The parallelity of the axes of the rolls in a horizontal plane is set by those same screws being deeper or less screwed into the frame of the bearing.

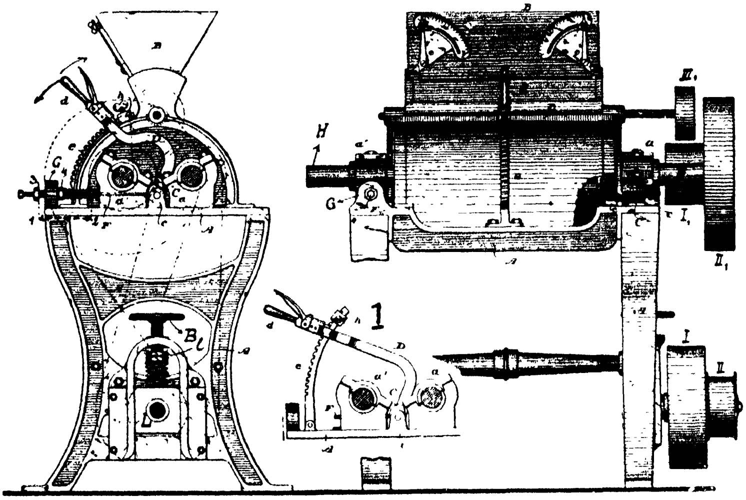

FIG. 255.

The head 3 of the screw 1–2 serves for screwing it into the arm of the frame, and thus adjusting the distance to which the bearings are removed ; the nut 4 regulates the tension of the spring. The motion is transmitted to the roll by belt-gearing, and the receiving belt-pulley is on the journal *H* of the fast grinding roll, which transmits the motion to the slow roll by means of jockey-pulleys I_1–I and II–II_1 ; from the shaft of the slow roll a cross drive III–III_1 runs to the feeding roll. The tension of the belts is adjusted by a screw *B* with a spring to mitigate the shocks. This spring presses upon the adjustable bearing of the jockey-pulley *I–II*, while the degree of its pressure is regulated by a nut and a lock-nut *l*.

The defects of the brake of direct action were noted when examining Noye's brake. But those mills do good service in the rough fodder-grinding of maize, barley, oats, &c. Among the reparable defects of this mill we may place the transmission of motion to the feeding roll from the adjustable grinding roll, for when the grinding rolls are being drawn apart the belt becomes stretched and then begins to work badly.

It is to be remarked here that the belting transmission of motion to the grinding rolls is a peculiarity characteristic of American roller mills. Only in mills doing rough, coarse work do the Americans employ toothed gearing.

T. W. Graham's original brake is shown on Fig. 256. The adjustable grinding roll *E* is set in a bearing *F*, one tail of which is connected with the rod *D*, while the other, *G*, with its point *H* turned to a globe, enters into a cylindrical socket in the frame of the fixed bearing *A*, which forms a part of the roller frame. Through the arm *K* of the lower tail there passes a rod *L* to the spring *M*. The rod *P* eccentrically set with its clip *X* on the finger *n*, the screw *D*, and the spring hold the bearings in a settled position. By turning the handle *N* down and pushing the rod *P* likewise down, the bearing *F* is made to revolve round the horizontal axis of the apple *Q*. To allow a free lowering of the left end of the spring rod *Z* there is a clearance *l* in the frame. A rough tramming of the roll-axes is done by means of nuts *o* and o_1, a more accurate setting by the screw *D* which also regulates the working distance. The pressure of the spring is adjusted by a nut l_2.

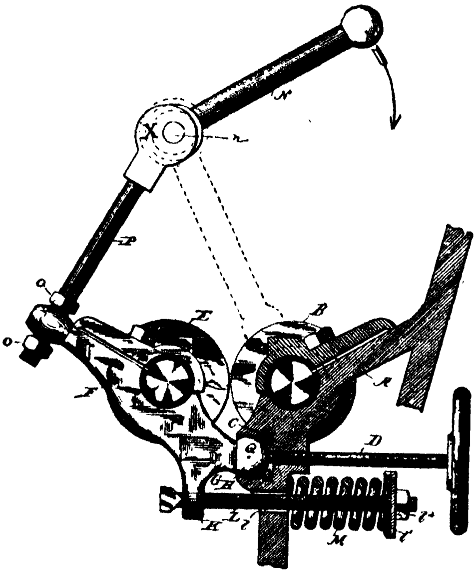

FIG. 256.

The brake of J. Dawson's four-roller mill is given in Fig. 257. The lower tails *D* of the adjustable bearings *E* are freely set on the hubs *G* with levers *K*. These hubs are eccentrically fitted on the journals of the shaft *H*, the rotatory motion of which is stopped by bolts *L*. The top tails of the bearings rest on the spring *V*. The screw rods *N* are fitted with their slips on the fingers of the discs *R*, one of which has a handle *X* with a lock *Y*. The discs are fixed on the journals R_1 of the shaft R_1 with keys. By turning the handle *X* to the right or left one can bring the grinding rolls to a fast or a loose run. The tension of the spring is adjusted by a nut *W* (having a washer on the rod with a clearance behind it). Seeing that the hub *G* is an eccentric, by turning the levers *K*, having previously loosened the bolts *L*, one may set the axis of the roll in a horizontal plane ; the parallelity of the axes of the grinding rolls is established by turning the hand-wheels *U* to the right or to the left, depending on the direction in which the axis slants.

Special attention is due to the idea of adjusting the axis of the grinding roller in two planes—vertical (by means of an eccentric hub *G*) and horizontal, so simply brought into execution. We must remark that all European factories do not give consideration to this question.

Fig. 258 shows us the brake of a two-roller mill, constructed by W. D. Gray, an eminent American engineer (Allis-Chalmers Co. works). Here both the bearings *D* and D_1 are adjustable ; their axes of rotation are o and o_1. The section of the brake is illustrated on Fig. 260, which shows the rod *E* to be an eccentric coupling with the axis b_6 of the lever *H*. The second end of the rod passes through the cup *d* with a spring d_1 of the tail of the bearing *D* resting against the screw d_3 with a hand-wheel. On the same axis b_6 there is eccentrically set the tail of the bearing D_1. The grinding rolls are thrown apart by pulling the rod *j* to the right. The friction drive to the feeding roll is arranged as follows : on the rod *E* there is a coupling *Q* with an offshoot *q* to which the loose belt-pulley *M* is screwed by the bracket of its hub.

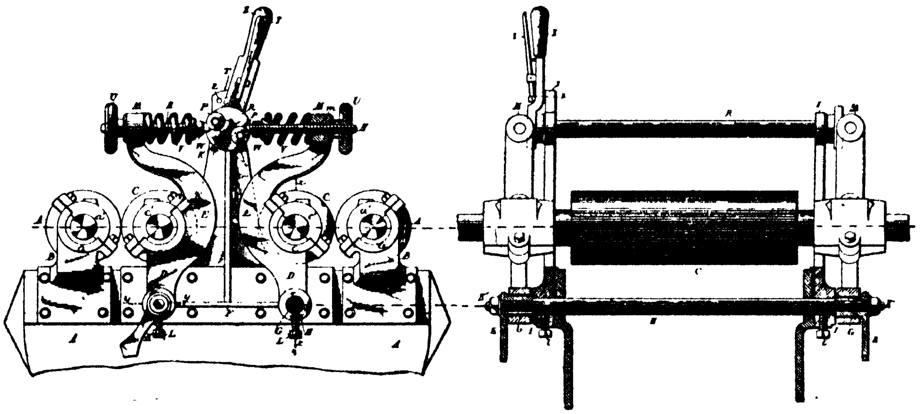

FIG. 257.

The coupling *Q* may be moved up and down the rod and fastened with a bolt *a*. When the rolls are set for a working run, the belt-pulley *M* comes into contact with the belt-pulley *N* on the journal of the right-hand roll, and the belt-pulley *L* on the journal of the feeding roll.

Fig. 259 illustrates the brake of a four-roller mill. The bearings of the middle rolls here are fixed. The details need no explanation, being a repetition of those preceding.

A more simple friction drive to the feeding rolls is to be seen on Fig. 261. Here only one friction roll *E* is loose ; to the second feeding roll the motion is transmitted by a crossed belt. The defects of the friction drive, in the first case (Figs. 258 and 259) lying in the fact that with the change in the working distance of the grinding rolls the position of the friction roll has likewise to be altered, are removed here since the position of the friction drive is independent of the position of the brake rod.

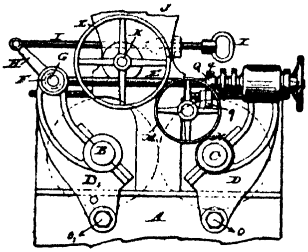

FIG. 258.

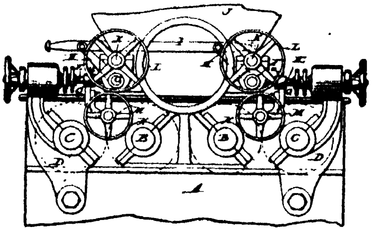

FIG. 259.

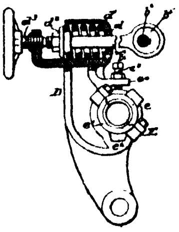

FIG. 260.

In Fig. 262 we see a very ingenious device for stopping the operation of the feed rolls by means of an ordinary cross-head coupling and a loose belt-pulley on the axis of the feeding roll. On the left-hand end (top left-hand drawing) of the roll *G* communicating the motion to the rods *E* of the brakes, there is set fast a hub *p* with a screw arm *P* (Figs. 3 and 4) which catches the flange *a* of the hub of the belt-pulley *L*, on the axis of the feeding roll *J*. This hub on its left-hand side is a cross-head coupling cogging in with the hub of the loose belt-pulley *N*. When the rolls are in a working position the roll *G* is turned so that the screw flange of the hub *p* points downwards and the spring *f* pushes the belt-pulley *L* forward till it couples with the belt-pulley *N*. When the grinding rolls are

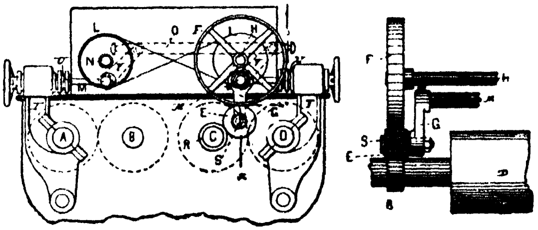

FIG. 261

running empty the flange *P* disengages the belt-pulleys *L* and *N*, and the operation of the feed rolls is discontinued.

A similar device for a loose and fast run of the feed rolls with toothed couplings and friction 2 is illustrated in Fig. 263, with this

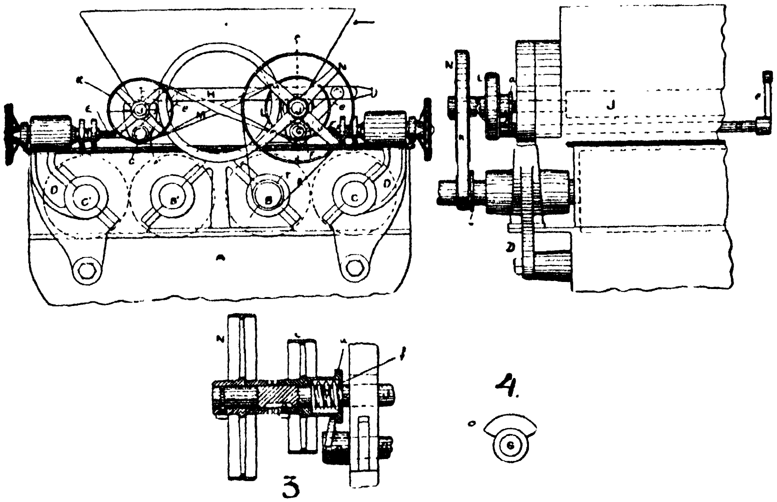

FIG. 262.

difference only, the disengaging mechanism of the grinding roll connected to brake hand-wheel, and the connecting of the couplings or of the friction, is performed not by a spring but by a crank lever *R* (with or without a fork at the end). On the rod *H*, which brings the

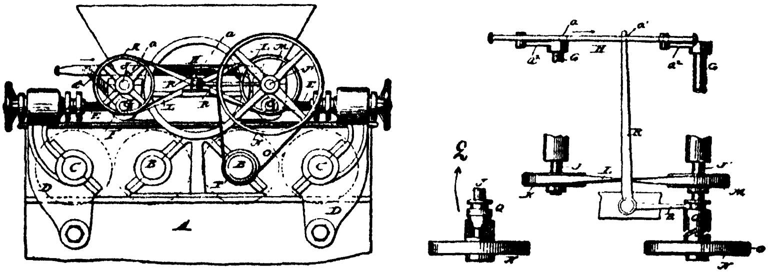

FIG. 263.

adjustments into action, there are two slides made to fit the free end of the crank lever *R*. When the rolls are in gear, and the rod *H* is pushed to the right, the end of the lever *R* falls into the slide *a* and keeps the coupling *Q* engaged with the hub of the belt-pulley *N*; when the run is loose, it is held by the slide *a*.

The latest model of W. D. Gray's roller mill is represented in Figs. 264, 265, and 266. A characteristic peculiarity of the American roller mills is, as has already been mentioned, the total absence of toothed gearings. Let us note first how the motion is communicated to the rolls. From the pulley of the transmission shaft, the belt runs first (Fig. 264) over the belt-pulley *A* of the outermost fast grinding roll and then over the jockey-pulley *C* to *B*, the belt-pulley of the third on the left-hand side fast grinding roll. In this manner, the fast rolls of the American roller mills are disposed asymmetrically—the inevitable result of transmission by belting. This arrangement cannot be avoided if the machine is to be compact. The slow grinding rolls with belt-pulleys *D* and *E*, the second and the fourth, receive their motion (Fig. 265) from the belt-pulleys *F* and *G* placed on the same shaft as the belt-pulley *C*. The belt-pulley *C* has a double function : firstly, it affords the possibility of enlarging the gripping angle of the belt-gearing of the pulleys *A* and *B*, secondly, by rising or falling it adjusts the tension of the belt.

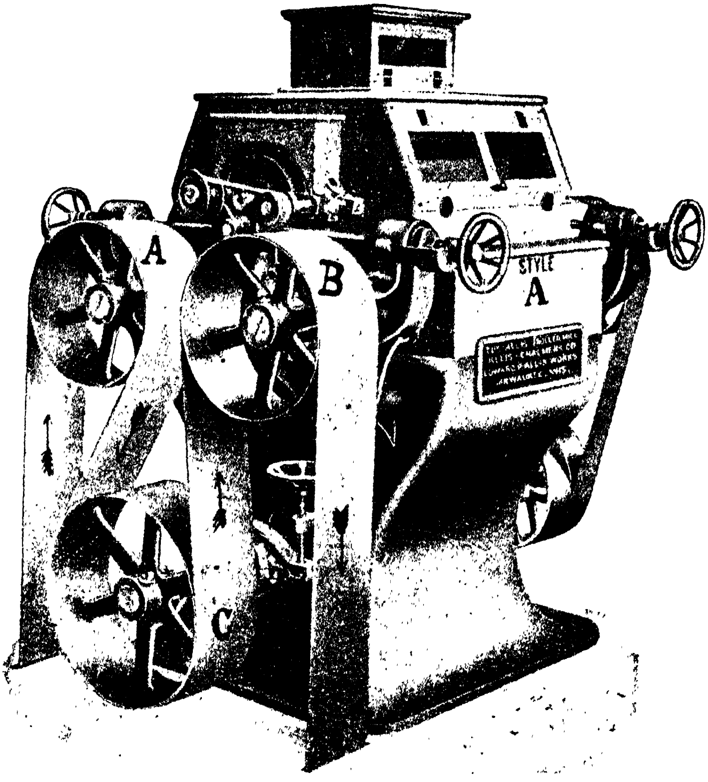

FIG. 264.

An adjustment of this kind of the tension of belts is a feature of the construction of roller mills of all American works, and is of very great importance. First of all, the tension of the belts being regulated in the manner described above, there is no need to take up the stretched belt; but the main point is that by increasing the tension, we can within a limit of 10 to 20 per cent. increase the capacity of the mill, which has often to be done when the mills are overloaded. The raising and the lowering of the jockey pulleys *C*, *F* and *G* is performed by means of hand-wheels *j* and screw rods connected by joints with the tails of the bearings *L*, which turn round the axis *O*. The screw rods pass through a consolidated bracket *Q* with a screw thread. Before proceeding any further, we must point out a material defect in Gray's adjustment of tension. The planting of independent adjustable bearings for the belt-pulleys *C* and *F–G* does not exclude the possibility of the shaft getting out of line, since its horizontality cannot be trued up on the belt-pulleys *F* and *G*; this tends to make the bearing *L* work hot and wear irregularly.

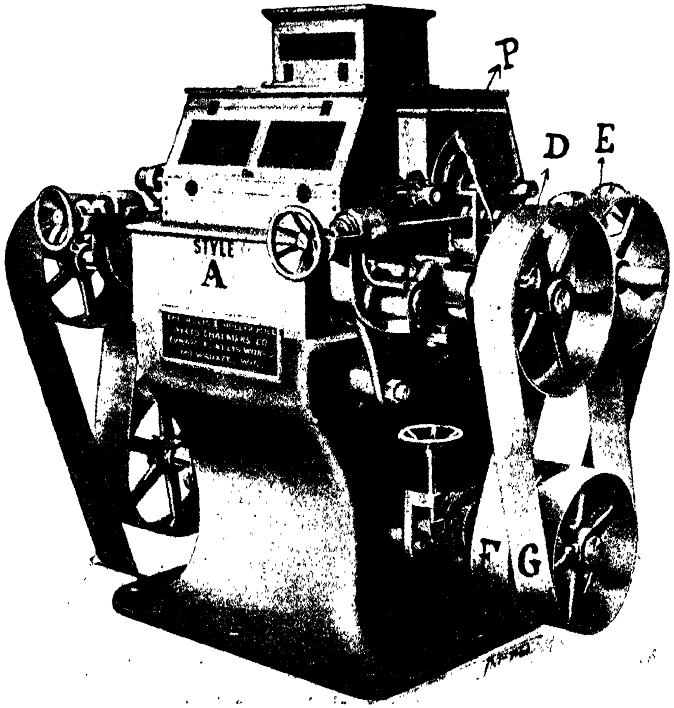

FIG. 265.

Proceeding now to describe the mill, we must point out that the mechanism adjusting the distance here is improved in so far that the eccentric rods *E* of the brake have one common axis *S*, which simplifies the construction. On the same axis is set the tail of the hub of the loose belt-pulley, over which there runs a belt transmitting the motion from the slow roll to the feeding rolls. In throwing apart the outer grinding rolls by turning the lever *P* to the left this loose belt-pulley is dropped down, the belt slackens, and the feeding rolls stop operating. This belt-pulley, similarly to the guide belt-pulleys and the belt-pulleys on the axes of the feed rolls, has collars (Fig. 266) which prevent the belt from running off. When the tension of the belt to the pulleys of the feed rolls is to be increased the bolt holding the hub of the tail of the loose belt-pulley is dropped, the tail turned to the right, and the bolt is again fastened.

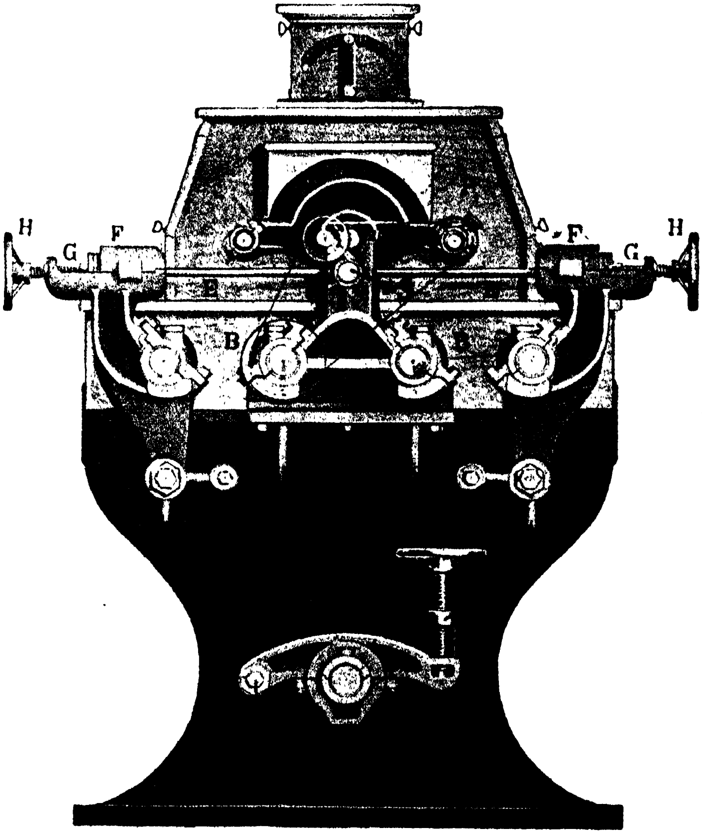

Fig. 266.

Nordyke & Marmon Co.'s Mill.—On Figs. 267, 268, and 269 we see the construction of a roller mill of one of the largest American works—that of Nordyke & Marmon Co. at Indianapolis. Fig. 267 illustrates the

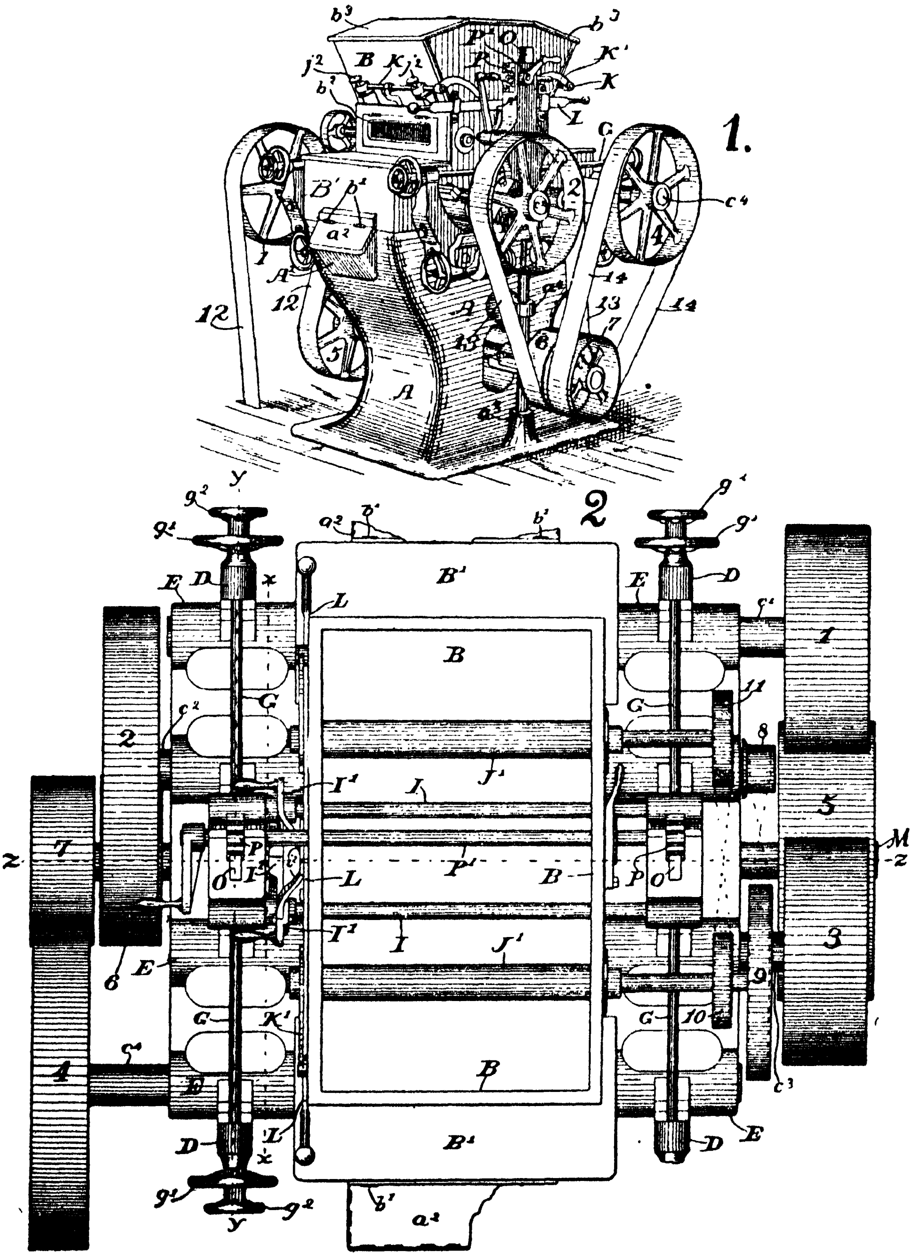

Fig. 267.

general view of the mill (1), and the plan (2) with the hopper off, Fig. 268 two sections, longitudinal (3), and along the brake mechanism (4), Fig. 269

details of the drive to the brake mechanism and to the feeding apparatus (5, 6, 7, 8, 9, 10, 11). The mill is driven by the belt-pulleys 1, 2, 3, 4—1 and 3 by means of the belt 12 running from the belt-pulleys on the shafting, 2 and 4 by means of separate belts 13 and 14 on the belt-pulleys 6 and 7. The jockey-pulleys 5, 6 and 7 run through the frame of the mill.

The adjustable bearings are built in the following manner: the two-tailed boxes *D* for the bearings *E* below (Fig. 268, 4) have an axis of rotation *d* (a bolt screwed into the frame) on which they are set with their eccentric d_1. This eccentric determines the distance to which the adjust-

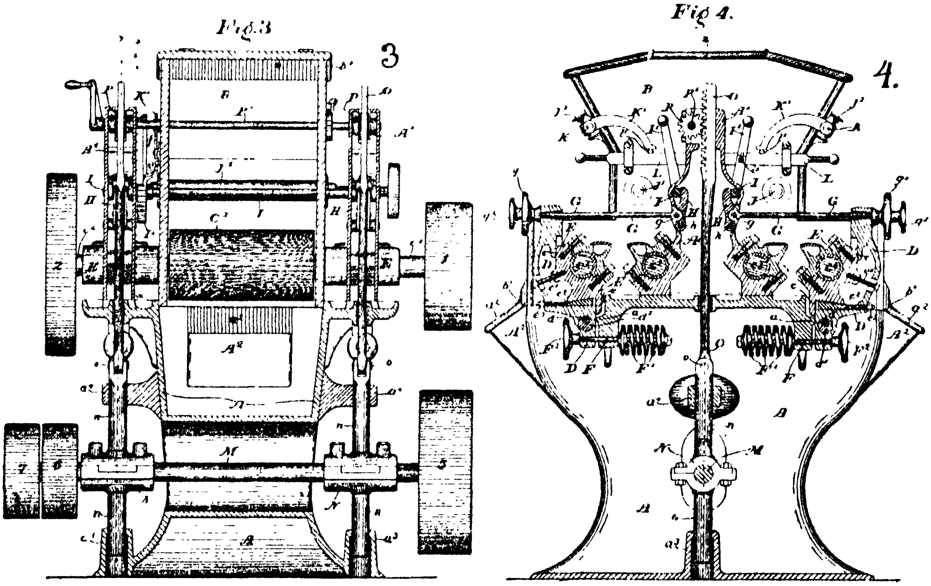

Fig. 268.

able grinding roll springs open in case a nail or any other piece of metal falls in between the rolls. The bearings *E* have surfaces *e* and e_2 turned in to the corresponding surfaces of the boxes *D*, to which the frame of the bearings is attached by bolts e_1. If the axes of the rolls require adjusting vertically, the bolts e_1 are loosened and the wedges e_3 tightened. When the regulation is ended, the bolts e_1 are readjusted.

The rods *F* of the brake pass through the lower ends of the shoulders *D*, under their joints, having the spring F^1 on one side, and the regulating brake of the spring hand-wheel F^2 on the other. These hand-wheels are screwed up till the shoulders have a tension sufficient to communicate a pressure of the desired force to the rolls. When a hard body falls in between the rolls and presses them apart, the springs contract,

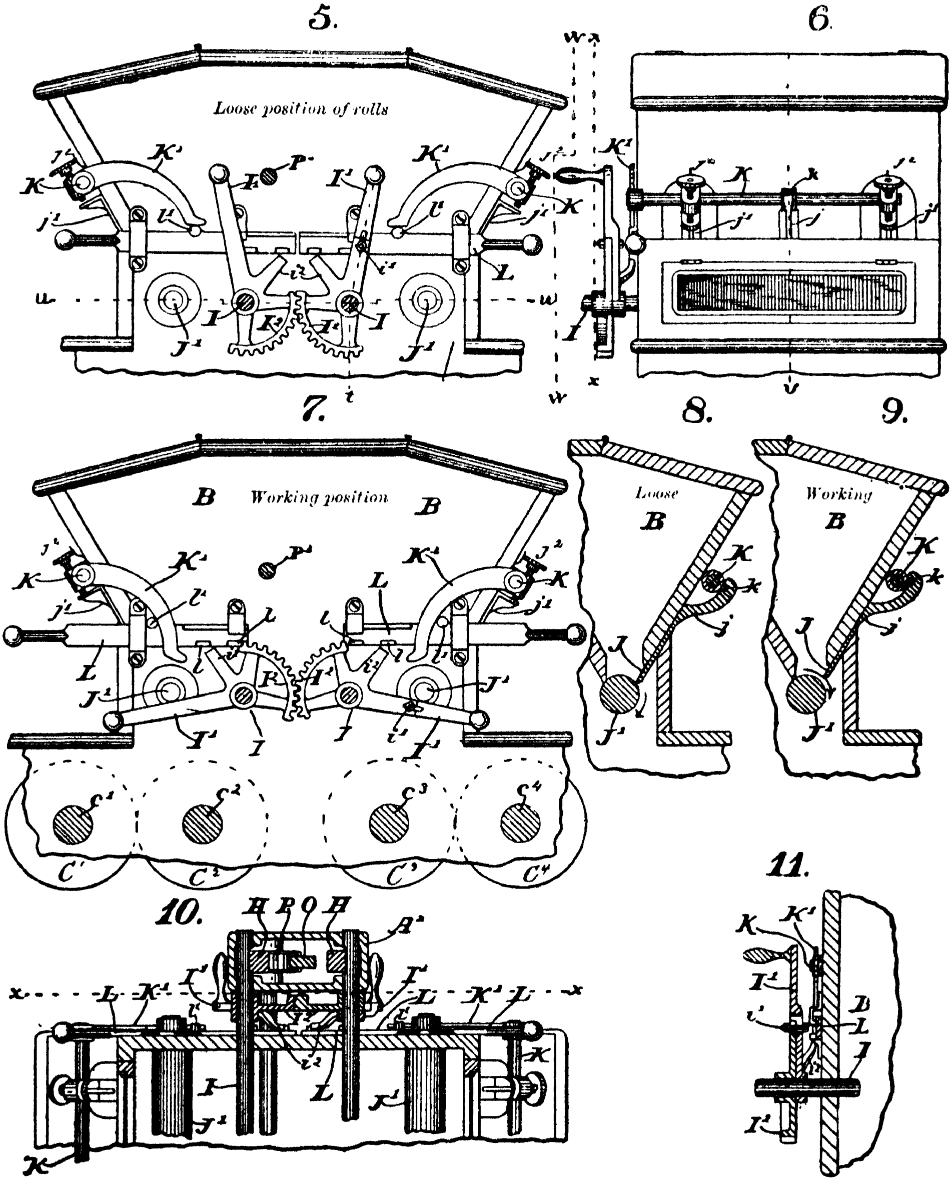

Fig. 269.

for the shoulders, owing to the eccentric couplings on the bolts, may travel along the axis *d*.

The rods *G* serve to move the upper ends of the shoulders *D* to the right and to the left, owing to which the grinding rolls approach or separate, *i.e.* the throwing in or apart takes place. At its inner end every one of those rods is connected by a joint *g* with a lever *H*, which draws the shank with it when moving.

The levers *H* have in the frame A^1 axes of rotation *d* by turning the cross-heads *j* the throwing in and out of the rolls is performed.

The handles J^1 are set on the journals of the cross-heads *J*. Those handles have segments of toothed wheels J^2 at their lower ends. One of the toothed segments may be thrown off and act independently of its lever, if it be desired that only one side of the mill should be at work. This is effected by making the toothed wheel and the lever in two parts, as shown in Fig. 269 (6 and 11), with a slot for the bolt i^1. When it is desired to fasten both parts together, the bolt i^1 is brought down, as shown, to the lower part of the slot and fastened there, so that the levers and the segments form one whole body and operate together. If it is intended that only one half of the machine should work, the bolt i^1 is pushed up to the top part of the slot, and then the handle and the segment are independent of each other. As this segment does not sit firmly on the shaft, the opposite lever may be displaced without touching the shaft it is set on.

With the aid of the above described adjustment both pairs of rolls, or either pair singly, can be thrown apart and then again brought together to exactly the same distance.

The lower ends of levers j^1 are provided with pins i^2, which, during the motion of the levers backwards and forwards, catch the claws 11 of the rods *L* (Fig. 269, 7), which are consequently brought into motion and draw the shoulders K^1 and the shafts *K* of the regulating gate by means of levers K_1 and pins l_1 with them. It is quite clear that when the levers *j* are disconnected and are working independently of each other, they bring into action each one of the rods independently.

The feed plates *J* are of thin metal and run along the feeding rolls J^1 with claws *j* and j^1 at the top. One of these claws *j* on each one of the plates couples with claw *k* of the corresponding axle *K* (see Figs. 8 and 9), and in this way the gate rises and falls with the revolution of the axle. Other claws, j^1, are fitted, so as to be able to catch the stop screws j^2, and consequently the gate is allowed to rise only to a certain height. It is best for the regulating screws to do the service of stop claws (see the fig.); in that case the rise and fall of the feed gate is under control. The feeding rolls J^1 are brought into motion in the direction pointed by the arrow by means of belts, the distribution of which in the machine is marked in dotted lines on the right-hand side of the plan of the roller mill (Fig. 267).

The shaft *M* through a connecting gearing of the pulleys 5, 6, and 7 is set on bearings *N*. With the rising and falling of that shaft the driving belts 12, 13 and 14 are tightened and loosened.

The bearings *N* are set on hatchet stakes *n* fixed in the arms of the bearings and pass through guides a^3 and a^4 of frame *A*.

The stems are connected by joints with the upper parts of the frame *n*, ending in toothed racks at the top.

The toothed wheels *P* are set on axles P^1 and engaged with the toothed racks of the stems *O*, which are thus enabled to rise and fall, dragging the shaft *M* and the belt-pulleys with them.

The motion is transmitted in the following manner : the main belt 12 drives the pulleys 1, 3 and 5, turning the grinding rolls C^1 and C^3 in one direction and the shaft *M* in another. With the aid of belt-pulleys 6 and 7, and belts 13 and 14 running to the belt-pulleys 2 and 4, the shaft *M* turns the grinding rolls C^2 and C^4 in the direction opposite to that of the rolls C^1 and C^3. There is a small pulley 8 on the shaft of the roll C^2, which drives the pulley 9 by means of a belt, one of the feed rolls J^1, and pulley 10 set on the same shaft. The pulleys 10 and 11 are connected by a belt which drives the other feed roll. The belts connecting the pulleys 8 and 9, 10 and 11 are not shown in the drawing, but their arrangement is marked by dotted lines on (2) Fig. 267.

On the axles *K*, the closer to the centre the better, there are claws K_1 (6) coupling with the claws *j* on the brushes and thus capable of raising and lowering the gates, according to the direction in which the rolls are turning. On these rolls (5) there are levers K^1 which with their weight turn the shafts in one direction ; in the other direction they are turned by means of claws l^1 l^1 on blocks *L*, which in moving lift the shoulders K^1 when they come in contact with those claws.

By means of the rods *L* the rolls *K* turn in one direction, covering the plates. When it is desired to shut the feed gates (or plates), the blocks *L* are moved in such a manner that the claws l^1 touch the shoulders K^1, which are lifted and turn the rolls *K*, thus causing the plates to drop, as is shown on (5) and (6) Fig. 269. When the gates are to be opened, the rods *L* are moved in the opposite direction, and the shoulders K^1 with their weight turn the rolls *K* back, thus opening the gate. As has been mentioned above, the levers J^1 have fingers i^2 which enter into the claws *ll* on the blocks *L*, thus lifting and lowering the gates with the same motion that brings the rolls together and apart. To keep this action of the apparatus effective in the operation of each block separately, the fingers i^2 are so arranged in respect to the claws *l* that they couple only if displaced from one position to another. The rods *L* are so placed that their ends are slightly raised, and when during the movement of the rod from one side to the other the finger i^2 touches the claw *l*, the rod rises and the finger i^2 passes under the claw *l* and stops between that claw and the one following; if the rod continues moving, the finger i^2 comes into contact with the next claw *l*, and brings the rod to a normal position when it is stopped. When the levers J^1 are turned to one or the other side to the extreme point (Fig. 269) 5 and 7, the fingers i^2 do not touch the claw *l* at all, and the rods *L* may be moved backwards and forwards quite independently of them.

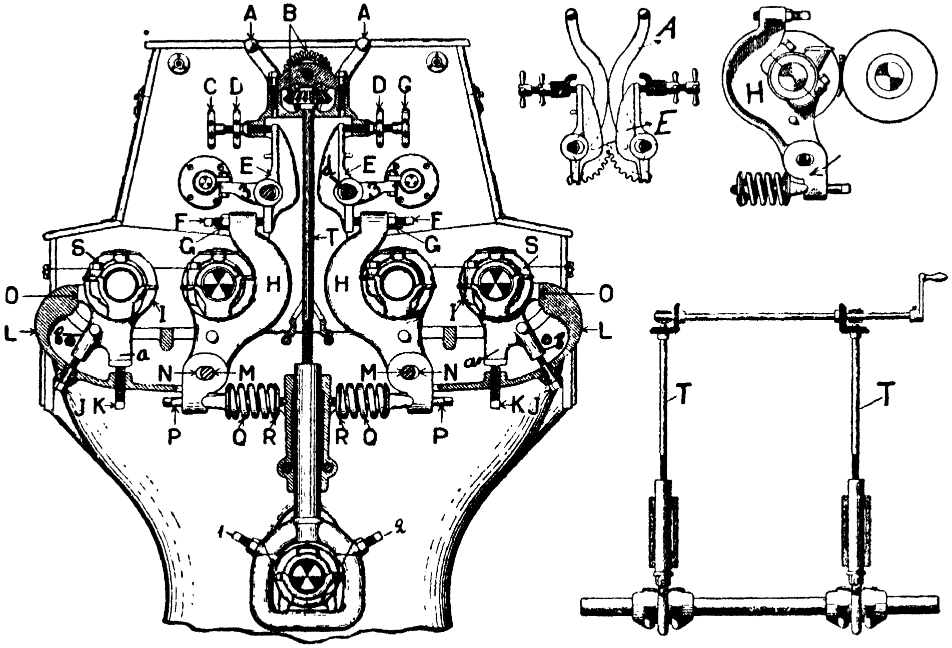

FIG. 270.

The latest model examined of the Nordyke & Marmon Co. mill is shown on Fig. 270. Here the adjustable bearings *H* are placed in the middle and the fixed ones are in the neighbourhood of the outer walls, and the bearings *S* of the outer rolls are so set as to allow of regulating them, and this is performed as follows: the bearings *S* have two tail-shaped arms *a* and *b*, one of which, *a*, rests freely on the bolt *K* screwed into the arm *L* of the frame; the arm *b* is fastened to the frame by a bolt *j* screwed into it. The planes of contact *O* of the bearing and the frame are planed to each other and determine the direction of motion of the bearing. If the bearing *S* is to be lifted or lowered, we loosen the bolt *j* and turn the bolt *K* to the right or to the left. When the axis of the grinding roll is set in a horizontal position, the bolt *j* is again tightened. The adjustable bearings *H* with brake are, generally speaking, constructed

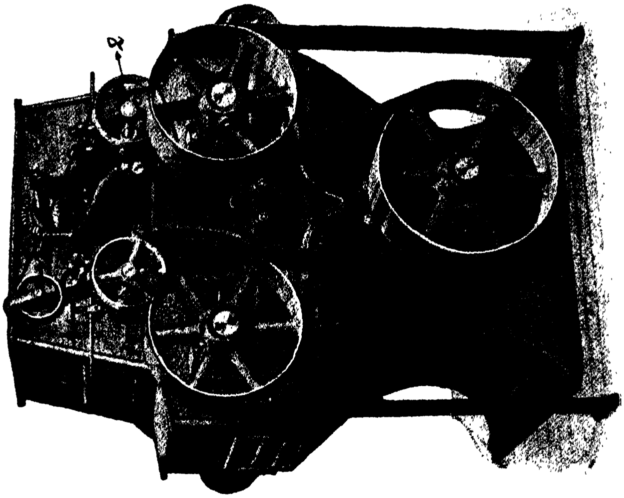

FIG. 272.

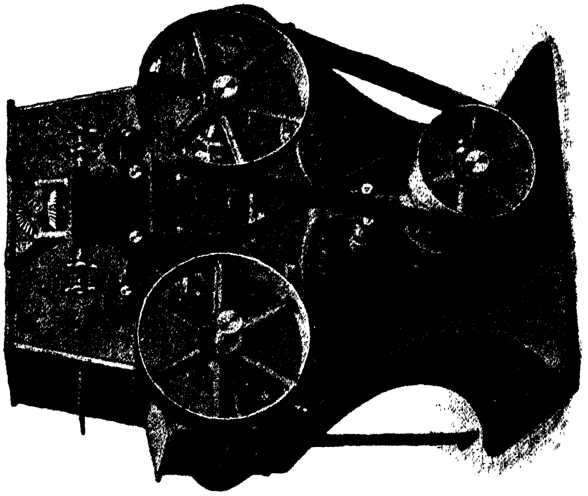

FIG. 271

similarly to those of the preceding model. The levers *E* for throwing in are eccentrically set on the hubs of the handles *A* with toothed sectors, and their rolls are thrown together in the required position. The axle *d* runs through the hopper and is supported by bearings in brackets 3 bolted to the arms of guards of the fixed bearings for the axles of the feeding rolls. By means of a screw with a hand-wheel *C*, and the hand-wheel *D* doing service as a lock-nut, the working distance between the grinding rolls is adjusted, and the parallelity of their axes set. The bearings of the jockey shaft are lifted by a rod *T* which has a square thread and is brought into motion by conic gears *B*. The cap of the bearings of the jockey shaft is kept on by the bolts 1 and 2. The tension of the spring is regulated by the screws *P*. Figs. 271 and 272 illustrate the front and the back view of the mill. Fig. 272 clearly shows how the feeding rolls are driven by belt gearing. The belt-pulleys 1 and 2 are set on the axes of the feeding rolls; on the hub of the bearing of the belt-pulley 1 is set a bracket 4 for the belt-pulley 3: this bracket is joined with a crank mechanism 5, its crank set fast on the axle *d* (see Fig. 270), owing to which at the moment of throwing the rolls apart the belt-pulley 3 is drawn to the left, the belt is loosened, and the feeding discontinued.

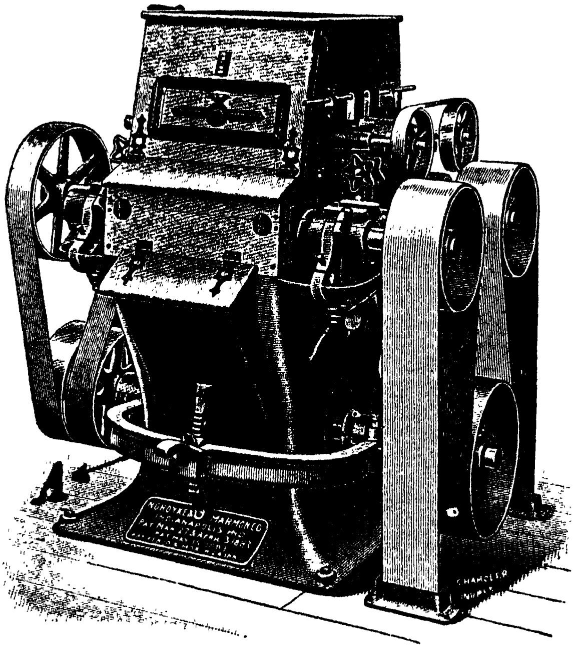

FIG. 273.

A more simplified construction of simultaneous lifting or lowering of the jockey shaft belonging to the same works is shown on Fig. 273, where the general hoop *A* carrying the bearings of the driving belt-pulleys is seen. The ends of the hoop rotate on journals fixed on the sides of the frame, while the middle has a ratchet stop.

A Feed-Crushing Roller Mill.—The feed-crushing roller mill shown in

Figs. 274 and 275 is used by the Americans to reduce the cakes obtained as a by-product in oil-pressing. The rolls of such mills with pyramidal corrugations are cast in open-hearth steel and their surfaces hardened. The arrangement of this mill is very simple. The roll 1 is set in fixed bearings, the other roll, 2, is placed in adjustable bearings *A*, furnished with a brake of direct action. The bearings *A* have cylindrical arms with which they are set into the slippers *B* lying in parallel guides *D*. The cups *C* holding the springs are attached to the frame by bolts. The tension of the spring is adjusted by bolts. On the reverse side of the bearings there are bolts by means of which the distance between the rolls is regulated.

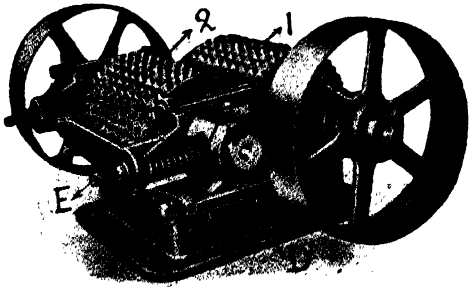

FIG. 274.

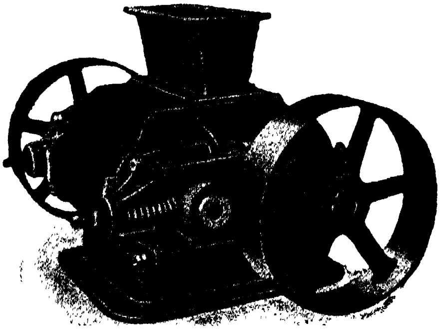

FIG. 275.

The diameters of the rolls of such mills are 300 to 350 mm., their length 600 to 800 mm., the number of revolutions of the fast roll 650, that of the slow 325, the number of powers required 15 to 25.

(iii.) *Roller Mills of the Fourth and Fifth Schemes.*

Three-High Mills.—C. Kapler's mill (Fig. 276) has three grinding rolls w_1, w_2 and w_3, placed diagonally one over the other. The hopper *O* is divided by a partition O^2 into two chambers. In the lower part of those chambers are disposed the feeding rolls a^1–a^2, to which the gates *m* approach, sliding on the outside surfaces of the inclined walls of the feeder. In each gate *m* there is a toothed rack m^1, coupling with the toothed wheel l_1 on the axis *l*, passing through the feeder. On the end of each axis *l* a worm wheel *n* is freely set with slots *q*, through which the screws of the stationary stems *p* at the end of the axes *l* can pass; with these screws the wheels *n* may be fixed to the stems *p*. The worm wheels *n* are coupled up with the screws o^1 on the transversal axis *o* at one end of the feeder; on the ends of this axis there are hand-wheels. When both worm wheels *n* are fixed on the axes *l* and the axis *o* turns, both the gates *m* accordingly draw away from the feed rolls a^1–a^2 and the feeding in this manner is regulated equally on both rolls. If it is wished to bring only one gate into operation, the worm wheel *n* of the other gate is disconnected with the stem *p* or with the axis *l*. On the ends of the axes of the feeding rolls a^1–a^2 there are set the belt-pulleys *R*, through which the driving belt (see dotted lines in Fig. 3) runs.

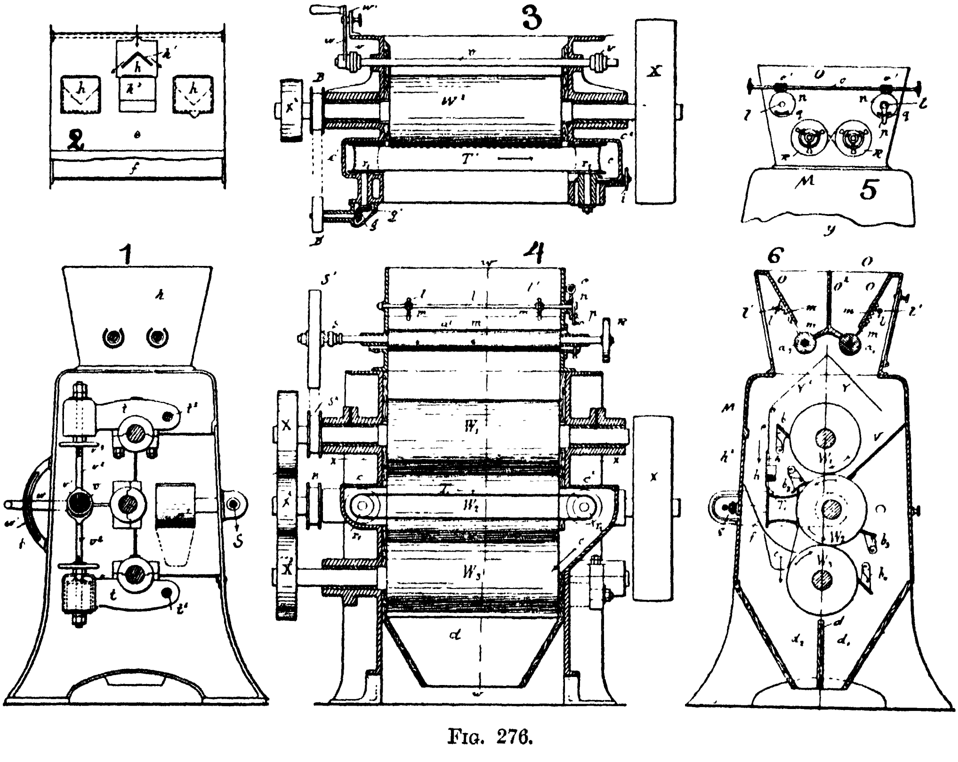

FIG. 276.

On the opposite end of one of the feeding roll axes there is freely set the belt-pulley S^1, which may be connected with the axis of the feed rolls by means of a toothed coupling *G*. The driving belt marked by a dotted line on Fig. 4 passes over the belt-pulleys S^1 and S^2 on the axis of the top roll W_1. Under the feeder two inclined plates Y_1 and Y_2 are arranged. The first supplying plate is placed over the top roller W_1 and from the lower edge of the plate Y_2 parallel to one side of the chamber *M* there runs a vertical partition *e*. An endless belt T^1 runs over the feeding rolls rr^1, which have a groove-like hollow on their circumference, so that the middle part of the belt lies lower than the rims; this belt runs parallel to the middle grinding roll W_2 beside it. The feeding rolls r^1 and r^2 lie inside the pockets c^1 and c^2, which protrude at the ends of the chamber, as shown on Fig. 4. The lower part of the pocket c^2 has an incline and forms a hopper c through which the product can flow out into the delivery hopper d^2. The axis of the feed-roll r^1 has a conic toothed wheel g^1 engaging the conic toothed wheel g on the same axis with the belt-pulley B^1 over which runs the belt which passes likewise over the belt-pulley B on the axis of the middle grinding roll W_2. The journal of the belt-pulley r^2 is joined with a screw i with the aid of which the tension of the belt T^1 may be regulated. On the outer surface of the roll W_1 there rests a scraper b^1, on the upper part of the roller W_2 the scraper b^2, on the lower part another scraper b^3, and lastly close to the side of the roll W_3 the scraper b^4. All those scrapers remove the product adhering to the rolls.

The partition c has windows h^3 closed by doors h opening to the outside, and fixed on joints to the upper part of the windows. On the inside these doors have V-shaped projections h^1. When the door is opened to a position shown on Fig. 2, allowing of the insertion of one's hand through the window h^3 to get a sample of the product reduced between the upper and the middle rolls W_1 and W_2, the product falling on the plate Y_2 opens the gate h and flows down the supplying plate f to the nip of the rolls W_2 and W_3. A door h^2 in the wall of the box affords an access to the windows h^3. The shaft of the middle roll W_2 is set in the fixed bearings of the boxes, and the shafts of the top and the bottom rolls W_1 and W_3 in adjustable bearings supported by levers $t\,t$ fixed at the points $t^1\,t^1$ at the ends of the box.

The rods v^2 form eccentric joints with the axle v; the other ends of those rods rest on springs encased in the cups of the levers of the bearings t. The axle v may be turned by means of the lever w moving on the curved guide w^1 to which it may be attached by a suitable screw. By turning the shaft v one can approach the bearings of the rolls W_1 and W_3 to the middle roll W_2 or remove them from it, thus regulating the degree of fineness of the grist.

G. Daverio's Three-High Mill.—On Fig. 277 is given the more simple construction of G. Daverio's three-high mill. The feed B is divided into two parts, every one of which has a separate feeding mechanism. For lifting and lowering the gate H there is the lever P, and a stop-screw with a hand-wheel C, for the more accurate feeding of the product. The feed roll of the right-hand side section supplies the stock to the working space between the upper and the middle roll, the roll on the left serves the middle and the lower grinding rolls. The rotation is communicated to the feed-rolls by a direct and cross-belt drive from the axis of the top grinding roll to the belt-pulleys *M*, which may be thrown off and in by hand with a cross-head coupling *H* with the aid of the lever *O*. The adjustable bearing for the lower grinding roll has a tail *D*, with a cup for the spring *K*. The lower roll is thrown in and out by the top lever *A*, with the aid of which this roll may be placed at any working distance. A more accurate setting is performed by means of a hand-wheel *E*. The tension of the spring is adjusted by nuts on the right-hand side of the brake rod. The top roll is thrown in and out by the lower lever *A*. The brake of this roll is arranged similarly to the one at the top.

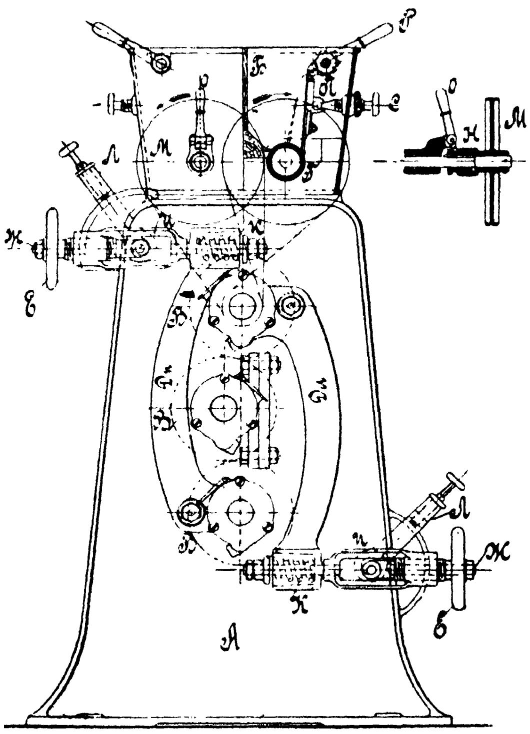

FIG. 277.

When this mill works in divisions the supplying plates are generally arranged as shown on Fig. 278, *i.e.* the product from the upper and the middle rolls passes through the isolated openings in the plate which directs the stock to the middle and the lower roll.

Willford's Three-High Mill.—The defects of the three-high mills with rolls of equal diameter lies in the fact that the middle roll, in doing double work, becomes worn more rapidly and requires a more frequent renewal of the corrugations. This causes a quick decrease in its diameter, and consequently, the necessary differential of their velocities is unbalanced. An American engineer, Willford, with the view to obviating this defect, recommends a mill with a middle roll of double the diameter of the rolls on either side of it. Fig. 279 represents this mill, where 2 marks the frame of the machine, and 4 the feed hopper with a feeding mechanism. The frame is one cast-iron block, while the hopper 4 is usually made of timber and suitably fixed to the frame. The top and the bottom rolls 8 and 10 are first placed into the frame through the middle aperture 20 in the wall, and then pushed with journals into the hollows 22 and 24. The middle roll 3 is set in its place between the other grinding rolls, and the metal caps 55 covering the openings in the walls are screwed to the frame. The openings are made in the opposite walls of the frame, so that it is possible to put the rolls in or take them out from either side, for the mill sometimes has to be erected in a position that would make the rolls inaccessible, if the apertures were only on the one side. With this construction all the rolls may be inserted through any particular opening, every one of which is sufficiently large to allow a passage for the largest roll.

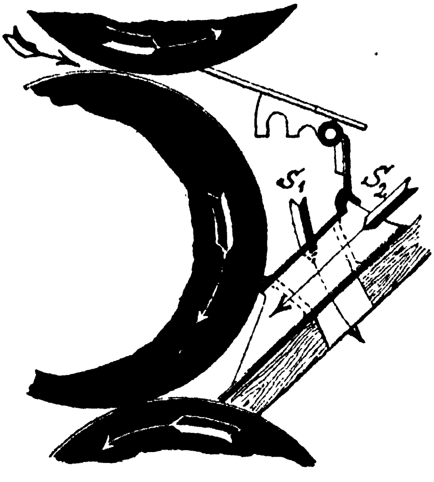

FIG. 278.

The hollows 22 and 24 constitute parts of the opening 20, but the openings themselves may be made so large as to embrace the hollows too, so that the top and the bottom rolls or one of them may be put in, and

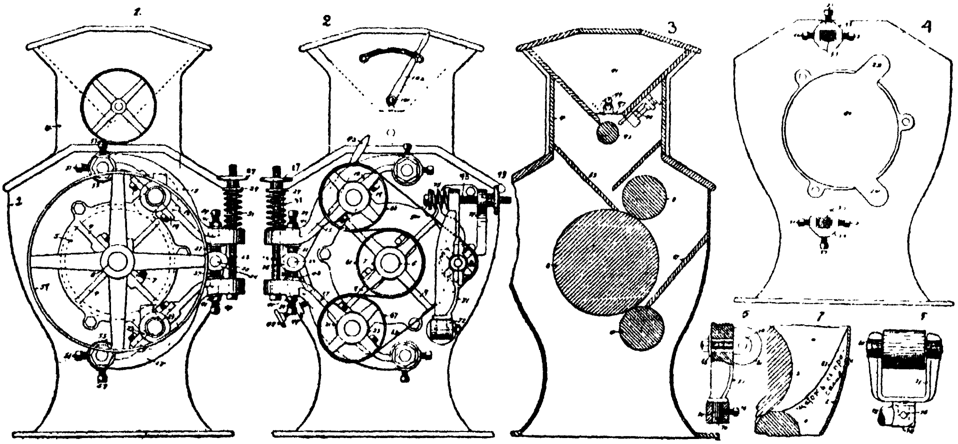

FIG. 279

then pushed aside to give place to the third roll. In such a construction the shape of the opening 20 is of no consequence, though the round shape with hollows for the journals of the top and the bottom rolls is preferable.

The journals 6 of the middle roll 3 are set in the bearings 7 in the caps 5 covering the openings 20, which have ribs 9 to impart greater strength to the cap.

The journals of the top and the bottom rolls are set in bearings, which are supported on levers 15–17, fixed by joints to the walls of the frame above and below the middle roll.

The vertical bolt 25 passes through the ends of each pair of levers. In its top part it has a screw thread and a hand-wheel 27 with a screw hub. Under the hand-wheel there is a washer 29, and between the washer and the lever is placed a spiral spring 31. Through the front wall of the frame, between the ends of the levers, there runs a shaft 33, with cross-heads 35, on which the slide-rods 37 rest. Those slide-rods are fixed to the levers by screws 39 and by adjusting nuts 41. The slide-rods 37 on each lever are independent of each other, and therefore by adjusting them the parallelity of the roll shafts may be trammed.

The shaft 33 has a handle 43 on one end, by means of which it can be turned and the ends of the levers parted with the aid of cross-heads, thus forcing the top and the bottom rolls away from the middle one. The handle 43 generally has a bracket 45 running under the shaft. Through the projection 49 there passes the coupling belt 47 resting against the bracket 45. By turning this bolt, the position of the rolls may be adjusted. The rolls may be thrown apart by means of a lever, and then brought to their primary position. The tension of the springs 31 determines the pressure of the top and the bottom rolls upon the middle one.

The bearings for the levers are formed on the ends of the square or flat stems 53, which pass through a thickening 55 on the outer walls of the frame (see Fig. 4). By means of bolts 51 and 57 the position of the axes of rotation of the levers may be altered.

On the shaft of the middle roll there is set a driving belt-pulley 59, with the aid of which this roll is driven. The surface of this roll being close to the surfaces of the upper and the lower rolls, the latter are rotated by friction with the middle roll, when the stock flows between them: for this reason the velocity of their rotation must be equal to that of the middle roll. To avoid this, there is a separate differential belt-drive, by means of which the velocity of rotation of the top and the bottom rolls is diminished in respect to the velocity of the middle roll. On the opposite end of the shaft of the middle roll is set a belt-pulley 61. The shaft of the top roll has a belt-pulley 65, and a similar belt-pulley 67 is on the shaft of the bottom roll. In the plane of these three belt-pulleys to the wall of the frame there is fixed a lever 71 with a hole at its upper end, through which there passes a screw 73. This screw has a spiral spring 75 between its head and the body. To the wall of the frame there is screwed a bracket 77 through which this screw 73 runs. This screw is provided with a nut 79 which rests against the bracket. In the lever 71 the journals of the belt-pulley 81 are fixed. A belt 83 runs to the pulley on the middle roll, to all the other pulleys, and to the fixed pulley 81, as is shown on Fig. 2.

The lever 71 is composed of two parts (Fig. 6), of which one part, 72, is fixed on a joint to the frame, and the other part forms a journal 70 entering into the boss 74 in the part 72. For coupling those two parts there is the bolt 76. Owing to such an arrangement, the lever may be turned on the axis, so as to place the belt-pulley 81 in the same plane as the belt-pulleys 65 and 67.

The Figs. 5 and 6 show the construction of the fixed belt-pulley, with the aid of which the motion of the belt may be directed forwards or backwards.

The bearing boxes 80 for each journal of the belt-pulley 81 are set independently of the lever, and have bolts 82 running through a fissure in the lever, which is opened in the middle so as to let a belt through it. Each journal of this belt-pulley may be set along the lever. By turning the hand-wheel 79 up the belt is tightened on the belt-pulleys, and the belt-pulley 81 communicates to the belt a tension equal to that of the spring.

The feed-hopper 91 contains an ordinary feed-roll 93 and an adjustable gate 95. In addition there is a device, by means of which the feed may be stopped without displacing the feed gate. This appliance consists of a metal plate 97 which may be stationed across the lower part of the hopper, forming a bottom. This bottom is connected with the crank 99 furnished with heads 101, the journals of which enter into the walls of the hopper. On the outside of the frame, to one of these heads is attached a handle 102. By moving this handle, the bottom may be brought to the position marked by dots (see Fig. 3); in this position the plate lies parallel to the walls of the hopper and does not impede the passage of the stock.

I. B. Allfree's Four-High Mill.—For three succeeding passages of the product the use of four-roller mills is suggested, one of which (of American construction) is shown in Fig. 280.

The frame *A* has vertical arms *B*. To those arms the bearings *C* supporting the fixed grinding rolls *DD* are fixed. These bearings are fastened to the arms by bolts *a*; at the lower ends there are coupling bolts *b* with the aid of which the bearings may be adjusted, because those bolts rest against a projection on the frame made for that purpose. On the other side of the vertical arm there are fixed in suitable positions two L-shaped brackets *E* supporting truckle axles *F*, which run through the whole frame, with necks at either end, protruding beyond the brackets. These brackets are eccentric in respect to the body of the shafts, and their duty is to support the adjustable bearings *G* for the rolls, and also the levers *H* at the other end.

In the upper parts of the L-shaped brackets *E* there are vertical slots (dotted out *e* on Fig. 6), through which the coupling bolts *f* pass. These brackets have adjusting screws *g* for setting the rolls in a parallel position, at one end, and a long horizontal opening *J* (see Fig. 6), the inner end of which is rounded, so that the shaft *F* may pass into it. A small bush *h*, with a cavity, on the side adjacent to the shaft *F* (Fig. 7) is set into the slot; this bush can freely slide in the slot. It is held in its position by a small spiral spring *i* to which the desired tension may be imparted by means of a screw *j* running through the end of the bracket and resting against the spring. The spring *i* with the bush sliding in the slot serves as an elastic stop to the truckle shaft *F*; the eccentric end of this shaft passes through one of the ends of the adjustable bearing *G* for the rolls, which is fixed to the neck of the shaft, so that in the case of a hard body falling in between the rolls, they can move apart, owing to the action of the truckle shaft *F*, the bushes *h*, and the spring *i*. The other ends of the roll-bearings are supported and adjusted by screws *k* with forked ends

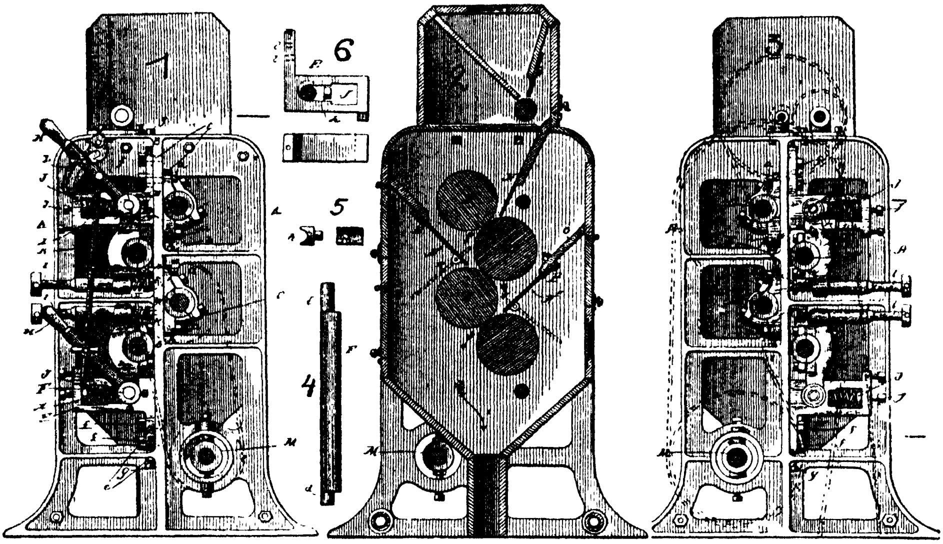

Fig. 280.

running from the middle arm through an opening in the ends of the bearings *G*. On these screws there are set hollow coupling nuts *l* which are on the outside of the walls of the machine and serve to bring the rolls together and apart, with the view to obtaining a product of the desired fineness. Between that part of the roll-bearing through which the screw bolt passes and the middle arm *B*, a spiral spring *m* with a nut and a washer behind it is placed. The purpose of this spring is to hold the roll-bearings in the position required, so that the rolls should not become worn, when there is no product between them.

If it is wished to throw the rolls apart at a moment's notice, the truckle shafts *F* are turned by means of the handles *H* fixed to the ends of those shafts. By turning the shafts, the roll-bearings *G* supported by the eccentric necks of the shafts are moved. The handles *H* are connected with each other by a stem *K*, one end of which is fixed to one handle, and the other passes through the tension bolt coupled with the other handle; in this wise the position of one handle may be adjusted in respect to the other one. One of these handles *H* is held in any unchangeable position by a lock screw with a nut, passing through the segment link *L*, which has its upper end fastened by a joint to the frame of the machine, so that this link is sufficiently loose to allow the roll-bearings *G* to move away when a hard body is caught between the rolls.

M is an ordinary American jockey shaft.

To the top of the frame any kind of a feeding mechanism may be adapted. The grinding rolls, as is seen on Fig. 2, consist of two fixed, *D*, and two adjustable rolls, *D′*.

Inside the frame, parallel to the rolls, there are placed three feed plates, *N*, *N′*, and *N″*. The top shelf *N* directs the grain flowing from the feeder into the space between the fixed top roll *D* and its adjustable neighbour *D′*. Having passed to the opposite surfaces of those rolls, the reduced grain is conducted by the plate *N′* to the working space between the upper adjustable roll *D′* and the second fixed roll *D*. After this passage its flow is deflected by the plate *N″* to the space between the fixed bottom roll *D′* and then pours down as shown by arrows.

The top shelf *N* is stationary, the other two, *N′* and *N″*, have joints below, shown in *n*, and their upper edges are joined by a slewing head *P* with a fixed rack *O*, so that when it is necessary to examine the product, the plates *N′* or *N″* may be lowered after loosening the slewing head, and the product then passes through corresponding doors into the frame, sliding down the inclined plate.

(iv.) *Roller Mills of the Eighth Scheme*

W. Gray and R. Birkholtz's Four-Roller Mill.—The roller mills of European constructions for successive passages of the eighth scheme (p. 214) represent the ordinary types of two-roller mill with the shafts of the corresponding pairs of rolls lying in a vertical plane. The number of passages is from two to four, and this process is performed in plain milling or the milling of feed stuffs. Of those mills we shall examine the American construction of W. Gray and Birkholtz, as the most original.

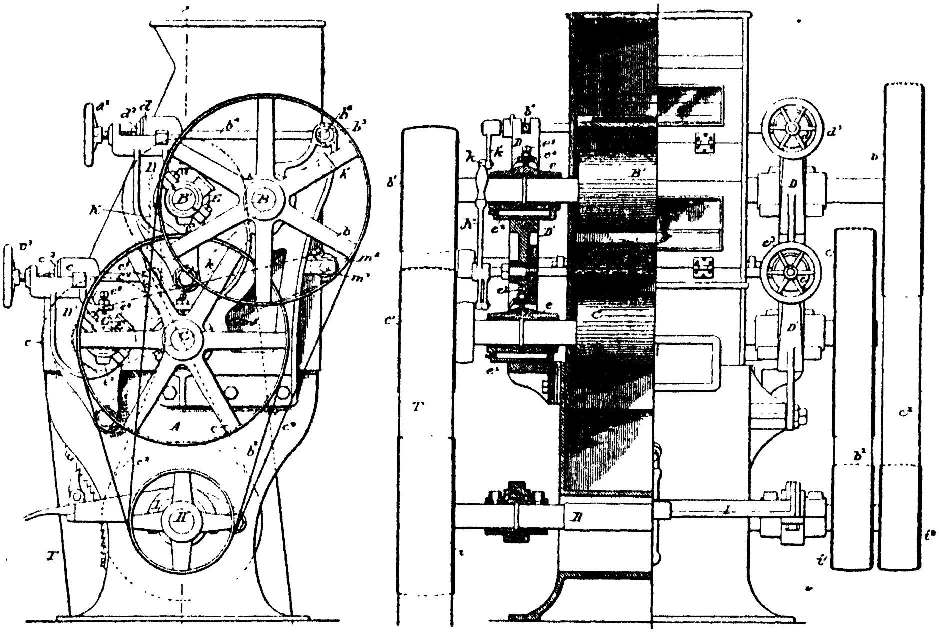

Fig. 281.

This mill is shown in Fig. 281. The rolls *BC* of each pair are set in fixed bearings, the other two rolls *DD'* in adjustable bearings with tail frames and brakes already familiar to us. The bearings have ball-arms (Sellers' type) for self-adjustment, and on the lower side they have longitudinal arms e^2 with which they drop into the slides *D* and prevent the bearings from rolling out of their seats.

The bearings are held in their set positions by screws e^3 screwed into the arms e^4 which hang over the bearings. The position of e^4 is such as to allow of removing the bearing from its place, once the screw has been loosened. For this purpose the hollow is left open on one side, and its shape is such that whilst the box or the bearing has a solid stay on the lower and the outer sides, which carry the pressure of the journals, the box may be easily removed by lifting it up and out. This means of supporting the bearings has proved in general practice to be very convenient, as it affords the possibility of removing any one of the adjustable rolls, together with its bearings, at a moment's notice, without touching anything in the mill.

The rolls are brought into operation by means of belts and belt-pulleys in the following manner. The jockey shaft passes through the lower part of the mill from one wall to the other, resting in bearings fixed in the frame *J*. One end of the shaft carries a belt-pulley *i*, the other end two belt-pulleys i^1 and i^2. The fixed rolls *B* and *C* have belt-pulleys *b* and *c* on the same side as the belt-pulleys i^1 and i^2 are placed. The adjustable rolls *B′* and *C′* have belt-pulleys *b′* and *c′*. The driving belt *T* runs through the belt-pulley *c′* under the belt-pulley *i* of the jack-shaft and above the belt-pulley *b′*, bringing directly into action both the adjustable rolls and the jack-shaft. From the belt-pulley i^1 of the jack-shaft the belt b^2 passes to the belt-pulley *c* and rotates the fixed bottom roll, while another belt c^2 runs to the belt-pulleys i^2 and *b* rotating the fixed top roll. For such an arrangement of the belts and belt-pulleys, it is necessary that the lower rolls should be moved aside, owing to which the belts and belt-pulleys may operate freely, occupying at the same time little space.

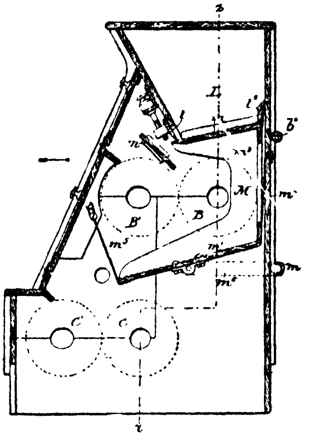

Fig. 282.

For an accurate adjustment of the rolls, and the possibility of quickly throwing them apart and together, W. Gray's construction, already examined, has been adapted. The upper and the lower rolls are simultaneously thrown apart and together by means of a handle *K* fixed to the lower roll c^6 with an eccentric and connected through a stem *k* with the crank k^1 on the top roll b^6.

For regulating the feeding of the mill, in the hopper *L* there is (Fig. 282) on one side a movable gate *l* which may be moved in a vertical direction. The bottom in the hopper is a shaking inclined toothed plate *m* placed above the top roll and attached to the top part of the shaking shoe *M*, to which, under the bottom rolls, is fixed another inclined plate *m′* of greater breadth. The shoe consists of two iron sideplates m^3 fixed to the edges of the feeding plates and strengthened by suitable cross pieces.

On the one side the shoe is supported by one or several belts m^4 attached by their upper ends to the frame; at the front edge it is supported by one or several belts or wires m^5 also attached to the frame; the shoe can move in a direction perpendicular to the shafts of the rolls. This motion is communicated to it by means of two eccentric drives m^6–m^7 from the general axle, receiving the motion with the aid of a belt-pulley set on it, and connected by a belt m^8 with the pulley on the axle of the roll C'. The feeding top shoe passes under the flap valve of the hopper and conveys the stock from the bottom part of the hopper to the fixed supplying plate n, which directs it to the working space of the rolls. Having passed through the top rolls the stock falls on the lower feeding plate m' which directs its course to the second pair of rolls.

To prevent the product from falling in behind the shoe, a piece of lining l'' is attached to the back wall.

7. *Transmission of Motion to the Rolls*

Toothed Gearing.—We have already examined the details of the roller mills having a special function—the feeding and the adjustment mechanisms, for instance. Now we must note the details of a general character, which are of no less importance than the feeding and the brake devices.

Of the details of a general character, the parts of machinery transmitting the motion are the most important. In our general review of roller mills we have noted that there are two types of gearing: the toothed gearing adopted by the European engineers and partly in American mills for rough grinding (the reduction of forage products), and the belt-gearing employed by the Americans only. Here we are speaking of transmitting the motion from roll to roll. To communicate motion to the feeding rolls, the European engineers generally use combined gearing, the flexible and the toothed, while the Americans employ only the former in their mills of the latest type.

Consider the toothed gearing given in Fig. 283 (1, 2 and 3). The first one, the simplest, is used for mills of small capacity, and in cases where the degree of evenness plays no great part. The second type of toothed gearing represents doubled chain wheels with a chess-board-like disposition of the teeth to lessen vibration in working. It has been adopted by some of the American works. The ordinary toothed gearing with a helical-like disposition of the teeth, shown on 3, has been adopted by almost all works. In this last gearing the wheels are provided with ring lubrication, used by Seck's works and by the American works of Wolf (both patents were claimed simultaneously).

In speaking of the merits of toothed gearing the accuracy it attains in the ratio of gearing must be pointed out. But the grave defect of the toothed gearings in the roller mills, where the distance between the shafts has to be altered, is the decreased efficiency when in operation and the shafts have to be brought nearer to each other in proportion to the wear of the rolls. The necessity of altering the distance between the axles of the gears demands an outline of the teeth according with the involute of the circle. Under our conditions, however, the axes of the wheels, in the most favourable circumstances, may only be brought 10 mm. nearer than the normal. Consequently the wear

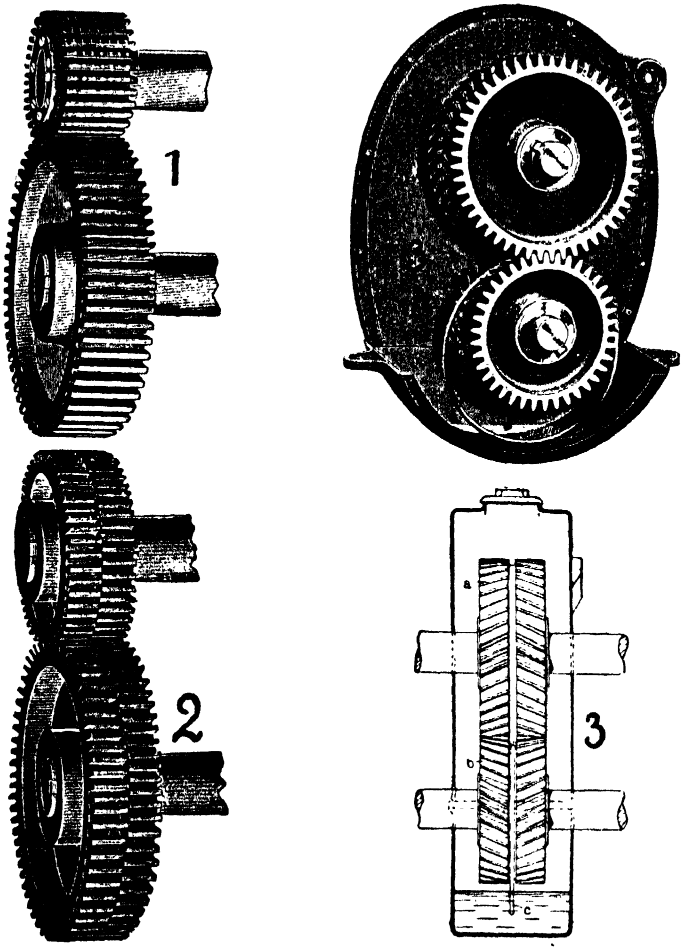

FIG. 283.

and renewal of the working surfaces may go only 5 mm. deep for each roll, otherwise the toothed gearing will be operating at a great disadvantage. Thus, if each of the rolls has worn 5 mm., new gear wheels with smaller diameters have to be installed, otherwise the gear will cause a great waste of power. In Russian mills this is generally not taken into consideration, and economising in new pinions the work is performed till the teeth break, regardless of the fact that more is lost in the expenditure of energy, and the fact that the motor has to be overloaded without increasing the capacity of the mills is regarded with surprise.

Thus the expediency of the toothed gearing may be acknowledged, but, when the rolls are in working position, the axes of the pinions can only at most be brought nearer together by about 10 mm. If the distance between them is to be still further decreased, the pinions must be changed.

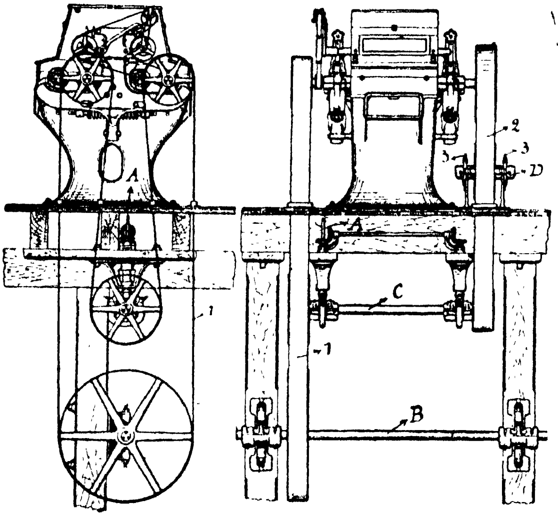

Fig. 284.

Belt-gearing. — Several of the belt-gearing constructions were dealt with when describing the makes of American mills. The shafts of the driving belt-pulleys are usually attached to the frame. But often, to simplify the construction of the mill, they are stationed outside and apart, as shown in Fig. 284. Here *B* is the axle of the shafting, *C* the jockey-shaft, 1 the driving belt to the fast rolls, and 2 to the slow. The tension of the belt is adjusted by toothed gears *A*, and the supplementary regulation of tension of the belts to the slow rolls is brought about by lowering or raising the bearing by screws 3.

Some twenty years ago, when the European engineers attempted to introduce belt-gearing, the principal argument against it was the impossibility of maintaining an accurate number of revolutions of the rolls, owing to the belt slipping. The work of the American mills of the contemporary makes, however, proved that this argument had no solid ground under it. The slipping of the belt within such limits, as to affect the accuracy of the transmitted number of revolutions of the rolls, is possible when the belt has stretched and its tension consequently has slackened. But the American construction of belt-drives obviates this defect by regulating the tension. The presence of an insignificant slipping motion cannot be denied, but, as we have seen, the ratio of velocities of the fast and the slow rolls for every break and reduction passage is within certain limits; while the influence of the slipping is so insignificant, as shown by practice in America, that these limits are never exceeded.

The advantages the American belt-driving has as against toothed gearing are very material, viz.:

(1) Noiseless and easy run of the mill.

(2) No relacing of the belt in case it becomes extended is required, the tension being regulated by a jockey-pulley.

(3) The reserve strength of the belt being sufficiently great, the capacity of each mill separately may be increased by 10 to 20 per cent. by a corresponding increase in the tension of the belt.

The latter is very important, as it permits overloading the mill without any injurious effect to the quality of the work, which cannot be attained on European roller mills, as the tension of the gear-belt from the shafting axle to the mill cannot be altered without relacing the belt.

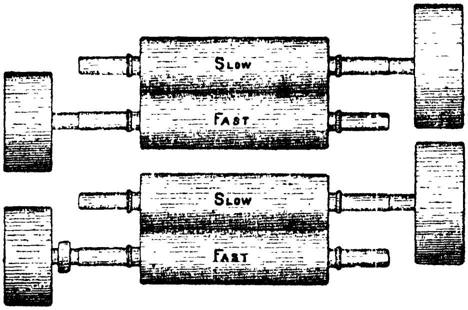

FIG. 285.

In some mills with belt-gearing each roll has a separate belt-pulley, as shown in Fig. 285. The necessity of compactly disposing the belt-gearing leads to setting the fast rolls asymmetrically.

8. *Capacity of Roller Mills*

Useful Work of Roller Mills.—In examining the action of the working organs in the roller mills, we saw that a rather complicated process of cutting the grain on break rolls or chipping by friction of the particles on reduction rolls is performed. Therefore the useful work of the roller mill may be defined only by experiment. However, the attempts to evolve theoretic formulæ of useful work which partly explain the process of milling, and partly may have a practical effect through the introduction of practical coefficients into them, should receive due attention.

The first and sole attempt to give theoretic formulæ of the useful work of the roller mills was made by Professor Afanasyeff,[1] and was based on his experiments on the resistance of the grain to pressure, performed at the mechanical laboratory of the Technological Institute, St. Petersburg. Repeated experiments with the resistance to pressure of grains (200 grains or more each time) of a normal moisture content and of approximately equal size, placed in between steel plates under a press, produced the following results :

TABLE XXV

Pressure in Klgs.	0	1000	2000	3000	4000	5000
Distance between the plates (thickness of the grain) in mm.	2·723	2·395	2·068	1·753	1·542	1·391
Compression in successive loadings	...	0·328	0·327	0·315	0·211	0·151

This table shows that the absolute quantity of elastic pressure is equal to one-third of the size of the grain.

The full loading up to the limits of elasticity of the grain fluctuated between 10 and 20 klg. to each grain in proportion to its moisture content, the less limit referring to the grain with more moisture. This corresponds to the loading of 50 to 100 klg. to 1 square cm.

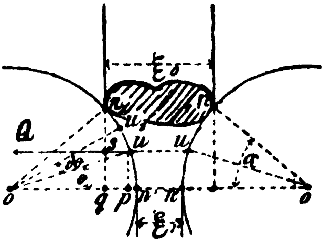

FIG. 286.

In defining the law of changing the pressure of the rolls on the grain or particles of it, Professor Afanasyeff reasoned in the following manner : supposing we have two rolls of equal radii r (Fig. 286) with the distance between the working surfaces ξ and the size of the stock to be treated ξ_0. Suppose that the pressure of the rolls upon the stock on the route it travels from n to n_1 is proportionate to its compression. If we mark the quantity of the pressing forces along the centre line P, and Q is some intermediate position of the stock u–u, then Q is defined from the proportion :

$$Q : P = su : qn_1 \quad . \; . \; . \; . \; . \; . \; . \; . \quad (1),$$

---

[1] *Flour Mills*, St. Petersburg, 1883.

for the pressures, when the compression is elastic, are proportional to the quantities of compression ($2\ su$ and $2qn_1$) being pressed from two sides. But since

$$qn_1=\frac{\xi_0-\xi}{2}$$

while in the drawing

$$\xi_0=2r+\xi-2r\cos\alpha-\xi=2r(1-\cos\alpha),$$

having performed the reductions and the substitution $1-\cos\alpha=2\sin^2\frac{\alpha}{2}$, we obtain :

$$qn_1=2r\sin^2\frac{\alpha}{2}.$$

From the same drawing we obtain the signification of su for the intermediate position of the stock :

$$su=2r\sin^2\frac{\alpha}{2}-2r\sin^2\frac{\theta}{2}.$$

By substituting these senses into the formula (1) we obtain :

$$Q=P\frac{\sin^2\frac{\alpha}{2}-\sin^2\frac{\theta}{2}}{\sin^2\frac{\alpha}{2}}.$$

The angles α and θ being very small, with a slight inaccuracy we may regard the sines as equal to the circular measure of these angles. Then we have :

$$Q=P\frac{\alpha^2-\theta^2}{\alpha^2}.$$

That is the pressure of a unit of area of the roll, whereas we are to find the pressure from n to n_1 so as to know the full work of the pressure. If the element u_1u of the surface of the roll corresponds to the angle $d\theta$, and the dimensions uu_1 on the generating circle of the cylinder is l, the elementary pressure will be :

$$dQ=d\left(P\frac{\alpha^2-\theta^2}{\alpha^2}l\,.\,u\,.\,u_1\cos\theta\right)=Plr\frac{\alpha^2-\theta^2}{\alpha^2}d\theta \quad . \quad . \quad . \quad (2).$$

The full pressure R is obtained when we take the integral of this term from α to o.

$$R=\int_o^\alpha Plr\frac{\alpha^2-\theta^2}{\alpha^2}d\theta=Plr\left(\alpha-\frac{\alpha^3}{3\alpha^2}\right)=\frac{2}{3}Plr\alpha \quad . \quad . \quad . \quad (3).$$

The point of application of this resultant pressure is obtained on our defining the moment of action of this force. The moment of action dQ is :

$$dQ\,.\,up=Plr\left(\frac{\alpha^2-\theta^2}{\alpha^2}\right)\theta d\theta=Plr\left(\theta-\frac{\theta^2}{\alpha^2}\right)d\theta,$$

for $up = r \sin \theta = r\theta$, the θ being small. By integrating this term, we arrive at the moment of the compressing force R in respect to the axis of the roll :

$$M = Plr^2\left(\int_o^\alpha \theta d\theta - \int_o^\alpha \frac{\theta^3 d\theta}{\alpha^2}\right) = Plr^2\left(\frac{\alpha^2}{2} - \frac{\alpha^4}{4\alpha^2}\right) = \frac{1}{4}Plr^2\alpha^2 \quad . \quad . \quad (4).$$

On dividing (4) by (3) we obtain the shoulder of the resultant of the pressures, by which we shall define the point of application of force R. This shoulder η will be :

$$\eta = \frac{3}{8}r\alpha.$$

If we distribute these R directed parallel to the plane of the axes, over the tangent and the radius (Fig. 287), we shall obtain :

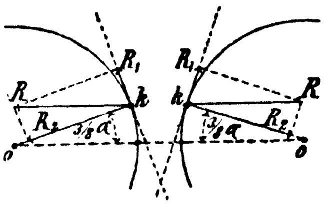

FIG. 287.

$$R_1 = R \sin \frac{3}{8}\alpha = \frac{3}{8}R\alpha \ ; \ R_2 = R \cos \frac{3}{8}\alpha = \frac{3}{8}R,$$

because the angles α being small, we may accept

$$\sin \frac{3}{8}\alpha = \frac{3}{8}\alpha \text{ and } \cos \frac{3}{8}\alpha = 1.$$

Then the motive power of each roll, imparting velocity to the product during the period from the null sense to the greatest v, equal to the rotating velocity of the rolls, will be

$$S = fR_2 - R_1.$$

But this moment is so insignificant that we may ignore it and consider the velocity of motion of the product between the rolls from the beginning of its ingress to its exit to be even and equal to the rotary velocity of the rolls. These considerations prevent our accepting as correct Professor Afanasyeff's inference, who regards $S = fR_2 - R_1$ as the motive power and further defines the work of the roller mills as the work of this force S.

The work of the forces fR_2 must be defined by taking their projection upon the direction of the motion of the product, *i.e.* upon the vertical plane.

Then the sense of the motive power will be :

$$F = 2fR_2 \sin \frac{\alpha}{2}.$$

Professor Afanasyeff's experiments have shown that $P = 4{\cdot}5\frac{\mu}{\delta}$, where δ means the thickness of a grain of wheat, and μ the relative compression equal to $\frac{\xi_0-\xi}{\xi_0}$. Availing himself of Professor Afanasyeff's experimental data ($P=4\cdot5\frac{\mu}{\delta}$—the average for dry grain) and introducing a correction with regard to the incomplete utilisation of the working surface of the rolls, Professor Zworykin suggests the following term for the efficiency of the rolls :

$$T=\tfrac{3}{4}\frac{Plra}{kk_1}\,.\,\sin\ \tfrac{3}{8}a\,.\,v=\frac{Plra^2v}{2\,kk_1},$$

where $\frac{1}{k}$ denotes a k-th part of the rolls loaded with product on the arch nn_1, and $\frac{1}{k_1}$-the k_1-th part of rolls over their length.

We must acknowledge this correction to be just, as the working part of the rolls is not fully occupied with product.

Then, knowing that

$$\mu=\frac{\xi_0-\xi}{\xi_0}=\frac{1}{3};$$

$$ra^2=\xi_0-\xi\,;\qquad P=4\cdot5\frac{\mu}{\delta},$$

we introduce those terms into T. Thus we obtain :

$$T=\frac{0\cdot25\,lv}{kk_1}\quad.\ .\ .\ .\ .\ .\ .\ .\ .\quad(5).$$

In this formula T is expressed in klgr.-mtrs., l in mm., and v in metres per second.

This formula leads Professor Zworykin to the conclusion that *the consumption of useful work for crushing the product fed in at a certain flow does not depend on the diameter of the rolls, but solely on its circumferential velocity and length.*

According to Professor Kick's experiments, who was testing soft wheat the grains of which were 6 to 7 mm. long and 3·5 mm. thick, the force crushing the grain while it is moving over 1 mm. of ground is 10 klg. Consequently, the work of crushing the grain ought to be 0·005 klg.-mtr. per second.

To define the consumption of useful work according to the data of Professor Kick, we must know the number of grains crushed per second and multiply it by 0·005. If the working surface of the roll running by per second should be given in square mm., it is equal to 1000 lv. The area of the grain is 6·5×3·5 mm. Then, with Professor Zworykin's correction, we obtain :

$$T=\frac{0·005\,.\,1000\,lv}{6·5\times 3·5\,k\,.\,k_1}=\frac{0·22\,lv}{kk_1},$$

which closely resembles the results produced by Professor Afanasyeff's investigations.

Consumption of Useful Work in Grinding.—The considerations of Professors Afanasyeff and Zworykin we have adduced have a purely theoretical value. Those formulæ elucidate the general character of the phenomenon but cannot be adapted to define the useful work of the roller mills, being deduced on the supposition that the rolls have equal velocities, which never happens in reality. The equal velocities of the rolls result in the crushing of the stock, whereas a cutting or chipping of the grain or particles of it is observed when the velocities are different. Thus, to define the useful work in reducing it is necessary to know the resistance to cutting, which requires an immediate experimenting on the cutting of grain. By this reason, having no other data, Professor Zworykin suggests making use of Professor Kick's experiments and evolves a series of formulæ defining the useful work.

According to Professor Kick's researches the resistance to the cutting of the grain increases from 0 to 9 klg. on the stretch of 0·5 mm. ; therefore the cutting work for one grain is equal to 0·00225 klg.-mtr. Accepting for the break rolls the circular pitch of the corrugation to be t, the velocity of the fast roll v, and its length l, we obtain that the number of grains passing between the rolls per second is

$$\frac{1000\,lv}{k\,.\,6·5t}.$$

As the circular pitch of the corrugation t must correspond to the dimensions of the stock cut, $t=k_1\delta=k_1 3·5$, consequently the useful work T for corrugated rolls will be expressed thus :

$$T=\frac{0·0025\,.\,1000\,lv}{3·5\,.\,6·5\,.\,kk_1},\text{ or about }\frac{0·1\,lv}{kk_1}\quad .\ .\ .\quad (6).$$

For smooth roller mills the useful work will be expressed by the formula :

$$T_1=\frac{0·16\,lv}{kk_1}\quad .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\quad (7).$$

These formulæ may become very valuable, if through the immediate definitions of the useful work of the roller mills with different l, v, and t

(t is needed for corrugated rolls) we find by experiment the coefficient

$$\frac{1}{kk_1}.$$

Theoretical Capacity of Roller Mills.—Proceeding from the foregoing inferences, we may mention several considerations regarding the theoretical capacity of roller mills.

If the thickness of the sheet of product flowing into the nip of the rolls be mark δ, then its volume passing in between the working surfaces is (with the same denominations of l, v, k, and k_1 as before):

$$V = \frac{1000\, l\,.\,v\,.\,\delta}{kk_1}.$$

Accepting the specific gravity of the stock to be 0·0000006 klg., we obtain the weight Q:

$$Q = \frac{1000\, lv}{kk_1}\,.\,0{\cdot}0000006 = \frac{0{\cdot}0006\, lv\delta}{kk_1} \quad . \; . \; . \; . \; . \; . \quad (8).$$

Thus we see that the capacity of a roller mill is a rather complicated function of five variables. Given the length of the rolls and the circumferential velocity of the fast roll, we may accept lv for this mill as a constant quantity. Then the problem of defining the capacity is simplified, for the capacity will depend on δ, k and k_1. These variables depend on the kind of milling, which determines what their respective values are to be. But it is impossible to give any limiting values for $\frac{\delta}{kk_1}$, because the milling diagrams are very variously arranged. Since we have no serious experimental data for $\frac{\delta}{kk_1}$ as yet, we are compelled to make use of the data of capacities of roller mills as given by the works, with corrections founded on general observations of the capacity of these machines at modern mills.

Practical Data of the Capacity of Roller Mills.—The capacities of break and reduction roller mills given below were taken from the data of European works tested on the plants in Russian mills, on milling systems, which are duly mentioned in the table. Naturally the factory data fairly accurately coincided with the capacities observed at the mills, for the builders of these mills more or less strictly adhered to their data. Very often, however, the capacity of one or another mill exceeded the guarantees of reliable works; this is always the result of overloading the machines at the expense of the quality of the work.

TABLE XXVI

Average Capacities of Roller Mills per Hour and the Corresponding Number of Powers Consumed[1]

WORKING SURFACE.	CORRUGATED ROLLS.													SMOOTH ROLLS.				
STOCK.	WHEAT.									RYE.			REDUCTION OF COARSE AND FINE MIDDLINGS.				
Kind of Grinding.	High.		Semi-high.			Single.			High.			Cast-iron Rolls.			Porcelain Rolls.	
Diameter of rolls . . .	220	250	220	250	300	250	300	350	250	300	350	250	300	350	300	350
Power consumption in H.P. per 100 mm. length of pair of roll.	0·2	0·3	0·2	0·3	0·4	0·3	0·4	0·5	0·5	0·6	0·7	0·4	0·5	0·6	0·3	0·4
LENGTH OF ROLLS IN MM.	CAPACITY IN KILOGRAMS[1] OF A PAIR OF ROLLS PER HOUR.															
400	700	800	500	600	700	500	600	700	300	400	500	250	300	400	250	350
500	800	900	600	700	800	600	700	800	400	500	600	300	400	500	300	400
600	900	1000	700	800	900	700	800	900	500	600	700	350	500	600	350	500
700	1200	1200	900	900	1000	800	900	1000	600	700	800	400	600	700	400	600
750	1250	1300	950	950	1100	850	950	1100	650	750	900	450	650	750	400	650
800	1300	1400	1000	1100	1200	900	1000	1200	700	800	1000	500	700	800	450	700
900	1400	1500	1200	1300	1400	1100	1200	1300	800	900	1100	600	800	1000	500	800
1000	1600	1700	1400	1500	1600	1200	1300	1500	900	1000	1200	700	900	1200	600	900
1200	1800	1900	1600	1700	1800	1300	1400	1700	1000	1200	1400	...	...	...	...	...
1500	...	2200	...	1900	2000	1400	1500	1900	1100	1400	1600	...	...	...	...	...

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[1] These data are the average numbers from German, Austrian, English, Swiss, and French works.

[2] 1 kilogram = 2·2046 lb.; 100 kilograms = 1·968 cwt. or 220·462 lb.

In the Table XXVI given opposite the average capacity and power-consumption are taken from the factory data.

The data of that table, regarding the breaking process (corrugated rolls), refers to the first passage or break. The capacity of the smooth rolls refers to the reduction of coarse and fine middlings, and is to be taken at 10 to 15 per cent. less when the product treated is low grade middlings (reduction of the offals).

We must say that the works state the capacity of their roller mills with great discretion, allowing a reserve of 20 to 25 per cent. sometimes, in comparison to the capacity attainable in practice. But we repeat, it must be borne in mind, that a capacity forced above the normal (sometimes reaching 35 per cent.) is only injurious to the work. Many cases are known in which the mills compelled the steam engine to work with an overload of almost 50 per cent. without any allowance for the steam capacity of the boilers.

Those mills ground 30 to 35 per cent. over the quantity of grain they were calculated to reduce, and the millers considered themselves to be the gainers. In their ignorance, however, they did not understand that by working with damp steam they almost doubled the expenses of production, not to mention the fact that the flour grew worse, which they, of course, would never admit.

The above table affording us no possibility of reckoning out the capacity of the roller mills for the various breaks, we must consult the following table, in which the working length of the rolls for different grinding systems and successive breaks are given:

TABLE XXVII

LENGTH OF ROLLS FOR ONE SACK OF STOCK REDUCED PER TWENTY-FOUR HOURS

BREAK		I.	II.	III.	IV.	V.	VI.	VII.	VIII.
High grinding .	Length of rolls in mm. for 1 sack per 24 hrs.	2·62-3·00	3·75-4·12	3·75-4·12	2·62-3·37	2·62-3·00	2·25 2·62	2·25-2·62	1·88-2·25
Medium (semi-high) grinding		3·00-3·15	4·50-4·62	4·50-4·62	3·00-3·75	2·62-3·00	2·25-2·62	...	...
Low grinding .		6·00-7·50	4·62-5·25	3·37-3·75	3·37-3·75	...	...	...	...
High rye grinding		4·12-5·37	4·50-4·62	3·12-3·75	3·00-3·12	2·62-3·00	2·47-2·62	Smooth crushing rolls 1·87-2·25 mm. per sack.	
Rebreak or scratch		3·75-4·12	3·37-3·75	3·00-3·37	2·40-2·62	...	...	...	...

The data of this table are average quantities for Russian mills working on hard and soft wheats. The smaller figures refer to the hard grain, the greater to the soft.

Baumgartner offers the following capacity for break and various roller mills, which is considerably below the data of the works:

TABLE XXVIII

Capacity of Roller Mills According to Baumgartner

1. *Crushing Mills* (*Quetschstühle*)

Diameter of rolls in mm.	D mm.	250	300	350	400	450	500
Capacity for 100 mm. of length in klg. . .	Q klg.	200	250	310	360	400	450

2. *Rolls for High Break*, *Hochschrot* (*Brechstühle*)

$D = 220$ mm., $Q = 250$ klg. (one pair of rolls).
$D = 250$ mm., $Q = 250$ klg. (three-roller mill).

3. *Break Rolls* (*Schrotstühle*)

Diameter of Rolls—D mm.		220	250	300	350	400	450
Q klg. for 100 mm. of length.	Wheat—plain grinding	...	80	100	120	140	150
	„ semi-high grinding . .	90	110	130	150	...	...
	„ high grinding . . .	125	140	165	...	...	...
	Rye—plain grinding	...	...	70	85	95	105

4. *Porcelain Rolls* (*Porzellanstühle*)

Diameter of Rolls—D mm.		220	300	350
Q klg. for 100 mm. of length.	Reduction of Coarse Middlings . .	25	45	65
	„ Fine „ . .	18	30	45

5. *Smooth Cast-iron Rolls* (*Hartguss-Glattstühle*)

Diameter of Rolls—D mm.		220	250	300	350	400
Q klg. for 100 mm. of length.	Reduction of Coarse Middlings . .	45	55	70	85	100
	„ Fine „ . .	30	40	50	60	70

It is to be regretted that Baumgartner does not mention the origin of these tables, which raise some doubts in our minds. We must remark, by the way, that in modern practice rolls of such diameters as 450 to 500 mm. are not known.

By putting our data in the form of capacities to 1 cm. or 1 inch for the whole break process, we obtain the following table :

TABLE XXIX

CAPACITY TO 1 CM. OR 1 INCH PER TWENTY-FOUR HOURS FOR THE WHOLE BREAK PROCESS IN LBS.

Kind of Grinding.	To 1 cm. of Length of the Rolls.	To 1 inch of Length of the Rolls.
High wheat grinding	111·55–128·79	278·87–321·98
Medium ,, ,, ...	128·62–140·92	321·62–352·30
Low ,, ,, ...	138·27–161·28	345·63–403·20
Rebreak or scratch rolls . . .	Depends on the number of rebreaks	
High rye grinding	120·11–141·12	300·28–352·80

If we compare the capacities reckoned out for the first break with the factory data, we find that our table shows 15 to 17 per cent. more than is given by the works. In calculating the dimensions of the rolls it is better to follow this table, as its data define a perfectly normal capacity of the rolls, without any superfluous reserve and without injurious overloading of the machine.

In computing the capacities of rolls for high rye milling we have kept in mind the fact that in the first break the grain treated has been previously split down its crease, in passing through smooth crushing rolls the capacity of which, as shown in the table, is defined at 1·87 to 2·25 mm. to one sack of rye per twenty-four hours.

When calculating the sizes of corrugated rolls, we must bear it in mind that their capacity for one and the same passage increases with the diameter, remembering at the same time that a greater amount of power is consumed. In selecting corrugated rolls for high and medium grinding, the diameter of 220 mm. may be decided upon if their length does not exceed 1000 mm. Should the capacity of the mill, however, require rolls longer than 1000 mm., then the diameter employed ought to be 250 mm.

For low grinding rolls 250 to 300 mm. in diameter should be used, and 300 to 350 mm. for single and high rye grinding.

Example of Calculation.—To illustrate clearly the use of the table for calculating the dimensions of the rolls, according to the capacity given of the mill, we shall take one example.

We are required to calculate the dimensions of the break rolls for a wheat mill on a high grinding system yielding 400 sacks per day. Supposing the wheat to be of medium quality as regards hardness, and in normal condition, we shall turn to the first limits of the data for high grinding.

For the first break we have : one sack of product per day is reduced by 2·62 mm. of length of the rolls. Consequently, the dimensions of the rolls for the first break are :

$$2{\cdot}62 \times 400 = 1048 \text{ mm.}$$

The capacity for high wheat grinding in our table being referred to the 220 mm. diameter of rolls, we must take a diameter of 250 mm. since the length of the rolls is great. But then the capacity of the mill will increase according to the factory data by 5 to 7 per cent. Therefore we may use rolls 5 to 7 per cent. shorter. Thus the dimension of the rolls for the first break will be :

First break—1000×250 mm., one pair of rolls.
Second ,, $3{\cdot}75 \times 400 = 1500$ mm.
Third ,, $3{\cdot}75 \times 400 = 1500$ mm.
Fourth ,, $2{\cdot}62 \times 400 \sim 1000$ mm.
Fifth ,, $2{\cdot}62 \times 400 \sim 1000$ mm.
Sixth ,, $2{\cdot}25 \times 400 = 900$ mm.
Seventh ,, $2{\cdot}25 \times 400 = 900$ mm.
Eighth ,, $1{\cdot}88 \times 400 \sim 750$ mm.

Thus we have obtained three pairs of rolls at 1000 mm., two pairs at 1500 mm., two at 900 mm. and one at 750 mm. It being always more advantageous to use four-roller mills, such a combination is inconvenient. For this reason, we shall take a pair of rolls for the sixth break at 1000 mm. instead of 900 mm., and for the seventh and eighth at 800 mm. instead of 900 and 750 mm. Such a combination is advantageous, because without reducing to the capacity, we shall have four mills with two pairs of rolls each.

One mill { 1000 × 250 mm.—First break.
{ 1000 × 250 mm.—Fourth „
„ „ { 1500 × 250 mm.—Second „
{ 1500 × 250 mm.—Third „
„ „ { 1000 × 250 mm.—Fifth „
{ 1000 × 250 mm.—Sixth „
„ „ { 800 × 220 mm.—Seventh „
{ 800 × 220 mm.—Eighth „

For the seventh and eighth breaks, rolls of 250 mm. in diameter may be employed. Then the capacity of the seventh break will attain the normal (according to our calculation), and consequently the sixth and seventh breaks will have a reserve capacity. However, if possible, the dimensions of the rolls according to the calculation should be adhered to. This may be done by coupling the rolls of the break and reduction passages, which depends on the suitable dimensions of the reduction rolls. According to our calculation, the fifth and eighth breaks remain without a pair. According to the number of kinds of meal, reduction rolls having a length of 1000 mm. and 750 mm. may be obtained, and then in one machine both break and reduction can be united. This would be unavoidable if we had (with the given capacity) seven breaks instead of eight.

A computation of the break rolls may be likewise made, with the assistance of Table XXVIII, where the capacity per day to 1 cm. is shown.

Example.—Let us suppose the given capacity of the mill per day to be 400 sacks of high wheat grinding. We are required to calculate the length of the break rolls, knowing the capacity to 1 cm. per day.

The aggregate length of the break rolls we obtain in cms. by dividing 280 × 400 by 128·79 (or 111·55 lb. which is the capacity per day to 1 cm. of the length of the rolls, according to Table XXIX, p. 309) :

$$\frac{280 \times 400}{128{\cdot}79} = 870 \text{ cm.}$$

The total length obtained must now be divided proportionately to the dimensions of each break roll shown in Table XXVII, p. 307 :

$$\text{First break} — \frac{870\,.\,2{\cdot}62}{21{\cdot}74} = 1050 \text{ mm.}$$

$$\text{Second ,,} \quad \frac{870\,.\,3{\cdot}75}{21{\cdot}74} = 1500 \text{ mm.}$$

$$\text{Third ,,} \quad \frac{870\,.\,3{\cdot}75}{21{\cdot}74} = 1500 \text{ mm.}$$

. . . . . .

. . . . . .

$$\text{Eighth ,,} \quad \frac{870\,.\,1{\cdot}88}{21{\cdot}74} = 750 \text{ mm.}$$

In this manner the dimensions of break rolls of the other types of grinding too, mentioned in Table XXIX may be calculated.

We shall pass to the definition of the number and the sizes of the smooth rolls after we have become intimately acquainted with the grindings. At the present moment we must direct our attention to the machinery finishing the work of the roller mills.

9. *Brush Machines*

The break process may not be regarded as finished until after the last break all the bran is thoroughly cleaned and the flour and middlings adhering to the bran which the grooves do not shear away are separated from it. An increased number of breaks would give certain results in this respect, but, firstly even the eighth break yields no more than 1 to 1½ per cent. of break flour, and therefore there is little sense in making the production dearer by adding another breaking passage ; secondly, a lengthening of the breaking passages results in the reduction of the bran, which lowers its value as feed. However, to make " rich " bran, *i.e.* with the mealy part of the grain not separated from it, means the loss of a certain percentage of flour (up to 1½ per cent.). Since that is the case, the sifted bran should be treated in a machine that will separate away the meal and is not expensive. For this purpose brush-machines are used.

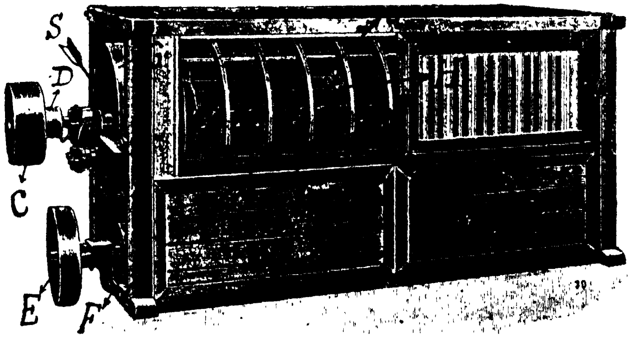

FIG. 288.

The plainest type of a brush machine which, with several alterations in its construction, may be employed for that work, is described in p. 112, Fig. 102. A more complicated brush machine, but at the same time having a greater capacity, is shown in Fig. 288. This (G. Daverio's) machine has a rotating drum *A* clothed with a sheet-iron sieve (removed in the drawing) with meshes ⅓ to ½ mm. in diameter, inside which there rotates in the same direction a drum with brush beaters *B*. The fibro brushes on these beaters are set in a helical line, owing to which the bran travels to the outlet of the machine. The delivery to the machine is marked by the arrow *S*. The brush drum is driven (200 to 240 revolutions per minute) from the belt-pulley *C*. The belt-pulley *D*, by means of the belt-pulley *E*, transmits the motion to the worm, while *F* with the aid of the belt-pulley *G* does the same for the drum with the sieve (24 to 30 revolutions). During operation the meal is obtained as throughs and the bran is tailed over.

For adjusting the distance between the casing of the drum and the brushes, there are the screws *a*, by which the ribs with the brushes are attached. These screws run through the rim of the pulleys *H* (three to four pulleys) fixed with keys to the shaft of the brush drum.

Daverio's works, as well as others, make these machines with fixed drums. Sometimes a part of the brush beaters is supplanted by steel ones spirally disposed. The casing of the working drum is also clothed with a wire sieve.

The capacity of such machines with a stationary casing is given at 432 to 1080 lb. per hour, *D* (diameter of casing) being 250 mm. to 720 mm., and *L* (length of casing) 1000 to 2000 mm.; others, with a rotating casing 864 to 2592 lb. per hour, with $D = 450$ to 700 mm., and *L* 1000 to 2500 mm.

10. *Detachers*

In grinding the fine and coarse middlings, when it is necessary to impart strong pressure to the smooth rolls, the crushing of a certain percentage of stock to flakes is inevitable—the meal flakes particularly often, when the rolls are badly fed and do not receive an even sheet of product, but narrow streams, owing to the damp product sticking to the feed plates and forming knots. The meal flakes thus formed and compressed fast may pass to the sieve in that shape and be removed as overtails, if no steps are taken towards loosening them.

Such flakes are loosened in detachers, which receive the product on its leaving the rolls and break the flakes down to meal. There are three types of detachers—brush, pin, and screw detachers.

Brush-detacher.—The ordinary construction of the brush-detacher is shown in Fig. 289. The cast-iron chamber *A* has a timber or iron cover *B* with an opening *D* for the passage of the product down arrow *S*. Inside the chamber, down its whole length, there is a fibre brush *C* running at 350 to 1200 revolutions. The stock passes in between the brush and the wire sieve *E*, where the meal flakes are reduced to flour. Part of the flour passes through the sieve and part is flung by the brush over the sieve as indicated by arrows S_1. The distance between the brush and the sieve is regulated with nuts F by means of a simple link mechanism. The ends G of the screws, passing through openings in the frame, serve as guides.

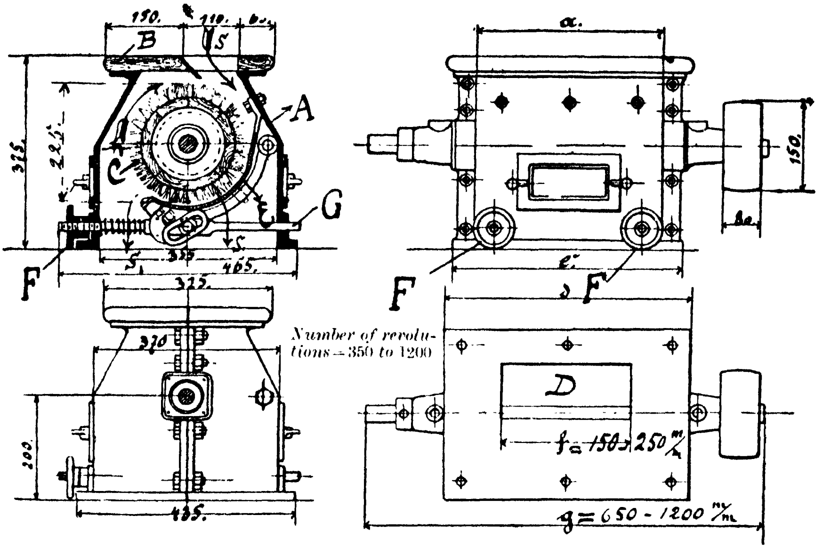

FIG. 289.

Lafon's Pin-detacher.—Fig. 290 represents a double pin-detacher from the French works of F. Lafon (Tours). The product moves as shown by arrows S and falls into conic sieve chambers A. Here it is caught up by the pins which break down the flakes. The pins are fixed on the hub C, which is attached to the axle B with bolts a. The covers D are cast in one block with the bearings for the journals of the axle.

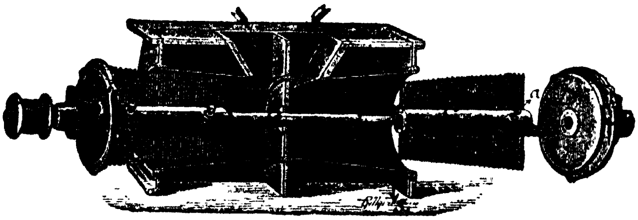

FIG. 290.

The loosened product flows partly through the sieve and partly through the outlet down arrow S_1. The number of revolutions of the pin drum is 1100 to 1750 per minute. The bearings are ring-lubricated.

Seck's Worm-detacher.—Both the brush and the pin-detachers answer their purpose—that of breaking down the flakes. But both again have the defect that they reduce the branny particles, owing to which the offal cannot be separated off on the dresser and give a darker colouring to the meal. Besides that, Lafon's detacher, operating by impact, has all the defects of the disintegrator already discussed.

These inconveniences are done away with in the new type of a detacher, shown on Fig. 291. Its main part is a short worm, rotating with the velocity of 250 revolutions per minute in a cylindric casing with a small dead space. This worm conveys the stock to the outlet of the machine, and the stock passes between the valve *d* and the roll *b*, which are brought into motion by the belt-pulley *a* with the aid of a worm gear, not shown in the drawing. The force of pressure of the valve upon the passage of the stock is adjusted by means of a spiral spring *e* and a screw *g*. For cleaning the roll there is a scraper *f*.

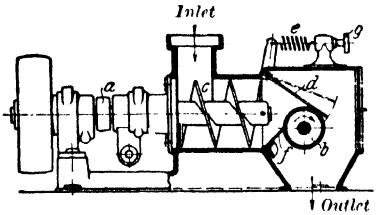

Fig. 291.

In a detacher arranged in this manner the stock is well stirred and its particles are rigorously rubbed against each other in the space between the casing outlet, the valve, and the roll. The flakes are very thoroughly broken down, while the mealy particles are but slightly reduced during the operation.

In this way all the flakes are triturated, and the particles of flour, bran, and germ separated from the middlings, after which the stock is easily and very satisfactorily dressed.

Its compactness is another good quality of this machine for reducing flakes of meal. This detacher may be placed between the roller mill and the elevator, or between the elevator and the bolting machine.

CHAPTER V

GRADING THE PRODUCT ACCORDING TO SIZE

I

SIFTING THE PRODUCT

Purpose of Sifting.—The character of the process of grain-reduction and its nature inevitably result in a product of various shapes and sizes.

The break process gives us particles of flour as well as a series of middlings of various sizes. But this product can only undergo a further and final treatment after it has been graded according to size.

In fact the distance between the working surfaces of the reduction machines, millstones, or roller mills at any one period of the operation is quite definite, and calculated to yield a product of a certain size. Consequently, if the product is of various sizes, a part of it, being smaller in size than the distance between the working surfaces, will pass between them untouched. If, however, we set the working surfaces at a distance smaller than the least-sized particles, the large grains will be too violently broken down, reduced to flour, and will form flakes. Now, this is injurious to the quality of the flour, to say nothing of the unproductive consumption of power incurred by the strong pressure of the working surfaces. Hence it is clear that if the work of the reducing machines is to be satisfactory, after every passage through the breaks or reductions it is necessary for the particles of the product to be graded according to size.

In recommending a series of successive reduction machines, we had the complex grinding systems in view, in which the necessity of sifting is clearly demonstrable. But it is likewise evident that sifting is just as indispensable in plain milling, in spite of the grain being reduced to meal in one passage through the grinding machine. The fact is, that however great be the pressure of the working surfaces upon the grain, the offals, being more elastic than the kernel, offer greater resistance to breakage, and part of them remains in the shape of bran. Sifting is also necessary for extracting the bran from the mass of meal.

Thus, sifting is necessary (1) in the complex milling process, to prepare the intermediate products for further treatment, by grading them according to size ; (2) in plain (single) milling, to separate the branny particles from the flour.

The bran must be likewise sifted off from the flour in the final stages of milling ; in the break process at the last break and rebreak, and in the reduction process at the final reduction of the dark branny particles of grain.

Working Surfaces.—For grading the intermediate products of milling and for separating the bran from the flour, bolting surfaces are used. We are already acquainted with the principle of action of these surfaces, having met it in the process of separating the large and small impurities from the grain, where we saw that all the sieves tail over the large particles as refuse, while the small particles are bolted through the sifting meshes. From the same grain cleaning department we know the shapes of the sifting working surfaces and the character of their motion. For grading the reduced particles of grain we have prismatic, cylindric, and flat sieves, similar to those employed in machines for grain cleaning.

But while the working surfaces in the bolting machines for grain consist of sieves of solid sheet-iron plates or of metal cloths, owing to the greater resistance these materials offer to wear, in grading the products of milling metal cloths are used only for the coarser particles. The rest of the product in the meantime is bolted on silk sieves, though many attempts are being made at present to substitute metal cloth for silk.

If we take home manufacture into consideration, then the hair-cloth (mostly horse-hair) used for sieves for home sifting should be mentioned. We may say that the hair-cloth, used from the remotest time for sifting, is better than silk or wire, as it is hydroscopic and consequently never swells or grows rusty. Further, it is sufficiently strong to stand a long period of work. But the uneven size of the hairs, their unequal diameter and length, does not allow this material to be used for factory-made sieves.

It was comparatively but a short time ago that woollen cloth of comb-yarn was largely used on plain short system mills owing to its cheapness. But the nappiness of the woollen threads rendered the sifting imperfect, reducing the quality and the quantity of the work.

Metal Cloths.—As regards solidity and durability, metal sieves are the best. But their essential defect is the liability to rust, which very rapidly destroys the sieves working in unfavourable, that is damp, conditions.

We must admit, however, that this defect only refers to iron sieves. Steel is more rust-resistant, while phosphor-bronze cloths excel even steel in that respect. Besides iron, steel, and bronze, the wire of the bolting surface is also made of pure copper. But copper sieves cannot be recommended, because that metal gives a poisonous oxide when the sieve works in damp air.

Though metal sieves for bolting fine middlings and meal have already made their appearance on the market, they have not found their way into the ranks of the machines generally used in mills, being very expensive.

When it is desired to employ metal sieves for bolting fine middlings and flour, phosphor-bronze cloths or of other rust-resistant copper combinations should be taken. In using metal sieves we must remember that, owing to the high heat-conductivity, the moisture from the raw product precipitates upon the metal sieve (the dew phenomenon), which is dangerous, for the reason that the moistened parts of the sieve immediately become blinded with starchy paste and the sifting will stop. For this reason bolting machines with metal sieves should be subjected to an energetic exhaust.

Silk Sieves.—A tissue of white or yellow raw silk, comparatively cheap, durable, and scarcely at all hygroscopic, is very successfully adopted, where metal sieves cannot be employed.

Good silk cloths, prepared of pure silk threads, are designated by the kind of their interlacing and also, like those of metal, by numbers, for products of different sizes. In making the choice of the cloth particular attention should be paid to the purity of the silk. Being an expensive material, it is often adulterated. Owing to finishing, silk of low quality often becomes firm, smooth, and glossy, *i.e.* possesses in its outward appearance all the good qualities of sterling cloth. In such a case even an experienced eye will not be able to distinguish it from good stuff. Finished silk, however, is very hygroscopic, and swells after absorbing a small quantity of moisture on being held a short time between slightly dampened fingers. This silk absorbs the moisture of the evaporating product, swells, and causes the meshes of the tissue to contract. The flour, turning to paste on the damp sieve, blinds it in the end and it stops working.

The finishing of bad silk,[1] *i.e.* imparting to its threads the firmness and glossiness of good material, is done chiefly by means of starch (coarse adulteration) and by means of Arabian resin (a finer adulteration). The

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[1] Dr. P. Hermann, *Coloric Textile Chemical Analysis.*

adulteration of the silk may be detected by immersing the sample to be tested into pure or an 80 per cent. solution of alcohol, shaking it two or three minutes (half a glass of alcohol solution and a sample of one-sixteenth of a foolscap may be taken), and then letting the solution settle for a half to three-quarters of an hour. If the silk is finished with starch, then a white, loose sediment will remain in the glass; if resin has been used for finishing we obtain a white turbidness, white flakes, or a white gelatinous sediment, according to the quantity of finishing stuff.

The silk sieves have two kinds of texture of their threads, linen and gauze texture. The linen texture shown on Fig. 292 is an ordinary cloth with the threads of the warp *a* and the woof *b* lying crosswise. The gauze texture (Fig. 293) differs from the linen in that its warp consists of two threads, *a* and *b*, one of them passing under the woof *c*, the other over it. In between the warps those threads cross each other.

The gauze bolting cloth is stronger and more durable as regards the even size of the sieve meshes (during cleaning, or in mounting). But the meshes of the gauze tissues are less regular than in the cloth of the linen texture.

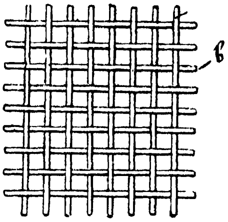

FIG. 292.

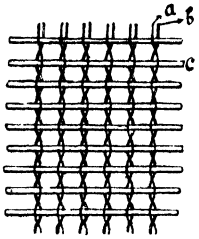

FIG. 293.

To make the shape of the meshes in the linen texture cloths more stable, threads of greater thickness used to be woven into the tissue 1½ to 2 cm. distant from each other, to impart more firmness to the cloth. But this was of little use, as at the same time it reduced the useful working area of the cloth and made the cloth more expensive. These attempts were discontinued some twenty years ago, but now they seem already to be forgotten, and such cloths have again appeared on the market.[1]

Modern technics of cloth manufacture produce a quite satisfactory silk tissue of linen texture, which very firmly resists displacement of the meshes, even when cleaned with a brush. It is only necessary to use the material of good factories, and beware of adulterated silk. A good silk cloth serves for three (on coarse and sharp stock) to six years (on fine and soft stock).

In choosing the cloth—metal or silk—one should see that the threads

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[1] The "Carré" cloths. The wear-resistancy depends not on the increase in weight or the solidity of the sieve caused by the thick threads, but on the standard quality of all the threads.

are of equal thickness and the meshes of equal dimensions. Only such a sieve gives *throughs* or overtails equal in size.

Any rough unevenness of the threads and an irregular yarn strike one on the most superficial examination of the cloth. But a somewhat inferior tissue may be told from good stuff only with the assistance of a particular kind of lense shown on Fig. 294.

This lense consists of two metal plates *A* and *B* folding up on a third plate, the stand *C*. The plate *A* has a square hole in it of ¼ to 1 inch, in the plate *B* the lens *L* is set. Before inspecting the cloth it is laid on smooth black or dark paper, and then the lense is placed as shown in the drawing. In examining through the lense the square piece of the cloth framed in the square hole through the plate *A*, it is easy to notice the regularity or irregularity of the threads and the meshes, and to count them to test the number of the cloth. To examine the silk more accurately it must be inspected through the lens in several places.

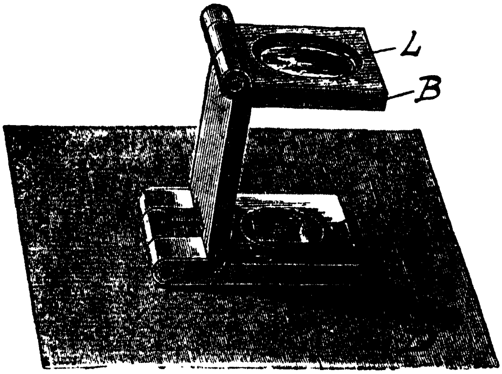

FIG. 294.

Numeration of the Cloths.—With the numeration of the metal sieves we become acquainted in the part treating of grain-cleaning. As regards the numeration of silk cloths, here we also have no definite fixed international standard.

Silk being used for sifting flour and grading the coarse and fine middlings according to size, numeration has been correspondingly established for the flour and the middlings cloths separately. In addition there is the Swiss and the French numeration of the cloths of both kinds. Further, the numeration of the flour-cloths differs from that of the middlings cloths. Almost all European works (except the French) have accepted the Zurich numeration of flour silks, and the Swiss for middlings; the same numeration is accepted in America, where the American Bolting Cloth Co. in St. Louis is considered to be the best factory.

The quality of the silks considerably influences their numeration, which explains why a different numeration has been adopted for middlings, a coarser product requiring a stronger tissue. In respect to their strength the cloths are divided into five kinds:

(1) Plain cloths (Prima) . . } for reels.
(2) Heavy cloths (Extra) . . }
(3) Double heavy (Double Extra). } for sifters and centrifugals.
(4) Treble heavy (Triple Extra) . }
(5) Middlings cloths (Gazes à Gruaux).

Of these five kinds of cloths those for middlings are the most dense (thicker threads).

The plain cloths (Prima) have the numbers: 0000, 000, 00, 0, 1, 2, 3 up to 20, and at the American factories up to No. 25. In most cases, however, cloths over No. 17 are not manufactured.

Before passing on to the further characteristics and comparison of silks, we give the numeration, number of threads, the number and size of the meshes in the Prima sieves (Swiss silks).

TABLE XXX

Silk No.	Number of Threads to 1 cm.	Number of Meshes to 1 square cm.	Dimensions in mm. of each side of the Meshes.
0000	7	49	1·43
000	9	81	1·11
00	11½	133	0·87
0	15	222	0·67
1	19	369	0·53
2	21½	460	0·46
3	23	529	0·43
4	24½	602	0·41
5	26	680	0·38
6	29	848	0·35
7	32	1037	0·31
8	34	1136	0·29
9	38½	1470	0·26
10	43	1844	0·23
11	46	2079	0·22
12	49½	2436	0·20
13	51	2591	0·19
14	55	2996	0·18
15	59	3481	0·17
16	62	3844	0·16
17	64	4096	0·153
18	66	4290	0·151
19	67	4422	0·149
20	68	4624	0·145

Of these cloths Nos. 0000 to 4 give large and small middlings as throughs, Nos. 5 to 7 dunst or coarse flour, while Nos. 8 to 20 give finished flour. In practice, however, the number of silk numbers is considerably limited, as we shall see when studying the diagrams of mills.

The heavy cloths (Extra) are manufactured for fine middlings and flour, and have twelve numbers from 6 to 17 inclusively.

The cloths of double density (Double Extra) have three numbers less than the Prima, from No. 0000 to No. 17.

The triple heavy silks (Triple Extra) like those of the double, are used only for fine middlings and flour, from No. 7 to No. 15.

When denoting these four types of cloth, they are marked in the following manner (we take the flour silk No. 12 for example):

Prima—12.
Extra—12 **X**.
Double Extra—12 **XX**.
Triple Extra—12 **XXX**.

With these crosses the corresponding silks should be marked in drawing the milling diagrams.

The middlings sieves, applied in purifiers, in the Swiss numeration are characterised in the following table:

TABLE XXXI

Cloth No.	Number of Threads to 1 cm.	Number of Meshes to 1 square cm.	Dimensions in mm. of each side of the Meshes.	Cloth No.	Number of Threads to 1 cm.	Number of Meshes to 1 square cm.	Dimensions in mm. of each side of the Meshes.
14	5½	28	1·82	44	17	285	0·59
16	6	37	1·66	46	17½	308	0·67
18	7	48	1·43	48	18½	339	0·55
20	7½	58	1·33	50	19	369	0·52
22	8½	71	1·18	52	20	398	0·50
24	9	82	1·11	54	21	429	0·48
26	10	99	1·00	56	21½	460	0·46
28	11	116	0·90	58	22½	498	0·44
30	11½	132	0·87	60	23	529	0·43
32	12	150	0·83	62	24	565	0·42
34	13	171	0·77	64	24½	602	0·41
36	14	190	0·71	66	25½	640	0·39
38	14½	213	0·61	68	26	680	0·38
40	15½	239	0·64	70	27	720	0·37
42	16	258	0·61	72	28	804	0·36

In their density the middlings sieves correspond to the Triple Extra. For grading the middlings cloths from Table XXXI should be employed, because the sharp product wears out the lighter cloths more rapidly. But sometimes the use of the Prima cloths (Table XXX) is preferable, because they are cheaper. For this reason we give the table of parallel numbers of the Prima and the middlings cloths (Table XXXII).

TABLE XXXII

Prima Nos.	Middlings Nos.	Prima Nos.	Middlings Nos.	Prima Nos.	Middlings Nos.	Prima Nos.	Middlings Nos.
..	14	..	..	..	42	3	56
..	16	..	30	1	44	..	58
0000	18	..	32	..	46	4	60
..	20	..	34	..	48	..	62
..	22	..	36	2	50	5	64
00	24	..	38	..	52	..	66
..	26	0	40	..	54	7	68

The French sieves are mostly prepared of linen texture, and their numeration is totally different to the generally accepted Swiss numeration.

The next table gives an approximate comparison of these two numerations (Table XXXIII) with the Prima cloths.

TABLE XXXIII

Prima Nos.	French Nos.	Prima Nos.	French Nos.
0000	20	7	95
000	15	8	100
00	30	9	110
0	40	10	120
1	50	11	130
2	60	12	140
3	65	13	150
4	70	14	170
5	80	15	180
6	90	16	200

Characteristics of the Intermediate Products and Flour.—Before considering flowsheets for the grading and flour dressing, it is necessary to settle the question of the terms applied to the intermediate products in connection with the above numeration of sieves.

The largest break product is obtained from the preliminary break (Hochschrot), when the grain is broken in two down the crease. If the broken grain is to tail over the scalper, sieves from No. 8 to No. 24, according to the size of the grain, must be employed. Then come the ordinary breaks from 6 to 9 in number. For high break as well as for the successive break passages we use wire sieves with meshes numbered per inch, which were spoken of on p. 322.

The largest product in the break process is called semolina, and since this semolina is sharp and rough, it is necessary to use wire sieves, which are more durable.

After each successive passage of the break stock through the grinding rolls, its size diminishes, and reckoning the numeration of the wire sieves to an inch, sieves with Nos. from 14 to 40 should be used for the last break. The dimensions of the break semolina may be reckoned at 1·4 mm. to 0·7 mm. and less.

Further, we have the rebreak semolina, for sizing which wire sieves are also required, Nos. 20 to 40. The dimensions of the rebreak semolina are defined at 1·35 mm. and less.

The product following in size is the middlings of various dimensions. Generally up to six numbers of middlings are distinguished. To obtain these middlings as overtails, silk cloths are used of the following numbers, according to the middlings numeration in Table XXXI.

TABLE XXXIV

NUMBERS OF MIDDLINGS AND THEIR CORRESPONDING SIEVES

Middlings Nos.	Middlings Cloth Nos.	Prima Silk Nos.	Dimensions of Middlings in mm.
1	20–24	0000–00	1·33–1·11
2	24–32	00–0	1·11–0·83
3	32–40	0–1	0·83–0·64
4	40–48	1–2	0·64–0·54
5	48–56	2–3	0·54–0·46
6	56–60	3–4	0·46–0·37

In giving the dimensions of the middlings in mm., we understand this to be their largest measurement or diameter, supposing them to be of a spherical shape.

After the middlings the product next in size is named "dunst." This product, dressing through grit gauze Nos. 60 to 68, is tailed over on Nos. 5 to 7 (Prima numbers).

Lastly, the granular flour is obtained as throughs from sieves Nos. 5 to 7 and the finished flour from Nos. 8 to 13.[1]

Diagrams of Bolting.—We are already acquainted with the general outline of the operation of the graders; we have now to study it more in detail.

In examining the process of sifting and grading the break stock, we notice three methods of sifting:

(1) The overtails are of uniform size, while the throughs are of various sizes.
(2) The throughs are uniform in size, the overtails different.
(3) The overtails and the throughs are both of various sizes.

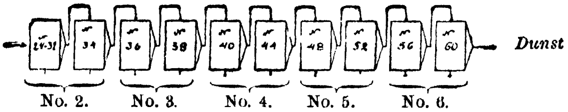

FIG. 295.

For grading by the first method, a sieve is chosen with meshes of a size which allows only the largest product to be tailed over.

In the second, the dimensions of the meshes allow only the smallest product to dress through the sieve.

For the third method, meshes suiting the medium of the intermediate products are selected.

The application of the third method is expedient when it is desired to divide the work of one sieve among several. In most cases the second and third methods of sifting are adopted.

Supposing we are required to grade middlings into sizes from Nos. 2 to 6 according to Table XXXIV. Then we must use sieves from Nos. 28 to 60. The first system (Fig. 295) overtails the middlings, the second (Fig. 296) dresses them through. The first system yields the largest middlings No. 2 as overtails, and the rest as throughs. To separate the middlings No. 3, next in size, a finer sieve has to be used—No. 34, &c. In this way the numbers of the sieves decrease until we obtain as overtails

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[1] In modern English mills the lowest flour silk number is usually No. 9, while in large modern mills throughs of Nos. 9 and 10 and even 11 are sometimes treated as dunst and further purified and reduced on the smooth rolls.

the finest middlings, No. 6, and dunst, as throughs. To perform the work in accordance with this diagram, the sieves have to be disposed one below the other. We have already met with such a construction of sieves, when studying the construction of grain-cleaning machines.

If employing the throughs system, we dispose the sieves in an order starting with the finer and ending with the coarser. The first product yielded as throughs by No. 56 corresponds to the finest middlings, the second larger ones, &c. In the second diagram the sieves are placed in one plane or some other form of surface. This type of machine we also met in the grain-cleaning section; namely, the reel-separator.

A comparison of these two diagrams leads us to prefer the first, in which there is little product tailed over in comparison with the general mass, and consequently each sieve will be but slightly worn. In the second diagram, in which the quantity of the throughs is small, the whole mass of product travels over the sieve, therefore the force of friction is much greater than in the first case, and the cloth wears more rapidly.

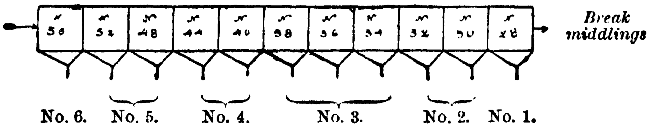


FIG. 296.

It is best to combine both these diagrams so as to separate the coarser product by the overtails system, and grade the finer product by the throughs system.

II

RELATIVE POSITION OF THE SIEVES

Having become acquainted with the grading diagrams, we shall now proceed to work out the relative position of the sieves.

We have the following diagrams of the disposition of sieves according to the system of grinding:

(1) A diagram of the disposition of sieves for sifting the product of plain (single) grinding.
(2) Diagrams for high grinding.
(3) Diagrams for rebreak.
(4) Diagrams for semi-high grinding.
(5) Diagrams for sifting the products of reduction of middlings and dunst.

The second and the third diagrams for sifting the products of high grinding consist of diagrams for the break and rebreak products, the reduction of middlings, and grinding of the low grade stock. In addition the diagrams of sifting for the high and the semi-high rye grinding likewise belong to this category.

(1) *Diagram of Sieves for Plain Grinding.*—The plain or single grinding completely reduces the grain to flour at one passage, excepting an insignificant quantity of offals, which, owing to their elasticity, remain in the shape of fine soft bran. The product obtained is soft, and therefore the sifting may be performed by the second system, *i.e.* by throughs, without danger of the sieves wearing. Fig. 297 represents an arrangement of covers for plain grinding. Experience has shown that the more product there is on the sieve, the coarser should the sieve be to yield as throughs a product equal in size to the throughs obtained when the sieve is less loaded. Therefore the first sieve we use is No. 10 or No. 11, while the second and third is one number higher, so that the flour from the first, second, and third sieves should be of an equal size. In this way the first three sieves give flour as throughs; the fourth, dunst; the fifth, middlings; and the bran is tailed over as refuse.

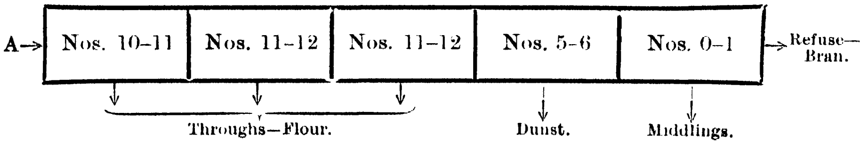


FIG. 297.

(2) *Diagram of Sieves for the Long System Break Process.*—The break process is performed, as we already know, in such a manner as to obtain as much middlings and as little break flour as possible. But some break flour is inevitable, and therefore the sifting diagram contains sieves for middlings of different numbers and flour sieves.

On Fig. 298 may be seen the diagram 2 for the first break. This diagram is a combination of the first and the second systems of sifting, *i.e.* the work is done by overtailing and by bolting. The product, first break, passes along the arrow *A* to the wire sieve No. 18 or No. 20 (we give the numbers of the wire sieves everywhere to an inch). From the overtails we obtain the first break semolina, while the throughs, the remaining product, run to the second wire sieve, Nos. 20 to 22. This sieve supplements the work of the primary grader, as this could not have taken out the whole of the break semolina. Therefore this sieve likewise overtails break semolina. The next is a silk middlings sieve, Nos. 34 to 36. The overtails of this sieve are the mixed middlings, Nos. 1 to 3, and the throughs likewise consist of a mixed product—fine middlings, dunst, and flour. The duty of this sieve, which gives no uniform product, neither as overtails nor as throughs, is to facilitate the work of the more tender flour silks, the fourth and the fifth, by separating the coarse product (middlings Nos. 1 to 3). The mixed middlings overtailed on the third sieve may be subjected to a further grading if necessary ; the throughs from it, in the meantime, pass to the fourth sieve, which bolts the flour. The overtails of the fourth sieve go to the fifth, and the throughs are again flour, which mixes with the flour from the fourth sieve. Lastly, the sixth sieve gives fine middlings Nos. 4 to 6 as overtails, and the dunsts as throughs.

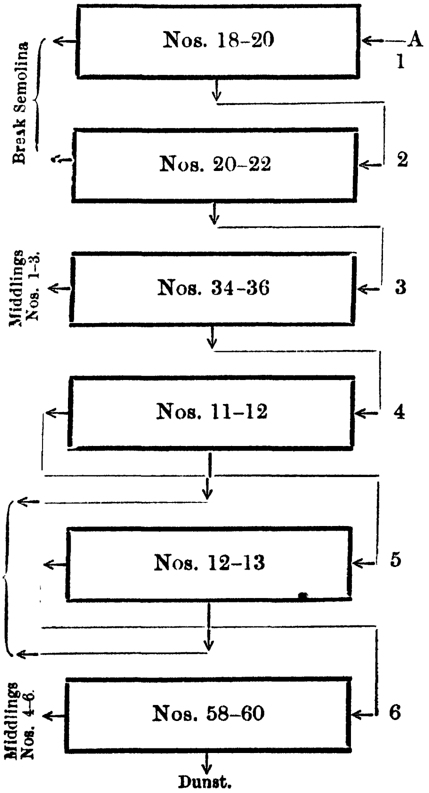


Fig. 298.

Thus, the sieves 1 and 2 give overtails, sieve 3 separates the product for further grading, sieves 4 and 5 give throughs, and the last, the sixth sieve, yields the graded product as tails and as throughs.

The sixth sieve could be, and sometimes is, placed after the third. Then the first four sieves would be operating on the "overtail system," and the last two giving throughs, the last sieve yielding dunst as tails. But the first plan of disposition is preferable, for the flour on the fourth and fifth sieves will be sifted better if they are more heavily loaded with product.

For a shorter break system, for instance, with six breaks, this diagram may be altered so that by placing instead of the second wire sieve the middlings sieve No. 24, we obtain middlings No. 1. Then the third sieve will yield middlings Nos. 2 to 3, which may remain unseparated. The other sieves can be left in their places.

In the diagram reviewed there is no sieve which would yield rebreak semolina. To obtain it, the second sieve, Nos. 20 to 22, may be substituted by a wire sieve, Nos. 24 to 26, which gives the rebreak.

The greatest quantity of middlings (amounting to 60 per cent. of the bulk of grist) in an eightfold break is obtained at the second, third, and fourth breaks, which induces us to examine the diagram of position of the sieves of, for example, the third break, the most characteristic one, as it yields up to 24 per cent. of middlings. This diagram is shown on Fig. 299.

The first wire sieve overtails break semolina ; the second and third, silk cloths, yield coarse and medium middlings, Nos. 1 to 4. The fourth and fifth sieves yield flour, while the sixth sieve bolts the dunst and tails over the fine middlings, Nos. 5 to 6.

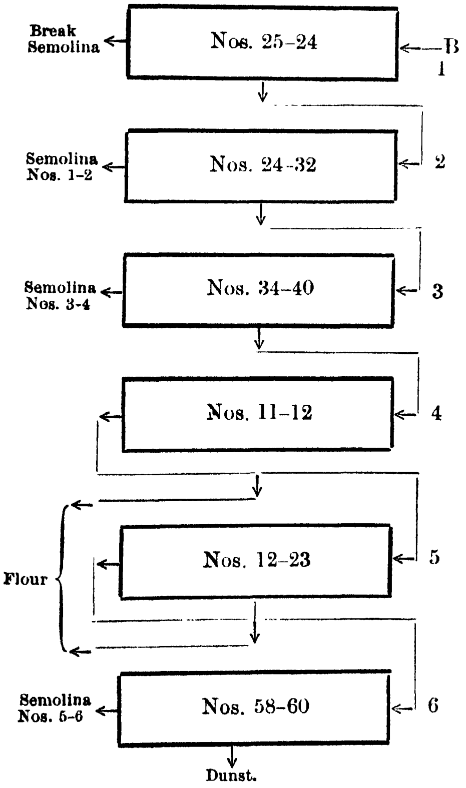


FIG. 299.

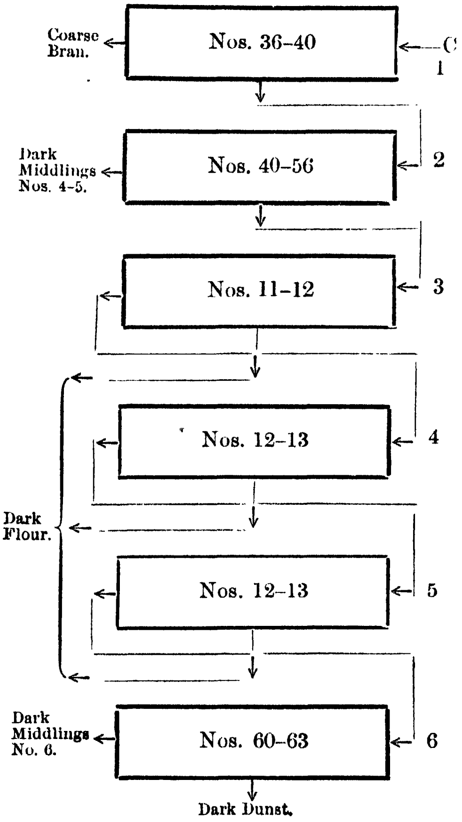


FIG. 300.

Commencing with the fifth break the size of the middlings diminishes, and at the fifth break there is scarcely any middlings Nos. 1 to 2. For this reason the numbers of the middlings sieves increase, and some of these sieves may be discarded and flour or dunst numbers set in their places.

The last break, which yields bran, dark middlings, dunst, and flour, is also characteristic. For the eighth break the diagram of sieves shown on Fig. 300 should be adopted.

According to this diagram the sieves 1 and 2 yield overtails, the sieves 3, 4, and 5 throughs, and sieve 6 both overtails and throughs.

The tails from the first wire sieve, the bran, are conveyed to the brush machine to remove the mealy particles remaining on them. The tails from the second silk sieve, the soft dark middlings, are sent for reduction. The throughs from the third, fourth and fifth sieves, lowest grade of flour, and, lastly, the throughs and the tails from the sixth sieve, dark dunst and small dark middlings, are likewise conveyed for reduction and reduced to low-grade flour.

(3) *Diagrams of Sieves for Rebreak.*—The number of rebreaks employed in the Russian mills varies between 1 and 5. In the last case the rebreak may be regarded as a parallel break, and the diagram of disposition of the sieves here scarcely differs from the diagrams for the shorter (semi-high) break process. But generally 1 to 3 rebreak or scratch rolls are used. For the rebreaks the diagrams of the sieves, in their general outline, are the same as those for breaking, with the sole difference that the numbers of the wire and the middlings sieves are higher, the product being finer.

(4) *Diagram of Sieves for Medium Break Systems.*—There is no essential difference in the diagrams of disposition of the sieves in the long and the medium systems; they differ only in the numbers of their sieves and their more rapid increase at the end of the break process for break semolina and middlings.

(5) *Diagrams of Sieves for Reduction.*—As in the preceding cases the diagrams of disposition of the sieves for sifting the milled product present a combination of throughs and overtails differing only in the numbers of their sieves and the number of "throughs systems." This diagram of sieves should be employed (*a*) for the reduction of middlings, (*b*) for the reduction of dunst and cleaning the offals, (*c*) for supplementary machines.

In all three cases the chief aim of the reduction is to obtain flour. Therefore, the greater number of sieves in this diagram should be set for flour, so as to separate the large product more accurately during the sifting process.

(*a*) The diagram illustrated by Fig. 301 shows the position of the sieves for sifting the product produced by the reduction of middlings. The highest grades of flour obtained from Russian grinding being generally granular (2 and 3 grades), and not differing in size from middlings No. 6 and dunst, this diagram presents two varieties of sieves: the first flour numbers yield coarse (granular) flour, the second soft or fine. The first sieve tails over the required product, and yields semolina Nos. 5 and 6 ; the next two sieves give as throughs a final product in the shape of coarse or fine flour, as required. The fourth sieve separates semolina No. 6 from the dunst.

We must note the fact that the numbers of sieves in all the diagrams we are examining depends on the construction of the sifting machine ; it fluctuates between 4 and 12. If the number of sieves is higher, more break, middlings, and flour systems are employed, leaving one dunst sieve. This is more minutely described in the milling diagrams.

(*b*) The diagram of sieves for reduced dunst and bran differs from the preceding in that the last sieve is missing and the numbers of the flour sieves are higher than usual (from Nos. 12 to 15), for the reduction product, if the pressure of the rolls is great, gives a fine flour. In this way one or two sieves yield overtails, separating the dunst, while three or four give flour as throughs, the last one at the same time tailing over the finer dunst.

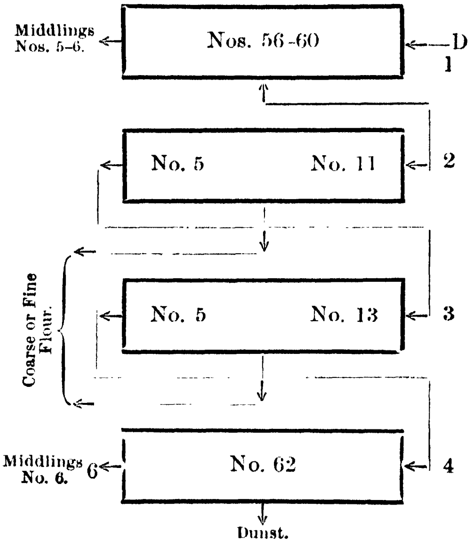


FIG. 301.

(*c*) In long system mills the flour obtained is often subjected to control, *i.e.* the middlings (in granular grades) or dunst (in fine flour) are separated away. Then the diagram resembling the one on Fig. 301, but without the last sieve, with a less number of sieves (never exceeding three) must be used. The throughs of the flour sieves give the final product, while the tails (middlings or dunst) from the first and the last sieves are returned for further reduction.

III

THE SIFTING PROCESS

Bolting through a sieve may be effected only if the product on its surface moves and is in motion. The particles of product, smaller in size than the meshes of the sieve, on passing through the mass of product to the bolting surface, will fall through these meshes.

An inspection of the reduced product shows us that it consists of particles of equal specific gravity, but different in size, and of branny particles, which are lighter. For this reason the whole of the product will settle on the sieve in layers, according to specific gravity. The top layer will consist of branny particles ; the layers under it, equal in specific gravity, will find their depth in accordance with their size, the smaller particles lying above the larger ones. Hence it is clear that the bolting system requires an extremely rigorous stirring of the product, so that the small particles should be able to reach the bolting surface and escape through the meshes. By shaking the sieve in this manner we must break up the natural order of the layers, bringing the upper layers of small particles to the bottom, and the large to the top for tailing over. That is why, in the diagrams we have reviewed, the number of flour sieves which yield flour as throughs is larger than the number of sieves from which overtails are derived.

The stirring of the product is effected either as in reel-separators of plain action (pp. 70, 71, Figs. 58, 59, 60), or with the aid of beaters, which catch up the product and fling it upon the sieve, or again, by the influence of the power lying in the plane of the sieve (p. 69, Fig. 57). In another type of sifting machines the power acting upon the product is the resultant of the pressure of air, perpendicular to the direction of motion, and a power parallel to that motion. In these machines the product is divided according to size as well as to specific gravity. A more rough adaptation of this method of stirring the product we saw in the grain-cleaning machines with aspiration, and we shall see it applied to the reduction product in purifiers with sieves.

The product passes through the sieve influenced by its proper weight and partly by the pressure of the layers lying above the particles to be sifted.

Let us examine the favourable conditions necessary to allow the particles a passage through the sieve. If the particle a (Fig. 302) is above the sieve AB while the product is travelling over its surface, in an ordinary case it is acted upon by the gravity mg (m the mass of the particle, and g acceleration of the gravity), and by the motive power T, directed upward at an angle α to the horizon. This direction of the power T is advantageous in this respect, that the product mixes better, the larger particles at the bottom being in this manner brought to the top. But the inconvenience of the motive power directed upwards lies in the fact that R, the resultant of mg and T, which propels the particles through the mesh of the sieve, is smaller here than in the case when T is directed downwards. In the first case the power mg is diminished by T_1, in the second it would have increased by T_1. Besides that, in the second case the resultant gm and T form a wider angle with the plane of the sieve than in the first, which favours to a greater extent the passage of the product through the sieve. This latter circumstance being of great importance, we shall examine it more minutely.

Supposing the resultant R to be directed to the surface of the sieve at a right angle and at an angle β (Fig. 303). If the direction R and the surface AB of the sieve form a right angle, then, through a mesh of the c size the particle m will pass, its diameter ab being almost of the size of e. But if R is directed at the angle β, then the mesh will afford passage to

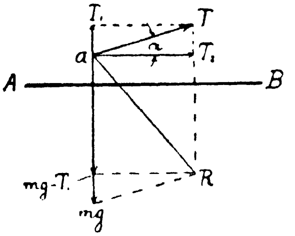


Fig. 302.

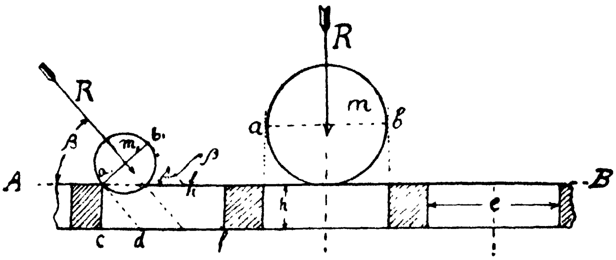


Fig. 303.

the particle m_1 with a diameter $a_1\,b_1$, which is expressed through e and the thickness h of the sieve, thus :

$$a_1b_1 = a_1f \sin\beta = (e - h\,Ctg\,\beta)\sin\beta = e\sin\beta - hGB,$$

since $\quad a_1f_1 = df = e - cd, \qquad$ while $cd = h\,Ctg\,\beta$.

Hence it is clear that the diameter of the particle is considerably smaller than the side of the mesh, and further depends on the thickness h of the thread too; the smaller the thickness of the sieve, the larger the particles sifted will be, and vice versa.

If we take a middlings sieve No. 20, which has $e = 1{\cdot}1$ mm. (approximately), and $h = 0{\cdot}2$ mm., then the direction of R being vertical, the diameter of the middlings will be 1 mm., and h here has no influence on the size of the middlings. Let us suppose now that R lies at an angle of 45°. Then

$$a_1b_1 = e\sin\beta - h\cos\beta = \frac{\sqrt{2}}{2}1{\cdot}1 - 0{\cdot}2 = 0{\cdot}63 \text{ mm.}$$

If $\beta = 30°$, then

$$a_1b_1 = 1{\cdot}1\tfrac{1}{2} - 0{\cdot}2086 = 0{\cdot}38 \text{ mm.}$$

In other terms, in the first case (45°) the particle which can pass through the mesh is almost double as small as in the case of a vertical R.

When R lies at an angle of 30°, $a_1b_1=0{\cdot}38$ mm., *i.e.* almost three times as small.

From the above we may conclude that the more favourable conditions for sifting are obtained, when R is perpendicular to the surface of the sieve. In this case for the products of equal size the number of meshes to a unit of the bolting surface will be greater than when R is inclined. The number N of threads to a unit of length will be :

$$N=\frac{1}{h+e}.$$

If we define the number of threads to 1 cm. for the three quantities obtained of diameters of the particles, we come to the following :

$$N_1=\frac{10 \text{ mm.}}{0{\cdot}2 \text{ mm.}+1{\cdot}1 \text{ mm.}}=7{\cdot}7.$$

$$N_2=\frac{10 \text{ mm.}}{0{\cdot}2 \text{ mm.}+0{\cdot}63 \text{ mm.}}=12.$$

$$N_3=\frac{10 \text{ mm.}}{0{\cdot}2 \text{ mm.}+0{\cdot}38 \text{ mm.}}=17{\cdot}2.$$

This answers the middlings numeration, $N_1=20$, $N_2=30$, and $N_3=38$.

Though the above considerations refer to one particle moving over the bolting surface, the character of the phenomenon remains the same for the mass. We must note, however, that when a mass of product is sifted, there is no such sharp difference between the numbers of the sieves, because sifting is a more complex process, and less easily analysed in theory than we have outlined it in respect to one particle.

Among the defects of an horizontal travel of the product we must reckon the more rapid wear of the sieves, because in this case the sharp edges of the particles of product act as incisors upon the fibres of the sieves. Thus experience mainly, and partly the elucidation of practical results by theory, lead us to the following conditions, which should be laid down as bases for us to build our estimate of the working surfaces of the sifting machines upon :

(1) The motion of the product to be sifted over the bolting surface should be such as to keep the mass of product continually mixing.

(2) The force acting upon the particles should act in a direction as near as possible to the vertical.

(3) The working surface of the sieve must be fully utilised and evenly loaded with product.

If the construction of the machine answers these three requirements, favourable results from the bolting are guaranteed.

IV

Construction of Sifting Machines

1. *Reels and Centrifugals*

As in the grain-sifting machines, the machines for sifting the products of milling may be classified in two groups: (1) machines with reciprocating motion, and (2) with rotary motion of the working surfaces. With regard to the outline of their working surface all sifting machines are likewise divided into two groups: (1) machines with flat sieves, and (2) machines with cylinder-shaped sieves.

In our examination of the bolting machines we shall commence by turning to their simplest shapes, *i.e.* to the reel-separators.

Polygonal Reels.—The constructions of polygonal reel-separators for grist do not differ materially from the grain reel-separators described on pp. 64 and 65. In large mills polygonal reel-separators have long ago been displaced in the milling department by more perfect machines. But since it is cheap, this machine is often set up in small local mills. For this reason we give the data of capacity of the polygonal reel-separators (Table XXXV, p. 336).

This approximate capacity is given for reel-separators with a diameter of 700 to 850 mm., the velocity of rotation being 30 to 35 revolutions per minute, and for those of 1000 mm. in diameter and running at the rate of 28 to 30 revolutions, their incline fluctuating between 5° and 6°.

Round Reels. — Resting upon the considerations mentioned on pp. 71 and 72, we regard the round reel-separators as the better type.

The incline of both the polygonal and the round reel-separators, owing to which the chain wheels and belt-pulleys have to be set on the axes in an inclined plane, must be reckoned in the number of their constructive defects. This defect is evaded in the new constructions by setting screw planks in the prism or cylinder of the reel-separator, which propel the product to the outlet of the sieve when it is in a horizontal position.

But the setting of these planks on the working surface of the reel-separator is inconvenient, and therefore the works of Thos. Robinson

TABLE XXXV

Capacity of Prismatic Reel-Separators

Dimensions of Prism in mm.		Working Area in Square Metres.	Capacity in lbs. per Hour.			Power Consumption H.P.
Diameter.	Length.		Break.	Middlings.	Flour.	
700	1000	1·75	504	180	126	0·10
	1250	2·25	648	216	162	0·15
	1500	2·70	792	288	198	
	1750	2·30	936	324	234	
	2000	3·60	1044	360	252	
	2250	4·08	1188	432	288	0·2
	2500	4·56	1332	468	324	
	2750	5·00	1512	504	360	
	3000	5·50	1620	576	396	0·25
	3500	6·46	1872	648	468	
	4000	7·40	2160	756	540	0·3
850	1250	2·78	792	288	198	0·20
	1500	3·35	972	342	234	
	1750	3·95	1152	396	288	
	..	..	..	..	..	..
	..	..	..	..	..	..
	..	..	..	..	..	..
	4500	10·34	3024	1044	720	0·5
	5000	11·50	3312	1152	1080	0·6
1000	2000	5·32	1548	540	360	0·4
	2500	6·72	1944	684	468	
	..	..	..	..	..	..
	..	..	..	..	..	..
	5500	15·12	4320	1548	1080	0·8
	6000	16·50	4824	1692	1188	0·9

offer the construction illustrated on Figs. 304 and 305. On the shaft of the reel-separator there are fixed four to six sprockets or more, according to the length of the reel-separator—to which there are lifters bolted down the full length of the separator. Into these lifters there are freely set the tails of the scrapers, where they may be turned by means of hand-wheels with common rods. At one, the screw-threaded end, the rods protrude through the cross-heads of the reel, and these ends are furnished with nuts by means of which they may be moved backwards and forwards, thus regulating the inclination of the scrapers, *i.e.* increasing or decreasing the thread of the helical surface formed by the scrapers.

During the rotary motion of the reel together with the beaters, the product falls on the surface of the beaters, and is flung back upon the cloth cover in the direction of the outlet. The inclination of the beaters determines the velocity with which the product to be bolted passes through the separator, while the regulation of their incline imparts a greater or a smaller velocity to the motion of the product. We have met this principle already in Dobrovy and Nabholtz's scouring machine.

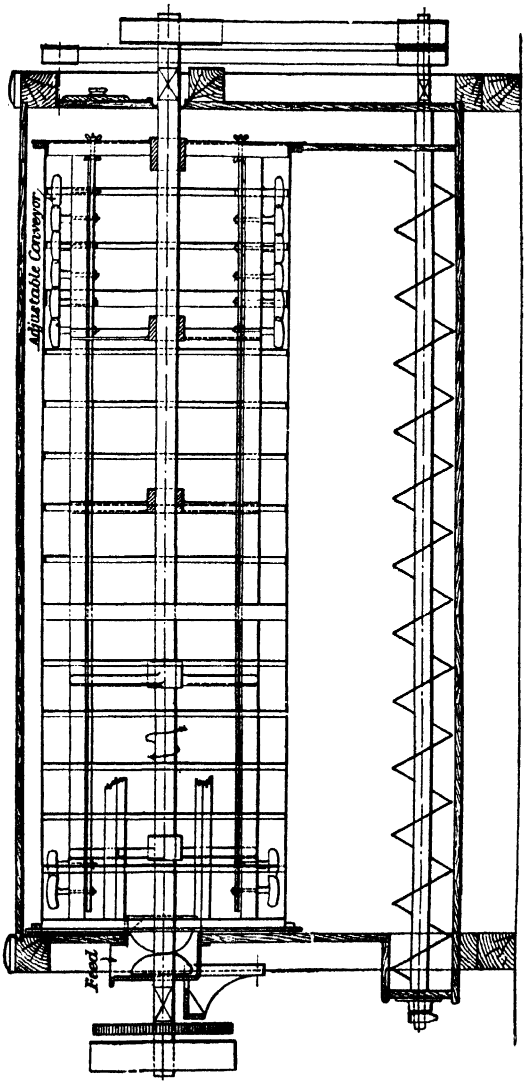


FIG. 304.

Centrifugal Dressing Machines.—The polygonal and the round reels of the ordinary type do not answer the second and third conditions of a favourable sifting (p. 337). In fact, the force imparting motion to the product is the component force of gravity, directed parallel to the side of the prismatic reel or at a tangent to the cylindric, while the greatest sifting area is one-third of the whole cover. That being the case, centrifugal reel-separators were evolved, the purpose of which is to compel the product to move at a more or less wide angle to the bolting surface, and utilise, if possible, the whole area of the sieve. To attain this end, two types of construction of the centrifugal are made : one of them with a fixed sieve-casing containing a rotating drum with helical beaters which catch the product up below and fling it upon the sieve ; the other has a rotating reel and inclined beaters rotating within it. In the first construction we have the principle of a horizontal scouring machine, in the second, that of a bran-dusting brush machine.

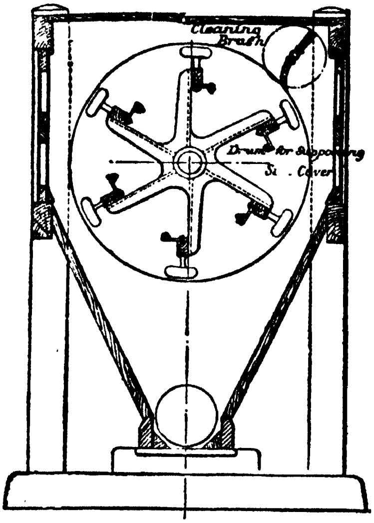


Fig. 305.

The adaptation of the scouring machine principle, however, is inexpedient here, because the pressure of the beaters through the product upon the lower part of the sieve causes the bolting cloth to become rapidly worn and spoiled, not to speak of the unnecessary power consumption. General practice has rejected this type of centrifugal, and we shall therefore pass it by.

A centrifugal with a sieve rotating in the same direction as the beaters obviates this defect, the beaters being set at such a distance from the bolting cloth that they cannot scoop the product up from below, and consequently do not tear the sieve. The operation is performed in such a manner that the rotating sieve lifts the product and drops it from a certain height on to the beaters, which throw the mass to be bolted to the working surface.

Before proceeding to describe the constructions of centrifugals of the second type, several theoretical considerations must be adduced. The first and the third conditions necessary for the sifting to be satisfactory (the mixing of the product and utilisation of the whole working surface of the sieve) are, evidently, attained in the centrifugal. Now we must define the incline of the working surface of the beater to the horizon, when the product rejected will fall on the sieve perpendicularly to the element of the cylindric surface.

The particle of product which has fallen upon the beater ab (Fig. 306) and received an impact, is under the influence of the gravity mg and $T = mw$, where w is the acceleration caused by the impact from the paddle. Examining the resultant R of these two forces, we see that if T were directed along the radius, *i.e.* normally to the element of the working surface, the force mg would alter this direction. Further, the force mg will likewise alter the quantity R correspondingly to the position of the beater at the moment it strikes the particle. Thus, the conditions of sifting on the whole working surface of the reel are not equal. To reduce the action of the force mg in this undesirable direction to a minimum, we have to communicate the greatest value to mw, which may be attained by the beaters running at high speeds, sometimes 6 to 10 metres per second.

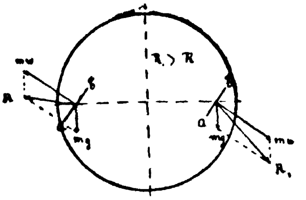


FIG. 306.

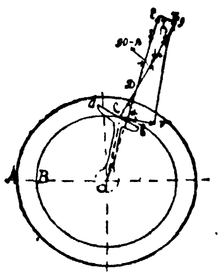


FIG. 307.

Let us now see under what conditions the force mw, or in other terms, the velocity of the impact of the particle, will be normal to the working surface, if the force mg is ignored. We shall suppose first that the cylinder and the paddles are rotating in one and the same direction, and prove that only in this case will mw be normal to the surface of the cylinder. If R is the radius of the cylinder (Fig. 307), and r the average radius of the periphery of rotation of the beaters, the circumferential velocity per second of the cylinder $v_0 = \frac{2\pi Rm}{60}$, where m is the number of revolutions per minute, and the average circumferential velocity of the beaters $v = \frac{2\pi rn}{60}$, where n is the number of revolutions of the beaters. If N is the resultant velocity with which the product strikes the sieve, it will then be normal to the sieve, when the velocity N_1, perpendicular to the paddle, is the resultant of this N and v_0, and the circumferential velocity of the paddles $V=N_1 \cos a$. But this is possible only when the beaters and the cylinder revolve in the same direction.

Marking the angle between V_0 and $N_1-\beta$ we find that $V_0=N_1 \cos \beta$. But according to the condition $V=N_1 \cos a$. Therefore, comparing N_1 we obtain :

$$\frac{V_0}{\cos \beta}=\frac{V}{\cos a},$$

or substituting the values of V_0 and V :

$$\frac{2\pi Rm}{60 . \cos \beta}=\frac{2\pi rn}{60 . \cos a}.$$

After reducing :

$$\frac{Rm}{\cos \beta}=\frac{rn}{\cos a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Since $\angle EDF=90-\beta$, and $\angle OCD=90+a$, from the triangle ODC we obtain :

$$\frac{OC}{OD}=\frac{r}{R}=\frac{\sin(90-\beta)}{\sin(90+a)}=\frac{\cos\beta}{\cos a} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Substituting the term $\frac{\cos\beta}{\cos a}=\frac{r}{R}$ from (2) to (1), we find :

$$\frac{m}{n}=\frac{r^2}{R^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

This correlation shows that with any inclination of the beaters the direction of the resultant R (Fig. 307) may be made normal to the surface of the cylinder, if suitable numbers of revolutions and radii of the reel and beaters be chosen. In inferring this correlativity of the number of revolutions and the radii the gravity of the product was not taken into consideration, and the velocity of the particle was supposed to be constant. Practical experience corrects this formula by altering the degree of ratio of the radii from 2½ to 3. Finally, therefore, we obtain :

$$\frac{m}{n}=\left(\frac{r}{R}\right)^{2\frac{1}{2}-3.}$$

The theoretical considerations of Professor Zworykin given here find a brilliant corroboration in the actual construction of centrifugals, the number of revolutions and the diameters of which we proved according to his formula, having obtained a great accuracy of correlativity inferred. In this way, that which is clear from simple theoretic inferences, practice has been seeking many years, until it reached the correct solution of the question after groping in the dark, having passed a lengthy number of rejected unsuccessful constructions and expended much money in that way.

Construction of Centrifugals.—Before deciding upon the modern type of a reel, the works offered many fairly different constructions of these machines. We shall not enumerate these types, but one of them, a reel from the works of Dost in Vienna, which at a certain period was very popular, demands our attention. Fig. 308 illustrates a cross section of the separator, and shows its reel to be of a star section. On being fed into the reel the product is lifted on the platforms *b*, drops from a certain height, and is caught up by the beaters *c*, fixed at an angle to the generating circle with two or three (according to the length of the reel) sprockets *A*. The incline of the bolting side *a* is so chosen as to have the product rejected by a blow from the paddles fall on *a* at a right angle. The sifted product is conveyed by a worm *B* to the outside.

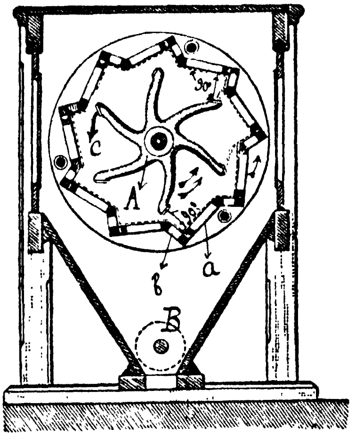


FIG. 308.

We have already seen that the product can fall at right angles on the sieves independently of their form. If this separator did work satisfactorily, evidently it was only owing to the happy choice of the velocities of rotation of the sieve and the beaters. But, speaking generally, this construction is less successful than that of the ordinary round reels. In the first place, the platforms *b* leave totally unsifted the product thrown by the beaters, since their motion is parallel to the planes of these platforms lying at a right angle to *a*. Further, the construction of the reel is rather complex, which makes clothing it with a sieve a difficult task. Lastly, the wear of the working surface was observed to be uneven, because *a* accepted almost the whole of the work, while *b* played the part of boxes supplying the paddles with product.

Fig. 309 represents the modern normal type of a centrifugal dressing-machine (Thos. Robinson). The product flows to the feeder *A* and is conveyed by the worm to the chamber *B* of the centrifugal. The drum *C* containing beaters is rotated from the belt-pulley 1. On the shaft of this drum, at the opposite end, there is set the belt-pulley 2 from which the worm *D* is brought into operation. On the shaft of the worm there are two belt-pulleys, 4 and 6 ; by means of the pulleys 4 and 5 the reel is rotated, and the spiral brush *E* for cleaning the cloth is driven by the pulleys 6 and 7. With the assistance of the ribs *F* which constitute the frame of the reel the product is lifted to a certain height, and then dropped upon the beaters. The beaters are disposed in the generating circle, but their propellers are bent to a helical line, as shown in Fig. 310.

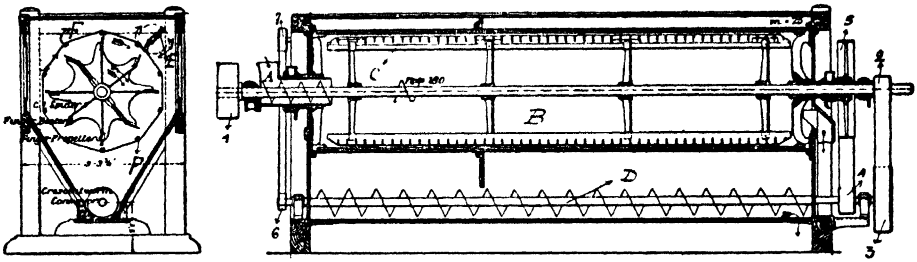


FIG. 309.

The bearings of the brushes may be transposed, so that the brush is approached to or removed from the sieve according to its wear or the necessity of a more rigorous cleaning of the bolting cloth.

Centrifugals of this type are built by almost all European works.

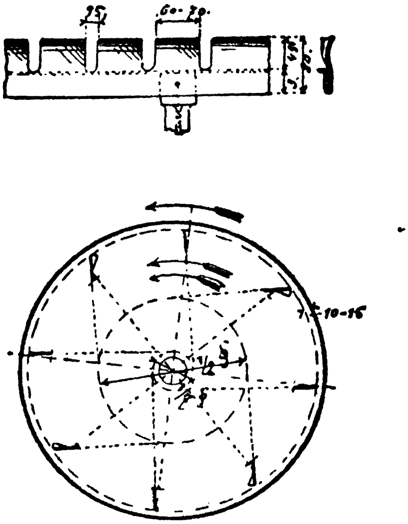


FIG. 310.

Very rarely the beaters bent to a helical line are discarded and solid beaters arranged at an angle to the generating circle of the cylinder. Fig. 311 illustrates a perspective view of Thos. Robinson's reel-separator furnished with such beaters.

Capacity of Centrifugals.—Since almost the whole of the working surface in the centrifugals is utilised, their capacity is far greater (nearly fivefold) than that of the ordinary reels, owing to which they are as yet not everywhere supplanted by plansifters in the merchant mills. They are generally employed for sifting the products of the final reduction, *i.e.* to receive them from the smooth rolls, which reduce the middlings and dunst, though formerly they used to be installed beginning with the fourth break. Table XXXVI gives us the capacity of centrifugals in accordance with their dimensions, the number

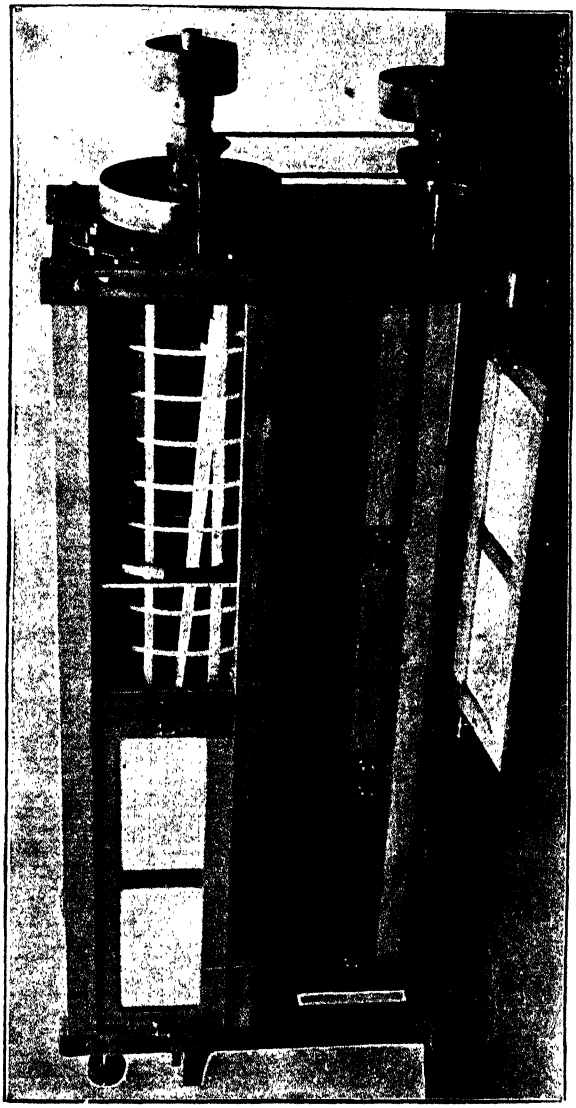


FIG. 311

of revolutions of the cylinder, and of the drum containing the beaters.

TABLE XXXVI

CAPACITY OF CENTRIFUGALS

Dimensions of Centrifugal in mm.		Number of Revolutions per Minute.		Capacity in lbs. per Hour.				Horse-power Required.
Diameter.	Length.	Cylinder.	Beater Drum.	Break.	Rebreak.	Middlings.	Flour.	
610	1500	30	250	900–1080	828–900	540–720	360–432	1·0–0·4
650	2000	30	250	1260–1440	1152–1368	792–900	540–612	1·5–0·6
700	2500	28	230	1620–1800	1440–1620	972–1080	720–828	1·8–0·8
800	3000	26	200	1980–2340	1800–1980	1260–1440	900–1008	2·2–1·0
900	3500	22	190	2520–3060	2160–2520	1620–1800	1080–1260	2·8–1·2
1000	4000	20	180	3240–3600	2880–3240	1980–2160	1332–1512	3·6–1·6

As concerns the power consumption, the quantity the centrifugal separators absorb running empty amounts to 80 per cent., consequently their useful work is very insignificant. This circumstance is the cause of their losing ground to more economical machines, which will now occupy our attention.

2. *Plansifters*

When studying the reel-separators, we saw that this type of sifting machine does not allow the use of the whole working surface of the sieves (plain reel-separators) or places in equal conditions of work (centrifugals). In addition, the plain as well as the centrifugal separators consume a large quantity of power. These defects induced the engineers to seek a more perfect type of machine, which was then offered by the Americans, together with the idea of an automatic mill.

Modern technics possess two types of plansifters, differing in the character of motion of their working surfaces :

(1) Machines with rectilinear reciprocating motion of the working organs.

(2) Machines with gyrating progressive motion of the sieves.

(i.) *Machines with Reciprocating Motion*

The simplest kind of such a machine is given on p. 31, Fig. 28, *G*. The different machines of the "Eclipse" (p. 64) or the zigzag separators are more perfect types of it And, lastly, Soder's plansifters may be pointed out as one of the best modern reciprocating bolting machines for reduction stock. This sifter is a an oblong timber box (Fig. 312) supported on steel spring stands. The box is brought into motion by an eccentric drive with a counterweight for balancing the inertia of the mass. Inside the box (Fig. 313) there are set five bolting frames.

This machine can very successfully do the work of a reel in the small farm mills, in case economy of space is a great consideration.

Proceeding now to give an estimate of the reciprocating machines, we must note that their advantages in comparison to the reel-separators consist only in their compactness. On the other hand, they have material defects, the cause of which lies chiefly in the character of motion of the machine. These defects are as follows :

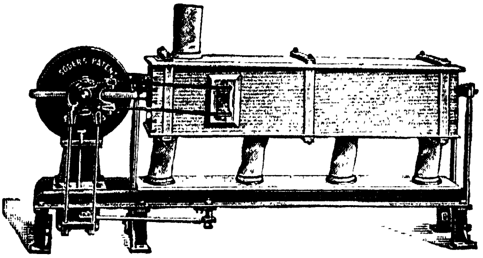


FIG. 312.

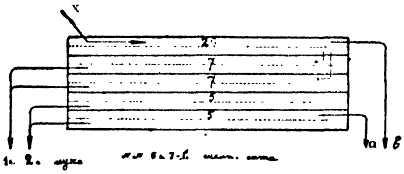


FIG. 313.

Copper cloth, No. 26. Silk gauze, Nos. 5 & 7.
X = Inlet of stock.

(1) Necessity of considering the inertia of the mass of the machine.

(2) Variable velocities of motion, causing an unevenness in the bolting of the product.

Owing to these defects, the application of reciprocating machines is very limited. It is only their comparative cheapness and compactness which makes their use in small short system mills possible.

(ii.) *Machines with Gyratory Progressive Motion*

The idea of the constructive principle of machines of that type is explained to us by G. Luther's grain-cleaning machine "Triumph," described on pp. 81, 82.

The main parts with a gyratory progressive motion are the box, where the bolting frames are arranged, or a box built of frames joined to each other and covered with bolting cloth ; then drop-hanger frames or stands, on which the box is established, and a shaft with an eccentrically set driving finger. The diagram of that sifter is given on p. 68, Fig. 56.

When the shaft A is in rotation, each point of the box s performs a gyratory progressive motion.

Before passing on to the constructive descriptions of machines of that kind, we must decide upon the fundamental requirements which should be answered by all machines of the type in hand, and prove this or that construction rational. These requirements are :

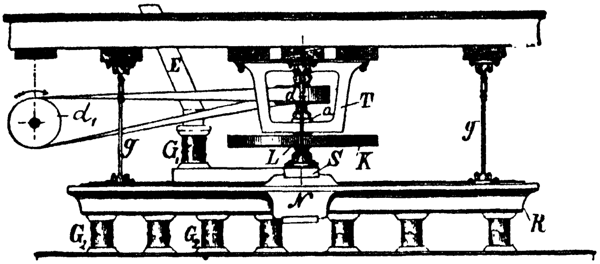


FIG. 314.

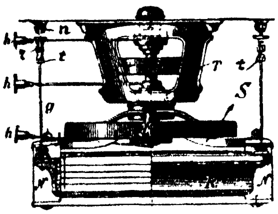


FIG. 315.

(1) Counterbalancing the centrifugal force of the gyratory motion of the working organ, the details of the transmission of motion being of the least possible size.

(2) Utilisation of the largest area of the bolting surface.

(3) Simplicity of shape and setting of the bolting trays.

(4) Constant cleaning of the working surfaces to avoid blinding.

To be able to make our estimate of the sifters from the point of view of the above requirements, it is necessary to become acquainted with the main types of construction.

K. Haggenmacher's Sifter.—The plansifter which brought about a revolution in bolting methods was invented by a citizen of Switzerland, K. Haggenmacher, at the end of the eighties of the last century. The original construction of this sifter is shown in Fig. 314. The box R, containing the bolting trays, is suspended on four rods g, and is brought into motion from the driving pulley d by a quarter-twist belt drive to the receiving pulley d. This pulley and the fly-wheel L, with a counterweight at K, have a common shaft, furnished with a collar a, with which it rests on the bearing in the cross-head T. The hub of the fly-wheel

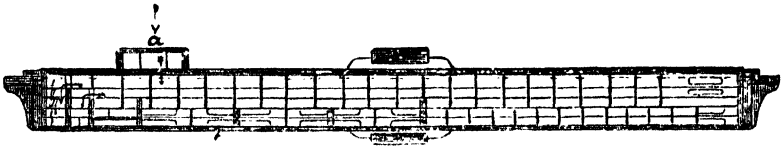


FIG. 316.

L has an eccentrically set journal, cast in one piece with the hub; this journal enters into the bearing of the cross-head *S*, coupled with the frame *N*, on which the box *R* with the sieves is set. The rods *g* are set (Fig. 315) in ball-bearings *n*. The product flows in down the spout *E* through a linen sleeve G_1 and is delivered after the sifting through similar sleeves G_2, whence it is directed for further treatment, or into bins, if it is flour. For setting the sifting box in a horizontal position, the rods *g*, consisting of two pieces, have nuts *t*, by means of which the lower piece of the rod may be screwed into the hub *r*, provided with a screw thread, thus making the rods shorter or longer. A longitudinal section of a box with five trays is shown on Fig. 316, their fixing on Fig. 317.

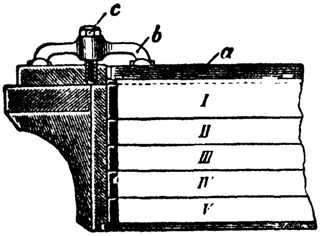


Fig. 317.

The sieves of that sifter lying in a horizontal plane, the product travels with the aid of slats, which operate in the manner described on p. 69, Fig. 57. This diagram shows us that the direction of the progressive motion of the product coincides with that part of its gyrating motion which is in opposition with the arrow of the setting of the slats. The different shapes of the slats (of zinc sheet iron) suggested by Haggenmacher are given on Fig. 318, but the straight slats set at right angles to the direction of the motion (part *y*) proved to be the most practical. If the slats are arranged as shown on Fig. 318, then the product fed in through *A* at the top will move along the arrows *s*. The frame here is divided by a partition, and its right and left part work independently, directing the overtails to the outlet *B*.

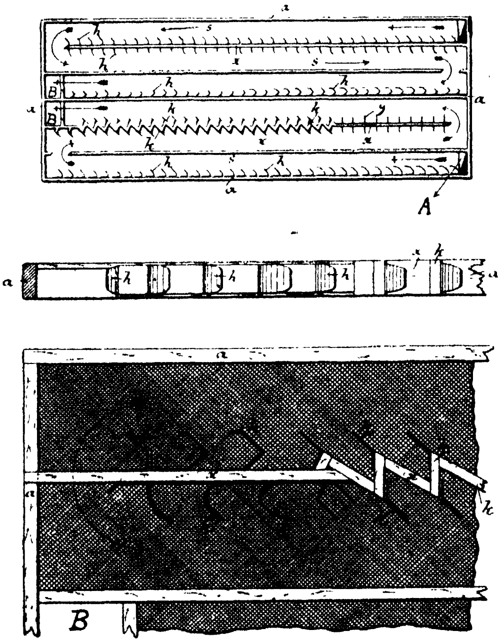


Fig. 318.

To get a clear notion of the sifting operation, we shall review the diagrams of the disposition of trays for break and reduction stocks.

The break product runs to the first and to the second sieves (Figs. 319 and 320) simultaneously and travels to the right, giving break semolina as overtails, and the remaining product as throughs. The product of rebreaks may be directed to the second sieve, if it is calculated for rebreak semolina. If the break product go only to the first frame, it will tail over the break semolina of the next order discharged through *b*, and bolt the rebreak semolina and the rest of the products. On the second sieve the products travel in the same direction, and therefore yield rebreak semolina as tails delivered out of the sifter through *c*, while the remaining middlings and flour pass through. The next sieve, No. 3, is designed to overtail the coarse middlings, beginning with No. 1, the throughs at the same time passing to the fourth linen (or sheet-iron) tray, where the slats are so disposed as to propel the product in the opposite direction. On reaching the openings *e* the product falls from the sheet-iron tray on to the fifth sieve, which through the openings e_1 gives the fine middlings and dunst as tails to the seventh sieve, and throws the flour upon the cloth of the sixth tray as throughs, which is delivered through *f*. The bolting tray 7 is divided into three sections with different cloths, which yield dunst and fine middlings as throughs, and tail over fine middlings which are larger than those of the throughs.

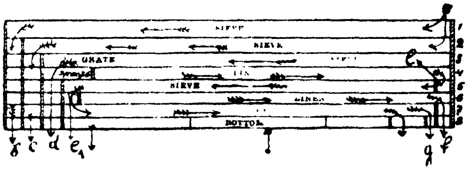


FIG. 319.—Diagram of Longitudinal Section of Sieves.

In this way the three first sieves operate by the "overtails system" and the two last ones by the "system of throughs." The throughs from the bolting frame 7 fall on the bottom 8 in which there are holes *h*, h_1 and h_2 for letting the dunst and the fine middlings out. The frames 1, 2, 3, 5, and 7 are called the working trays, while those of linen or sheet iron, 4, 6 and 8 are called collecting trays. This diagram contains only one flour tray, 5, but to have the flour more accurately sifted there are two or even three flour trays set in case a large quantity of break flour is yielded. The blinding of the sieves 3, 5 and 7 is overcome with the aid of shakers, which will be spoken of later.

The diagram of the trays for the stock reduced on smooth rolls is shown on Figs. 321 and 322. Since those products present a mixture of fine middlings and dunst with a considerably preponderating quantity of flour, the sifting away of the latter offers greater difficulties than in the first case. For this reason each working tray is succeeded by a collecting one, and the process of sifting is done on the following lines. The bolting working frame 1 with cloth No. 60 XX receives the reduced

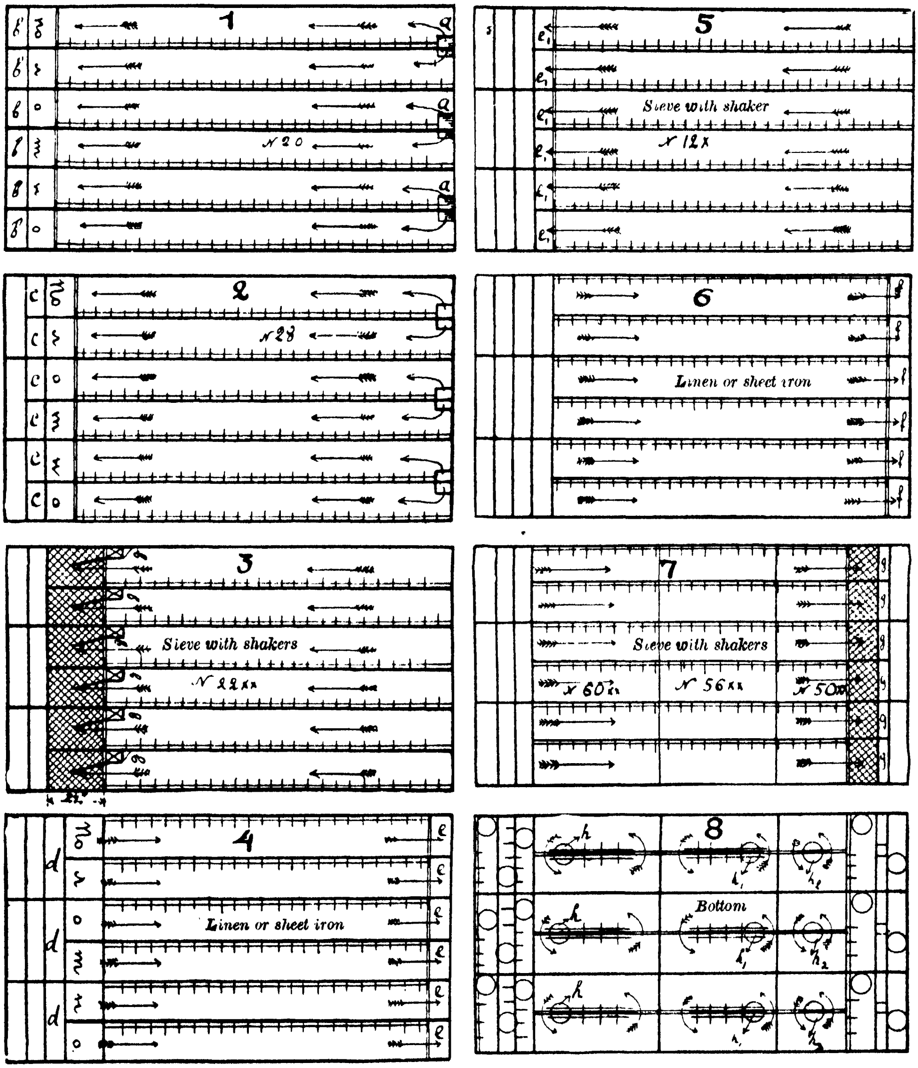
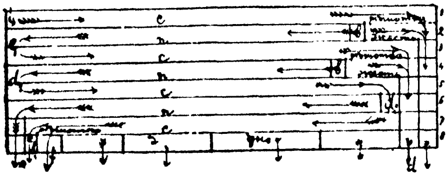


FIG. 320.—Plans of Sieves and Linen Frames

stock and yields fine middlings as tails, which is ejected from the sifter at *c* through all the trays. The dunst and flour go to the cloth of the collecting tray 2, down which they travel in the opposite direction and are passed to the working tray 3 with a dunst sieve No. 5 XX, tailing over the coarser dunst, which is directed to its exit through *d*. The throughs from the third tray travel over the fourth cloth through the openings d_1 to the working tray 5 clothed with sieve No. 12, which yields finished flour as throughs, to be delivered through the outlet *e*. The tails from the fifth tray go to the last working surface 7, furnished with flour sieves of different numbers (Nos. 12 and 13), which sift flour through on to the collecting bottom, and tail over the finest dunst. Consequently, the first two sieves here, 1 and 3, are operating on the "overtails system," separating away the fine middlings and dunst or dunst only (this depends on what the product ground on the smooth rolls is, whether it



c—Sieve
n—Linen
d—Bottom
p—Grate
e—Sheet Iron

FIG. 321.—Diagram of Longitudinal Section of Sieves.

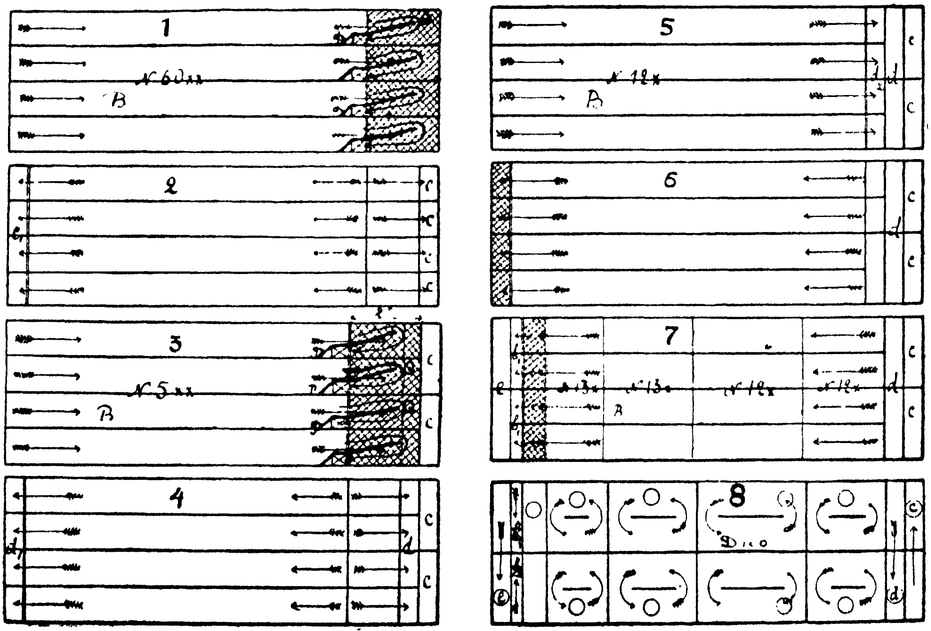


FIG. 322.

B—Shakers. *D*—Bottom. 1, 3, 5, & 7 are sieves. 2, 4 & 6 are cloths.

is coarse or fine middlings), and the sieves 5 and 7 on the “throughs system,” yielding ready stock.

In the first diagram there are marked three sifting trays with shakers, in the second four. It has already been mentioned that the shaking of the sieves is necessary to clean the meshes blinded with product. The trays 1 and 2 of the first diagram need no shaking, the sieves being fairly open (Nos. 20 and 28, wire), besides which the product is sufficiently coarse to clear the meshes by the pressure of its mass. For the silk sieves, particularly those for dunst and for flour, which dress through, a tapping action to keep them clean is indispensable, and is performed generally by means of large wheat grain, gutta-percha balls, or the grains of leguminous plants.

Let us watch the travel of the tapping grains in the second diagram. Down the same spout with the product, or along a separate one, the grains of wheat or pease are conveyed to the first tray and run over the sieve, shaking it, being bodies of greater weight. On reaching the slat PQ, and falling upon an open wire cloth, the product passes through it, while the tappers travel over it and turn in the direction indicated by the arrow to the openings b, through which they pass on to the cloth of tray 2 and proceed, together with the product, to the left. Once arrived at the opening c_1 the product and tappers pass on to the sieve 3, and again in the same manner go to the cloth 4. Then through openings d_1 and d_2 they fall successively upon the sieves 5 and 7. From the tray 7, passing the open wire cloth by, the tappers fall out at the outlet b_1 to the elevating mechanism, which carries them again to frame 1. The elevating mechanism is a vertical worm with a small thread, stationed on the outside or inside the section.

Section through A B.

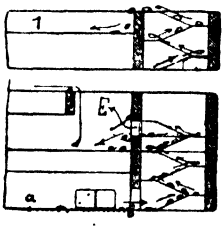


FIG. 323.

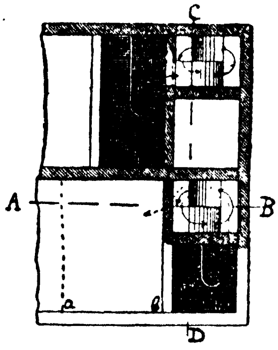


FIG. 324.

Section through C D.

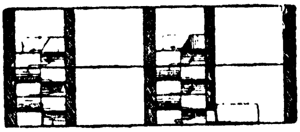


FIG. 325.

Figs. 323, 324 and 325 show the elevation of the tappers disposed inside the box. Here inclined planes are used in the place of a worm. From the last sieve (Fig. 323), having run over the open wire cloth, through which the product passes to the outlet spout, the tappers reach the first inclined plane, along which they ascend to the first horizontal plane, influenced by shocks, effected by the rotation of the sieve. From the first landing they ascend to the second over an inclined plane having a retrograde motion, then to the third, and so on to the first bolting tray. During all the time of the work each sifting tray should be covered with tappers which form an uninterrupted chain covering the sieves and stretching through the elevator. Generally the tappers from the last sieve are carried to the first. But sometimes in the vertical canal there are made openings *E* to the nearest trays, owing to which part of the tappers fall on the trays with the openings *E*, and part ascend to the first tray.

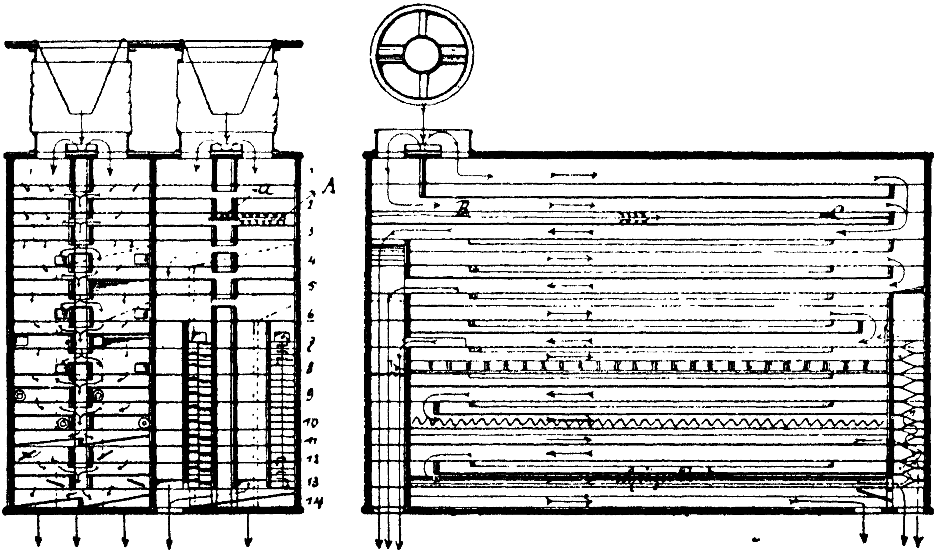


FIG. 326.

Fig. 324 illustrates the plan, and Fig. 325, a section through *CD*, which make the construction clear. On Fig. 326 may be seen the general disposition of such a cleaning device.

The defects of cleaning the sieves by means of tappers consist in the fact that the sieves have to be overloaded with superfluous weight, which are a cause of their rapid wear. The other shakers, such as spiral springs, chains, &c., have the same defects.

To obviate these defects the shakers are sometimes displaced by brush cleaners, which are diagrammatically shown on the same Fig. 326 (cleaning of the second sieve). The wooden rod *A* has soft hair brushes at the top and the bottom, and the working upper part of the brush touches the lower surface of the sieve, while the other end rests on a sheet-iron tray. At the end of the rod, free of the brushes, there is a timber finger *a*, which enters into the guiding canal *BC* and prevents it from moving to the right or to the left. When the sieve is in motion the brush travels along one side of the channels, turns back on reaching their corners, and runs along the other side.

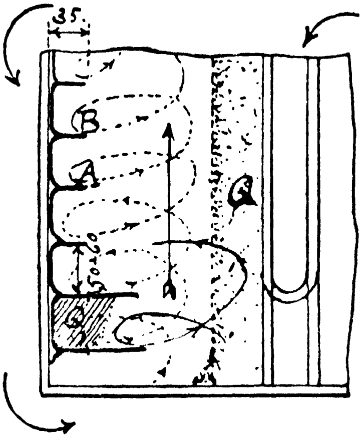


FIG. 327.

The brushes clean the sieves better, if the hair is sufficiently soft, influence their wear very little, and therefore brush cleaning has been adopted by almost all makers. This cleaning, however, has its own, though insignificant, defects. In the first place, the guiding channel annuls a certain part of the working surface of the sieve, and secondly the corners of the bolting trays remain untouched by the brush and are consequently not cleaned.

The product travels in the channels of the trays of the sifters with the aid of slats, as we have seen; the speed of motion depends on the number of revolutions and the degree of eccentricity defining the radius of rotation of each point in the sifter. The degree of eccentricity defines the width of the main channels on the trays. For an explanation of this phenomenon we shall turn to Fig. 327. The radius of rotation of each particle of product on the sieve is equal to the degree of eccentricity. The larger this radius, the greater is the wave of the curve *AB*, of the resultant motion of the product under the influence of centrifugal force, of the impact from the slat, and of gravity. If the channel taken is too broad, we shall have immobile dead masses Q. To move these masses also, the slats could be made longer; but then we should obtain dead masses Q_1 between the slats. The question concerning the normal width of the channels and the length of the slats is solved by general practice, since it cannot be solved theoretically, the quantity of the force of friction being indefinite. General practice gives, for instance, the following correlation of the number of revolutions, the width of the channel, and the radius of rotation (Table XXXVII, European works):

TABLE XXXVII

Number of Revolutions per Minute.	Radius of Rotation in mm.	Width of Channel in mm.
190	90	220
200	85	170–200
210	80	170
220	75	160
220	70	140
240	65	140

We must say, however, that these average values of the elements of the sifter and its motion do not give uniform work as regards quantity as well as quality for each bolting tray. Since each tray operates with products of various sizes, the coefficients of friction of the product against the sieve for each tray are likewise different.

In practice the values given in the table are generally decided upon in accordance with results of the work of the dunst and the flour sieves, where a small number of revolutions causes a choking up of the sifter, *i.e.* the channels become blocked with product, which does not move forward and so chokes the machine. A high speed is also injurious to the work, because the overtails will contain a large amount of floury particles if the product travels rapidly. However, a normal speed of motion of the fine and mealy product corresponds to too great a velocity for the mixture of coarse (break, rebreak, middlings Nos. 1 to 3), and fine products previous to their separation, owing to which the overtails will consist of fine middlings, dunst, and flour. That being the case, Professor Zworykin very justly considers that the sieves grading fine middlings, dunst, and flour should be inclined upwards in the direction this product travels, to reduce the velocity of its motion. Then it would be possible to choose a number of revolutions for the sifter favourable to an efficient sifting both for coarse and fine products. It is to be regretted that this simple idea has not been utilised by any of the works, although its realisation would have imported practically no constructive complications into the sifter.

Bunge's Round Bolter.—Haggenmacher's sifter was succeeded by a round bolter designed by Bunge; the scheme of its construction is as follows (Fig. 328): A cylindrical box consists of separate rings b coupled together by bolts c symmetrically at four points and suspended on three or four reed or steel rods T^1. The box is brought into a gyratory progressive motion by means of a finger i set eccentrically to the shaft h_1. In the box there are fixed round bolting trays a and trays a_3 with conic discs e, having the same function as the cloth in Haggenmacher's sifter. The product flows down the spout d along the axis of the sifter and falls upon the sheet-iron cone D, whence it evenly descends to the sheet-iron cone e_5 with a slighter incline. Over the cone e_5 the product runs to the ring b, where it falls on an open sieve A, which yields the large product as tails and the rest as throughs. The tails, having passed down the axis spout f, drop on the conic bottom C, and is directed to the outlet spout f_1. The throughs pass to the sheet-iron cone e and fall on the sieve B. The further motion of the product is clearly seen in the drawing. The sieves B and C give flour as throughs, which is discharged through spout e_2, and tail over middlings delivered by the spout f_2. Under the sieves there are arranged the brushes K_1 fixed to angle-iron rings k, which are freely set on timber rings a_3, and rest on flat rings o. The brushes are brought into rotary movement by the motion of the sifter, and remove any stock blocking up the meshes of the sieves.

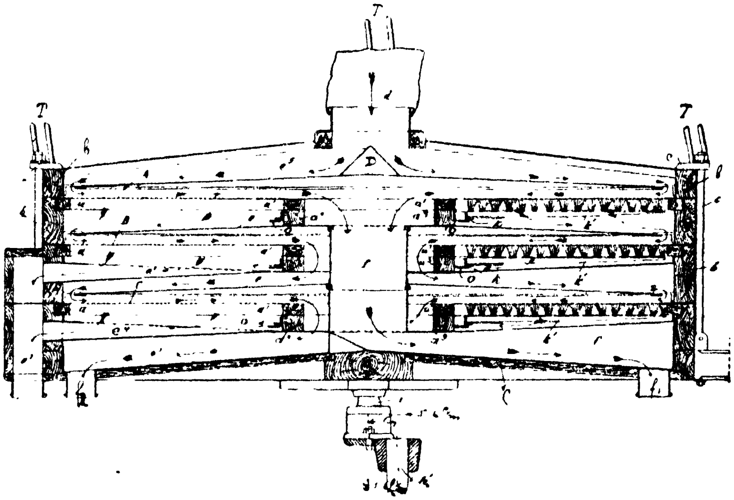


FIG. 328.

An end elevation of Bunge's bolter is given in Fig. 329.

Instead of the conic sheet-iron discs, in the models of a later date horizontal flat discs were recommended, with slats on the outer and inner rings, while American engineers offered spirally disposed combs, as shown in Fig. 330. Here we have a working tray over which the product travels from the axis to the periphery by a spiral route.

Before proceeding to give a comparative estimate of the merits and demerits of the square and round bolters, we must become acquainted with yet another type of sifters.

Konegen's Sifter.—The two-box sifter, built by the Amme-Giesecke and Konegen works, is a modified construction of the two-box sifter first invented by Engineer Konegen, who set himself the problem of giving a balanced motion to the machine. The circumstances favourable in dynamical respect to the work of two-box sifters will be examined below; at the present moment we shall turn to the modern construction of Konegen's sifters.

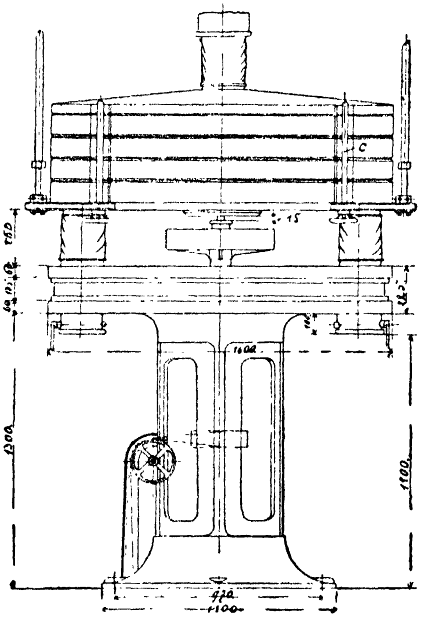


FIG. 329.

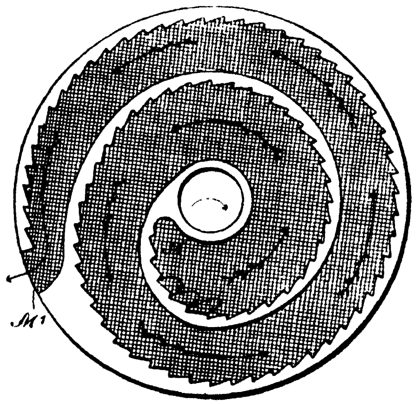


FIG. 330.

According to the way in which the boxes or blocks of the sifters are erected, two types are distinguished: one suspended by means of four cane rods (Fig. 331), and one in which the boxes are supported on four stands (Fig. 332). The manner in which the boxes are hung is their sole difference.

The sifter boxes are built of separate trays. The bottom or collecting tray of the first sifter is screwed on to two rods fixed to the main frame, and the other trays, numbered in corresponding order, are laid upon it.

When the trays of each box are fitted up, they are coupled together by four bolts fixed on joints to brackets bolted to the main frame, which consists of two parallel **H**-iron beams *f*, joined by a third cross-beam. The suspended types have riveting sets for cane rods on their longitudinal beams, while those supported have brackets fixed for the stands. The stands have the following arrangement (Fig. 333): The foundation is a cast-iron box containing a plate of the same metal with a leather

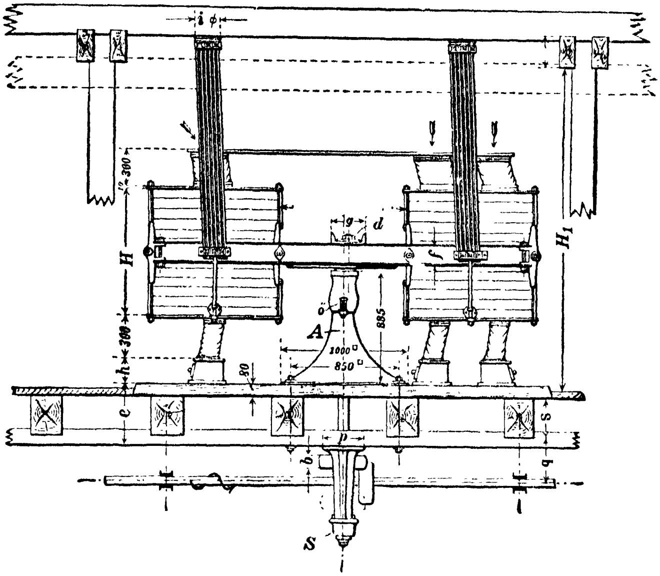


FIG. 331.

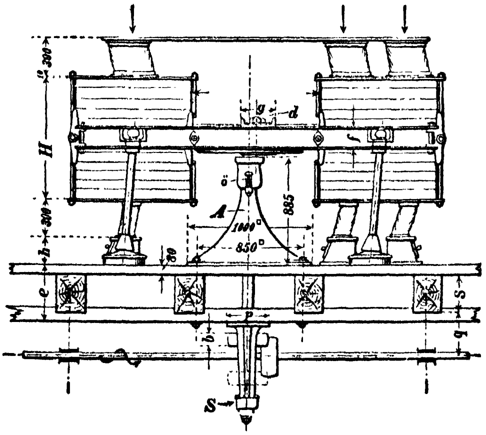


FIG. 332.

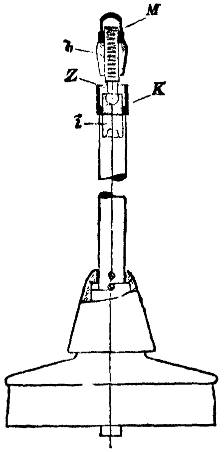


FIG 333.

lining soaked in oil. A cast-iron shoe for the steel stand is set in the plate. The shoe and the plate are covered with a casing. Into the stand there is screwed a bearing *i* for the ball vertical journal *Z*, which is screwed into the bracket *b*, attached to the longitudinal **H**-iron beam. A lubricator *K* is screwed on the bearing *i*, and a cap *M* on the vertical journal *Z* to give the stand a more elegant appearance.

The footstep *S* for the shaft transmitting the motion is set in a drop-hanger frame, and its bearing in the frame a_1. The shaft *W* is joined to the fly-wheel, which has a counterbalance, by means of the hub *h* of the fly-wheel, screwed on the threaded part of the shaft. For lubrication there is the cup *o*, out of which the oil runs into the bearing (Fig. 334). The cup *o* is supplied with oil from the outside.

On Fig. 335 is shown the balance-wheel from the top. Between the adjustable weights *w*, serving for additional regulation, there is a box filled with lead. The finger *k* of the balance-wheel enters into the adjustable bearing enclosed in the cast-iron frame, which is fixed between longitudinal **H**-iron beams. With the aid of bolts *b* the hub of the bearing may be adjusted to set it correctly when erecting to alter the degree of eccentricity. A perspective view of the Konegen sifter is shown in Fig. 336.

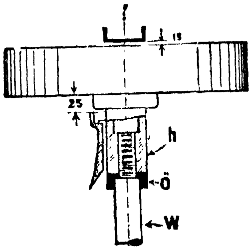


Fig. 334.

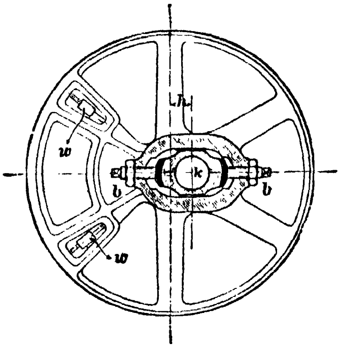


Fig. 335.

A Two-box Sifter by "Seck Bros." Works.—The plansifter shown in Figs. 337 and 338 is a model of a two-box balanced sifter of the newest type. The left- and right-hand side boxes are joined by a timber frame of joists in a square section. The frame coupled together between the boxes by two-angle channel irons forms the base of the sifter. On the one side of this frame on the stands *e* and supports, rest both the boxes of the sifter, which are a series of sieve trays arranged in stories, and coupled together by rods *h*, fastened with one end to the frame; on the other side the frame couples in with the fly-wheel *e* and the shaft *b*, which impart a gyratory motion to the sifter.

We shall first direct our attention to the dismantling of the boxes and the erection of the sifter. The rods *h* are fastened by joints to the frame. The top ends of the rods entering into the slots of the cast-iron

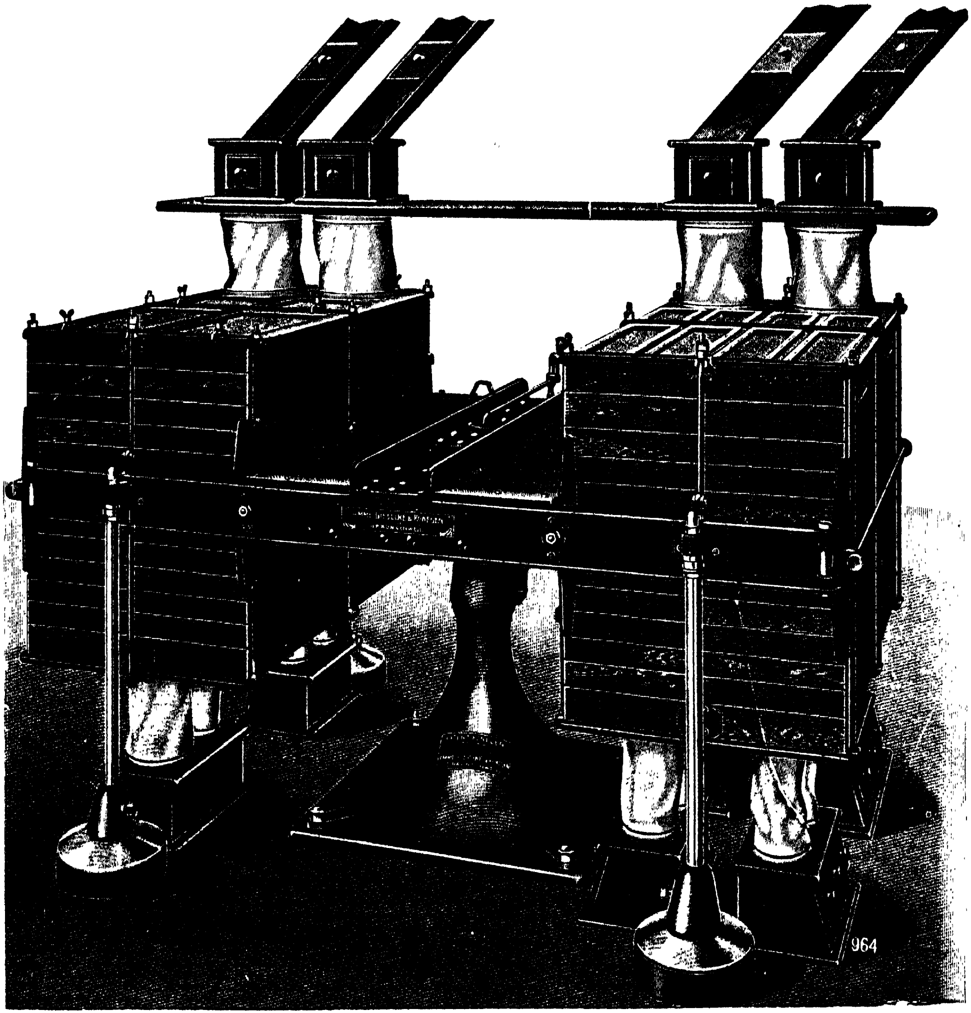


FIG 336.

cross-bars over the boxes have a screw thread, and with the aid of nuts allow the frame of the sifter to be tightened. When the sifter is to be taken apart the nuts are loosened, the rods turned down, and the cross-bars removed, then the bolting trays are taken off one after the other. The bolting trays from the lower part of the box are removed downwards after the rods have been loosened.

As mentioned above, the whole mass of the sifter is supported on four stands. The stand is an iron rod *e* (Fig. 338), which carries a

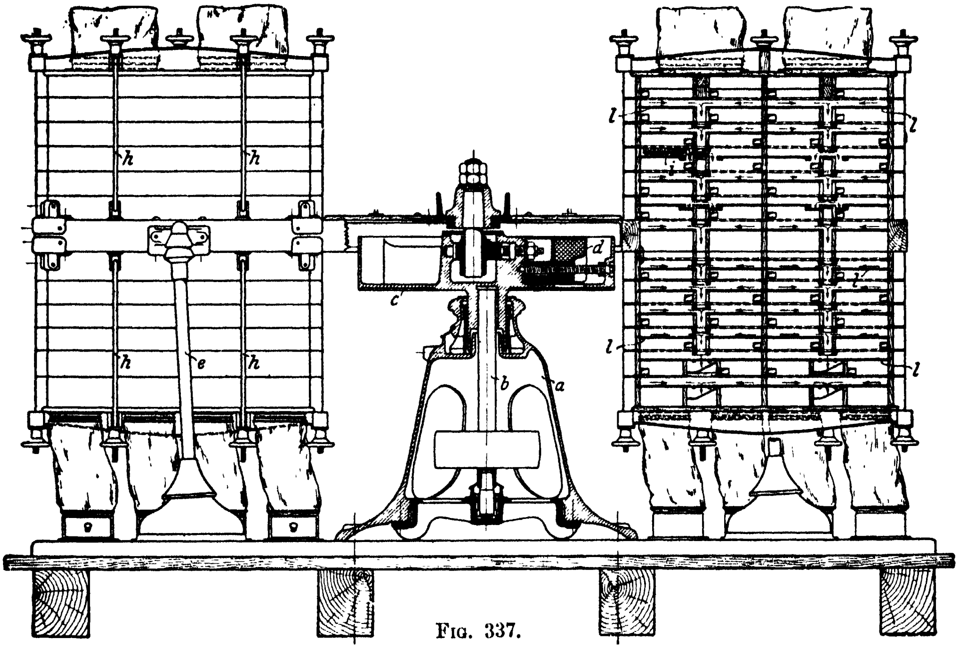


Fig. 337.

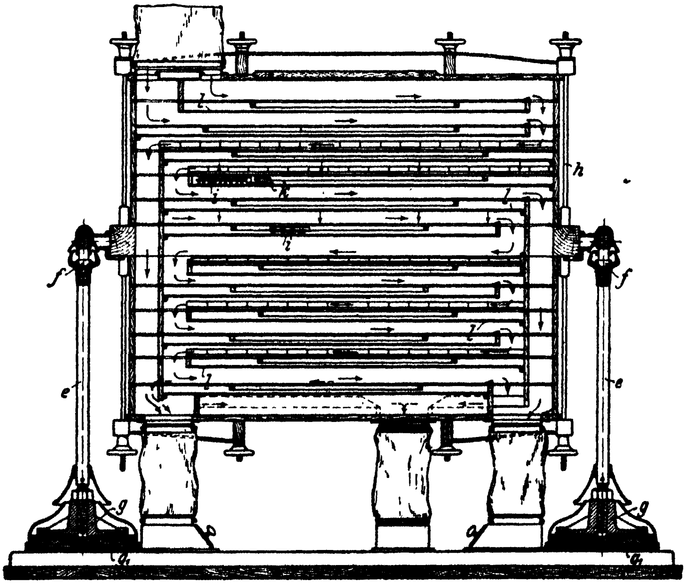


Fig. 338.

ball bearing at its upper end, and a buffer vertical journal g resting on a flat bearing g_1 at the other end. Between the buffer and the bearing a piece of leather is placed to lessen shock. The ball vertical journals fixed to the frame of the sifter rest on the footsteps *f*, and in this manner the sifter is supported on rods *e*. The rods *e* being always set aslant in respect to the vertical axis of the sifter, it is evident that the horizontal component of the weight of the sifter is communicated by pressure on the shaft *b*.

Since the rods constitute one of the most essential details of a sifter, two other types of rods evolved by Seck should be described, and more minutely.

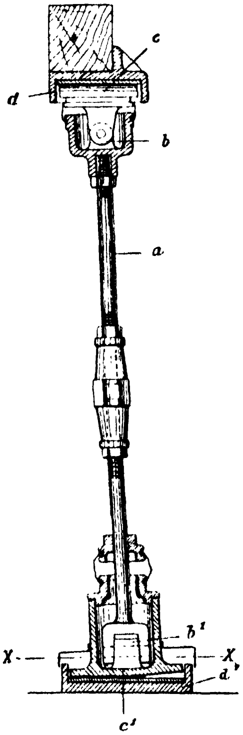


FIG. 339.

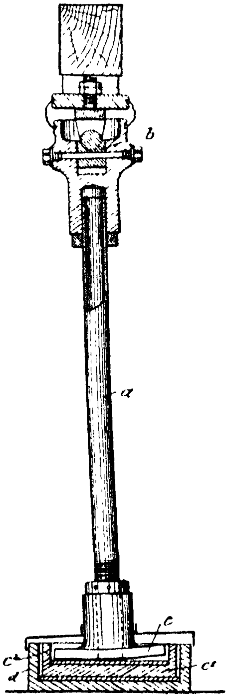


FIG. 340.

Fig. 339 illustrates a rod built of two parts connected by a two-twist nut which affords the possibility of adjusting the length of the rod.

The stem *a* is connected by joints *b* and b^1 with boxes *c* and c^1, which roll over the bearing surfaces *d* and d^1. One of the surfaces (the top one) is fixed to the frame of the bolting machine, the other lies on the ground. In the drawing we may see that the journals of the joints are turned at an angle of 90° in respect to each other.

Each one of the boxes on the side next to the support is cylindrical in shape, and the axis coincides, or nearly coincides, with the axis of the journal of the joint lying opposite. The box freely swings to either side as far as is necessary for the circular motion of the sieve.

To prevent the sieve when operating from running out of the limits of the motion required, the bearing surfaces of the boxes towards their rims are bound by planes tangent to the cylindric surfaces of the boxes.

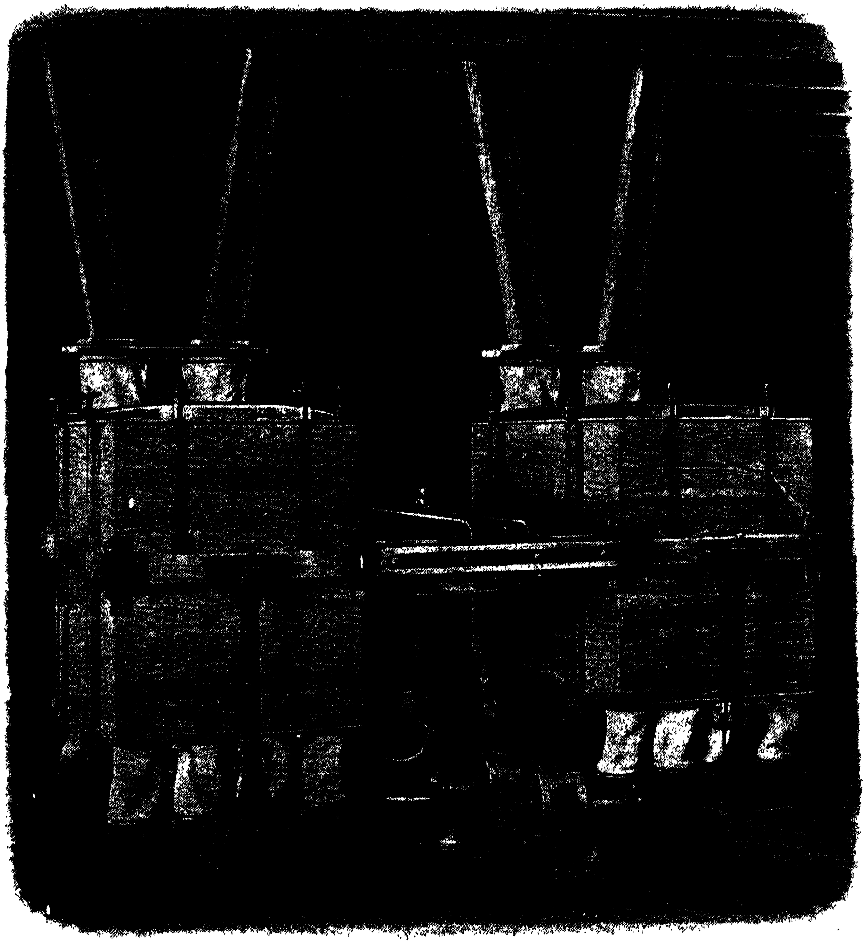


FIG. 341.

Fig. 340 illustrates the second type of support. Here, different from the preceding case, the boxes with the mutually perpendicular planes of swinging are transferred to one end of the prop in such a way that the top one swings over the back of the one below. Thus, both the boxes form the bottom joint, which at the same time keeps the swinging rod from turning over.

The top end of the rod is connected with the box of the bolting machine by means of an ordinary universal (Hooke's) joint.

The upper box *c* rests on the flat back of the box c^1, which has its plane of swinging turned at an angle of 90°. The lower box lies loose in the box *d*, and on its back has flanges c_2, serving to direct the box *c*.

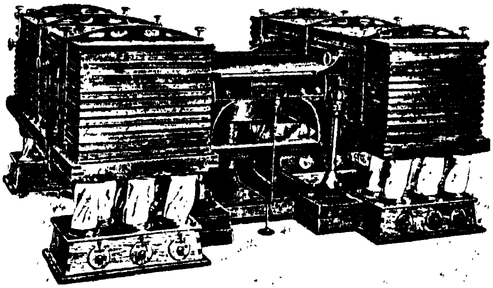


Fig. 342.

The sifter is brought into motion in the following manner: the shaft *b* with a driving pulley, set in a bearing, is brought into rotary motion. The upper end of the shaft *b* being coupled by a pin with the hub of the balance-wheel *c*, the latter is likewise set rotating. This fly-wheel has a ball bearing with an adjusting device, disposed eccentrically to the axis of the fly-wheel. In the fly-wheel there is a counterweight *d* which may be transposed by means of a screw. The hub of the fly-wheel, serving as journal during the rotation of the fly-wheel at the same time, is set in the bearing of the frame *a*, which is also coupled

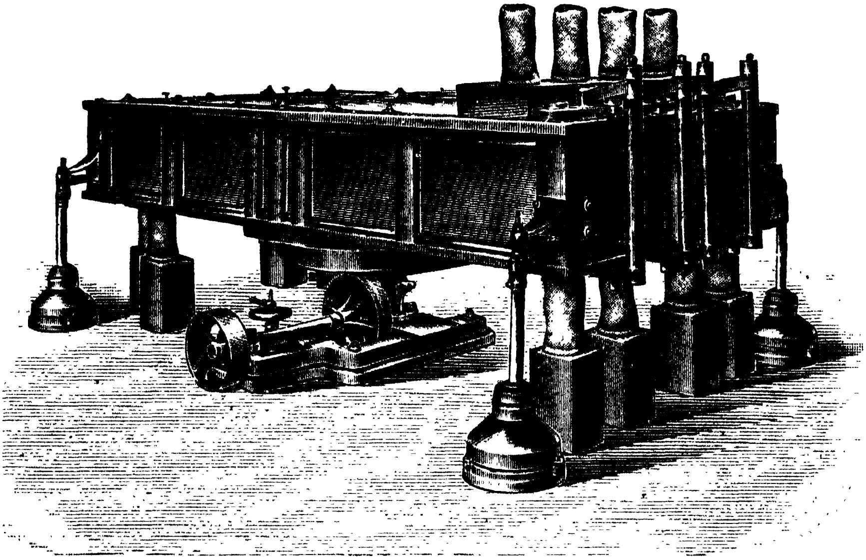


Fig. 343.

with a cross-head carrying the footstep bearing of the shaft *b*. The sifter runs at the rate of 190 to 200 revolutions per minute.

The number of sieves is twelve ; the travel of the product is shown clearly enough. The cleaning of the sieves is performed by means of brushes, which act in the manner described on p. 352, Fig. 326. A perspective view of the Seck Bros. sifter is shown on Fig. 341.

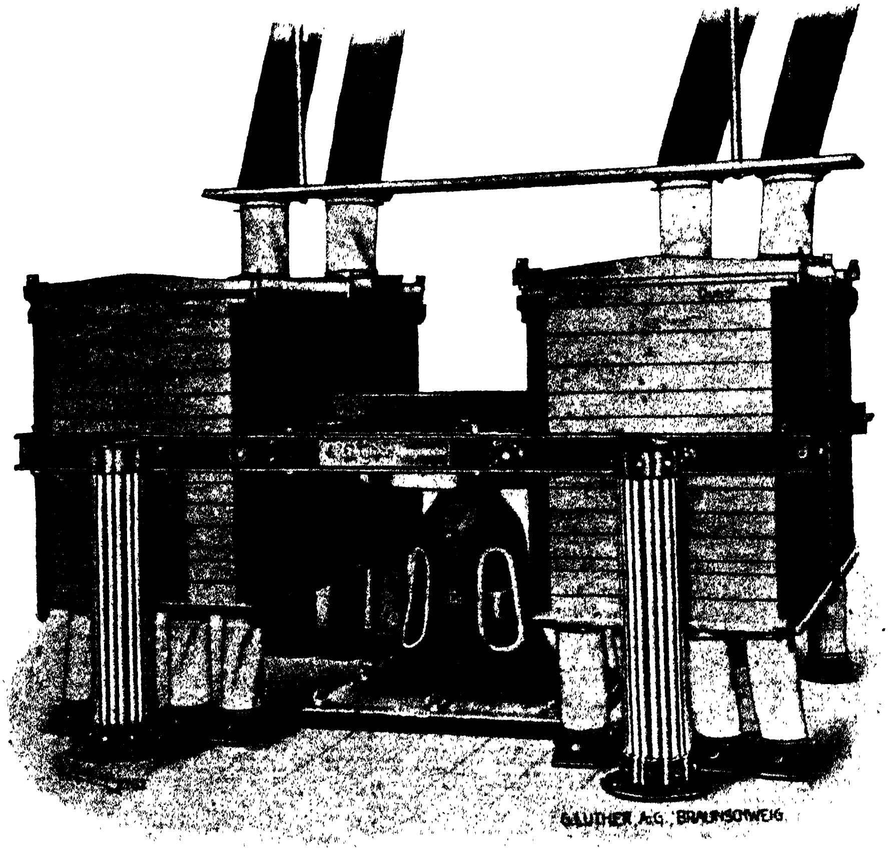


Fig. 344.

After Konegen's sifters were put on the market, two-box sifters were also constructed by other makers.

The mounting of two-box sifters is the same at almost all European works. The mounting by G. Daverio's works differs to a more or less extent, the perimeter of the supports of their rods lying between the boxes. A perspective view of G. Daverio's sifter is given in Fig. 342. Fig. 343 represents Dobrovy and Nabholtz's one-box sifter with a friction drive and four exterior conveyers for the shakers. Fig. 344 represents G. Luther's two-box sifter on cane supports.

3. *Dynamics of Plansifters*

Before passing to a further description of the construction of sifters, it is necessary to mention several considerations concerning favourable conditions of motion for sifters of different types.

We are given a single-box sifter (Fig. 345), the motion of which generates a centrifugal force of every point of it round its axis of rotation. The centrifugal forces of each point of the sifter being parallel at any particular moment of the motion, they may be summed up after the law of parallel forces, and give us the resultant F applied in the centre of gravity O of the sifter. The force F gives the moment Fa in respect to the plane, which is perpendicular to the axis of the bearing c_2. To prevent any fracture of the shaft in the bearing c_2 or excessive thickening of it, it is necessary to set a counterweight on the shaft, which would give an equal and directly opposite moment in respect to the same plane of the bearing c_2. The counterweight is generally made in the shape of a balance-wheel with stationary and adjustable weights, as we have seen in the construction of Konegen's sifter or that of Seck.

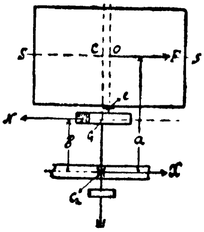


FIG. 345.

Thus, if the weight in the balance-wheel gives a centrifugal force N, when rotating, then the condition from which this force is defined will be :

$$Fa = Nb, \text{ whence we define } N = F\frac{a}{b}.$$

But since $a > b$, the centrifugal force N of the balance-wheel must be greater than the centrifugal force F of the sifter.

Having fitted the counterweight, we obtain two forces, F and N, which have a tendency to turn the axis of rotation cc_2 about the horizontal axis. From turning to the right, the position of the forces being as given, the axis of rotation is kept by the reaction X of the bearing. The value of X will be defined, if we take the moments of all the active forces in respect to the point c ;

$$Xa = N(a - b).$$

Having $N = F\frac{a}{b}$ and on defining X from the preceding equation through F, we obtain :

$$X = F\,\frac{(a-b)}{b} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

The force X, with such a construction of counterbalancing the centrifugal force of the sifter, will always be present. Its direction alters with the motion of the sifter for each position, which imparts great vibration to the building. Besides that, sifters of this type, producing a very considerable moment of force F of the point c_1, require a driving journal of large size, which owing to the great pressure of the journal upon the bearing e leads to a rapid wear of its bush.

Taking all that into consideration, it became necessary to invent a method of balancing the centrifugal forces of the sifter, where X would be equal to nought. Since X will be equal to nought if $a=b$, Engineer Konegen, taking these considerations as basis, offered the construction of a two-box sifter, shown diagrammatically in Fig. 346. In this drawing we see that $a=b$ when the centre of gravity of the sifter boxes and the counterweight of the balance-wheel lie in one horizontal plane.

Machines made in accordance with Konegen's diagram give a perfectly well-balanced run and do not require a journal of so great a size as the one employed in Haggenmacher's arrangement.

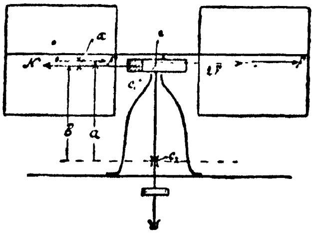


FIG. 346.

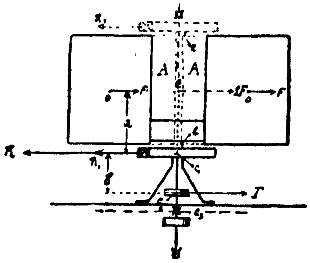


FIG. 347.

An unsound idea for a two-box sifter is suggested by Bühler's works in Uzwil, which places the fly-wheel with a counterweight lower than the boxes (Fig. 347). But by setting a second fly-wheel with an inverse counterweight at c_2, it attains the annulment of the injurious force X. For defining the centrifugal forces R and T of these two fly-wheels, the a and b given, *i.e.* with position of the fly-wheels to be found, we have:

$$R=2F+T \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

And taking the moments $2F$ and T in respect to the point c_1, we obtain:

$$2Fa=Tb \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

Out of (3) we define $T=\frac{2Fa}{b}$, and out of (2) we obtain $R=\frac{2F(a+b)}{b}$.

The same plan for cancelling the force X might be adapted to the single-box sifter, and it has been done by American engineers before

Bühler, as we shall see below. The necessity of making the journal excessively large, owing to the heavy pressure on it (the moment $2Fa$ is very great), does not allow Bühler's works to construct sifters with a large number of trays, as in sifters of Konegen's type. Therefore the largest number of trays in these sifters does not exceed seven.

As it was mentioned just now, the idea of balancing the Bühler sifter has been borrowed from the Americans, but it turned out just as badly as the borrowing of the idea of the two-box sifter from Konegen. The American engineers place the second fly-wheel (Fig. 347) higher than the box of the sifter, and balance the pressure caused by the centrifugal force $2F$ on two fingers *e*. Such an arrangement of the balance-wheels gives their centrifugal forces $R_1 = F$ and $2F$ in the total, whereas in Bühler's

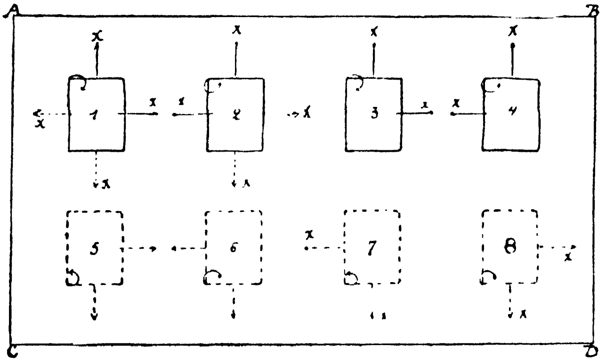


FIG. 348.

diagram R is always larger than $2F$, and is equal to $2F$ only when b is infinitely large, which is, of course, impossible.

In drawing an inference from the above considerations, we must agree that the best, perfectly balanced makes of sifters are shown in the two-box diagram of the type illustrated in Fig. 346, after which comes the American diagram in Fig. 347, which allows the spaces A to be utilised, wasted by Bühler, owing to the idea of Konegen's two-box sifter being misunderstood.

The use of the single-box sifters (Fig. 345) can be justified only by their extreme cheapness, because these sifters shake the mill buildings greatly, when disposed in the manner accepted by our builders.

These machines being still erected in mills, it is necessary to point out the best way of erecting them in the buildings.

The sifters are generally arranged lengthways by the plan of the floor which is necessitated by the longitudinal disposition of the roller mills (Fig. 348). To reduce the vibration of the mill by the forces X, there must be an even number of sifters. In our diagram there are four, and they run in pairs to the right and to the left. But this to a certain extent involves a longitudinal vibration of the mill, since the forces X longitudinally disposed in opposite directions at the moment of the greatest longitudinal declination of the sifters cause the contraction or extension of the floor, the resistancy of which is sufficiently great.

At the moment of the greatest transversal deflection of the sifters the forces X act in one direction and tend to upset the building. If the run of the sifters is so set that the sifters 1 and 2 give the greatest declension to the wall CD, and the sifters 3 and 4 to the wall AB, a moment of forces $2X$, twisting the building, is obtained. It is possible to plant four sifters so that the forces X of the transversal direction would also give alternately a contraction and an extension of the floor. That would be possible with a great number of sifters. However, even if this were successfully done, once started, the sifters would soon be thrown off their run, for the unequal slipping of the belts on all the sifters alters the number of revolutions. Hence the shocks imparted to the building are unequal in force, and attain the widest limits after unequal periods of time.

The only means of combating the vibration of the mill building, which leads to frequent repairs, and even to its ruin, is to throw out the single-box non-balanced sifters and replace them by two-box ones.

Another phenomenon when the run of the sifter loses its evenness, is called " wandering." The wandering generally takes place at the starting of the sifter, and when it has once begun it may gain in power until the stands or the drop-hanger frames of the sifter break. This phenomenon has its origin in the fact that the sifter being started, the force of friction of the pin in the bearing tends to turn the box round the axis of the pin in the direction opposite to the rotation of the finger.

To make that clear (Fig. 349), we shall take the points where the supports or the suspension rods are fixed, 1 (left-hand side) and 2 (right-hand side). With the normal motion of the sifter the point 1 or 2 must travel in the circle K. But if the sifter has a tendency to turn round the axis of the finger in a circle M, the point passes into position 1^1, so that its trajectory of motion acquires an elliptic form L. At the same time the point 2 moves to point 2^1 and gives a trajectory L^1—a compressed circle. The nearer to the axis of the finger, the less is the deflection from the circular motion, and the point 3, being in contact with the finger, has no deflection from the normal circular motion K. Hence it is clear that in the stands or drop-hangers 1–1 the wandering causes an extending deformation and a contracting deformation in the stands 2–2. And if the forces causing the tensions are sufficiently great they may lead to breakage.

To avoid this constructive defect some of the works suggest various means of communicating a rigidness to the system joining the supports and the boxes of the sifters.

Since it is necessary that the supports should be parallel during the operation of the sifters, attempts are made to hold them in that position by supplementary kinematic junctions.

One such device is shown on Fig. 350. The two-box sifter illustrated is set on four supports *a* of an ordinary construction. On the foundation frame *v* there is set a shaft *b* which can rotate in bearings *r*. At the ends of the shaft are set rods c^1 and c^2, the ends of which, 3 and 4, are connected by Hooke's joints or a spherical journal with rods $d^1 d^2$ attached likewise with joints to the frame of the sifter at the points 1 and 2. It is quite evident that the supplementary stands make the frame more rigid, and form no obstacle to the gyratory progressive motion of the sifter. In this system the shaft *b* could have been placed on the lower part of the box, and then the kinematic junction *b–c–d* would be reversed in respect to the plan given. These supplementary junctions may be also fixed to suspended sifters.

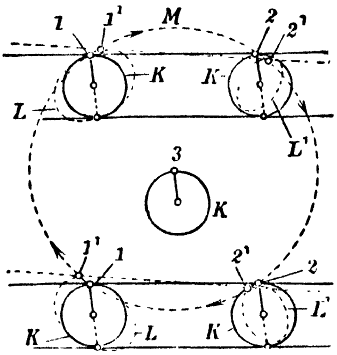


Fig. 349.

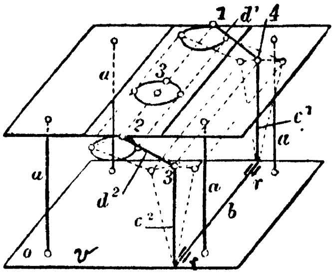


Fig. 350.

Another construction of the junctions is illustrated in Fig. 351. The top ends of the system c^1–b–c^2 here have circular discs f^1–f^2, which glide between two guide-plates g^1–g^2 attached to the boxes of the sifter. The system c^1–b–c^2 being perfectly rigid, the centre line of the discs is always parallel to the shaft *b*. When the sifter is in rotation the discs will be running up and down, to the right and to the left (components of motion), therefore wandering is here impossible.

A third method (Fig. 352) gives the system n^1–b–n^2, the ends of the levers h^1 and n^2 being joined fast to the foundation supports a^1 and a^2. A detail of these junctions is to be seen in Fig. 353.

A variation of the third method, where the diagonally set stands are joined and not the side ones, is shown on Fig. 354.

Of all the systems examined, only the second prevents wandering (Fig. 351). The two other systems do not give absolute regularity, and they therefore should be displaced in the models offered by some of the European works, which are mostly variations of the second method (Bühler Bros. and Kapler).

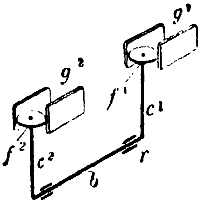


FIG. 351.

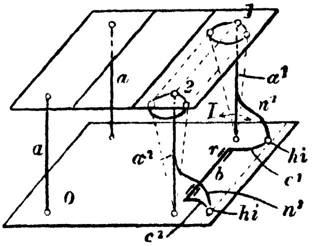


FIG. 352.

The problem of preventing the tendency to wander has been perfectly, correctly, and expediently, from the constructive point of view, solved by the American works and by Thos. Robinson's works in England.

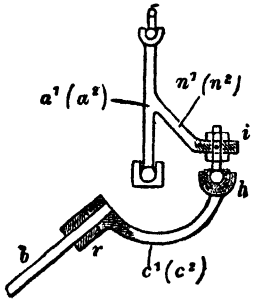


FIG. 353.

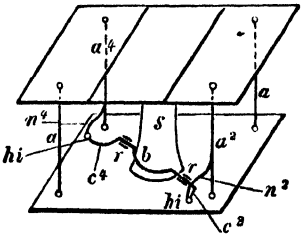


FIG. 354.

We shall first examine the American method.

Fig. 355 illustrates the transmission of motion to the box of the sifter evolved by the I. Schultz O'Neile Co. of Minneapolis. The toothed gearing to the shaft 4 is set in the main frame, to which a cross-head 7 is bolted. On the cross-head there are set adjustable bearings, a detail of which is shown on *C*, for two rods 14 with rolls 15 freely set on them. These rolls enter into the guiding cross-head and slippers 17 bolted to the frame. The shaft 4 is joined fast to the cross-head 24, into which the driving pin set in the lower part of the sifter box enters. To the same cross-head, with bolts *O* having a spring thrust, is attached a counter-weight 25, which may be brought closer or farther with the aid of nuts *a*. When the sifter is set in motion, its box performs a gyratory progressive motion, which is composed of the motion of the rolls to the right and to the left, and of that of the guiding slippers 17 backwards and forwards.

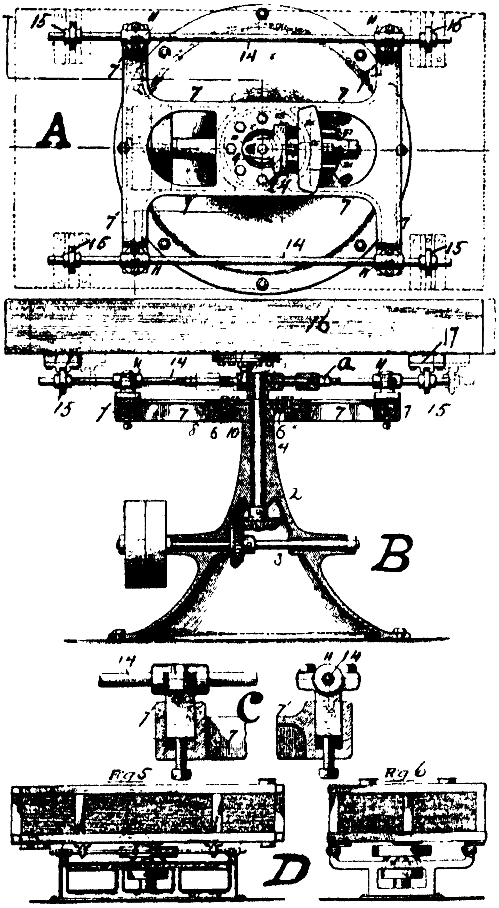


FIG. 355.

Fig. *D* shows the construction for large sifters. In this wise, here we find adapted the principle examined in Fig. 351.

It is difficult to judge of the rigidity of this machine or of its efficiency, since the sifters have made their appearance on the market but lately.

The problem of obviating any wandering was solved in the most expedient manner by the American engineers, who first suggested adapting two driving pins.

Figs. 356 and 357 illustrate the method of transmitting the motion to A. Wolf's sifter, eliminating all possibility of wandering. The box of the sifter is supported on four stands *B*. The driving pins *f* of the fly-wheels freely enter into the hubs *d*, which are adjusted by means of bolts d^1. The balance-wheels *F* with the counterweights are brought into rotation from the belt-pulley *S* with the aid of toothed gears h-h^1. To impart a greater smoothness to the run a belt *g* is set on the fly-wheels *F*. In this construction the turning of the sifter round its axis, *i.e.* the wandering motion, is impossible.

Of the European works, that of Thos. Robinson in England constructs the transmission of motion on the same principle, *i.e.* with the aid of two cranks. On Fig. 358 we have a diagrammatic illustration of the transmission in Th. Robinson's two-box sifter of the latest type. The boxes *A* are joined together by **H**-irons 1. The cranks 4 are fixed in plates 5 joined to the **H**-irons and cross-bars 6. The balance-wheels 2 with counterweights are brought into motion by one common belt 3, running over the driving pulley *S* and the jockeys 7–7^1. The jockey 7

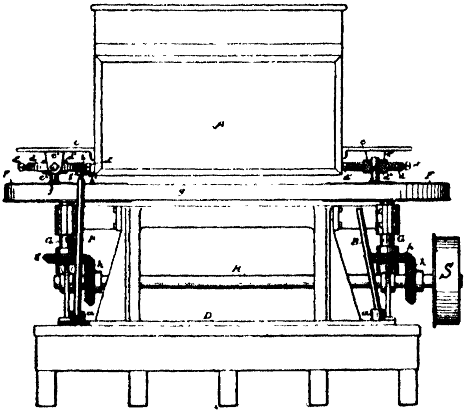


Fig. 356.

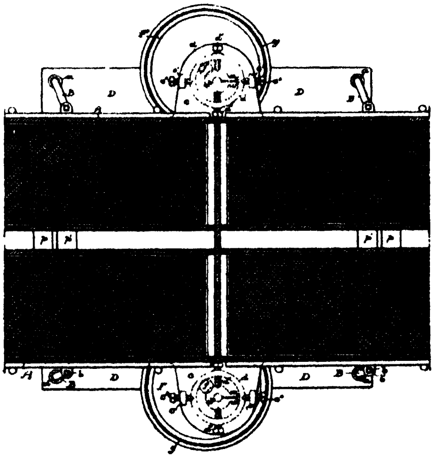


Fig. 357.

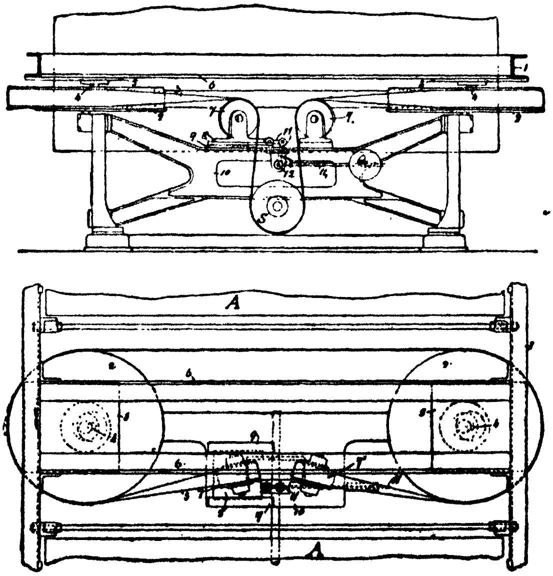


Fig. 358.

at the same time serves as a belt tightener. The frame of the bearing holding this jockey is set in the guiding cross-head and slippers and joined by lever-joints 11–12–11_1, the last of which has an adjustable weight *Q*. By moving it to the right or to the left, we may slacken or tighten the belt. A perspective view of the sifter is shown in Fig. 359.

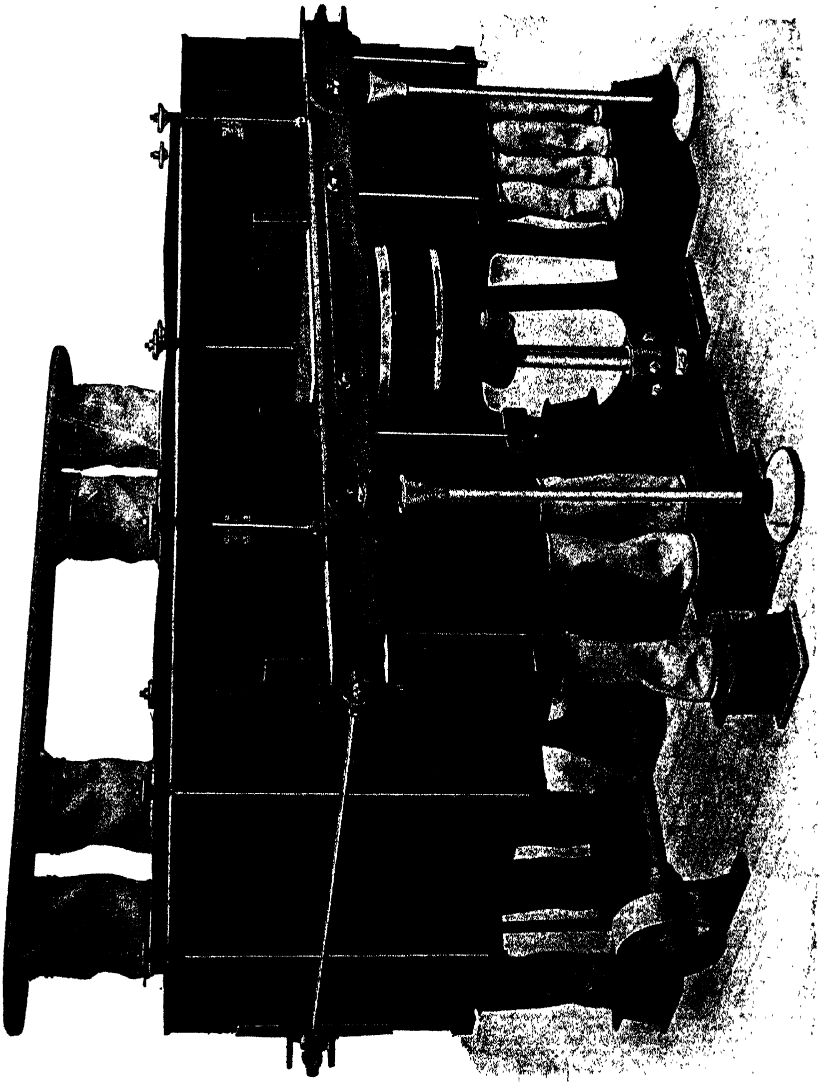


Fig 359.

The drive evolved by Thos. Robinson is decidedly superior to that of A. Wolf, as it discards the rigid and uneconomical tooth gearing. But Wolf's drive is better in so far that each balance-wheel has an independent gearing. However, both the drives should be absolutely accurate. In Th. Robinson's drive there must be a great accuracy in the equality of diameters of the fly-wheels, otherwise, even with the difference of 1 mm. in the diameters, the belt will acquire a strong slipping motion on the smaller pulley, which will cause a rapid wear of the belt.

In our opinion Robinson's construction might be improved by throwing the belt off one of the pulleys and connecting the driving cranks by a coupling rod. In this way even a considerable difference in diameters of the fly-wheels would be of no consequence.

Thus, making an estimate of the types of sifters from the point of view of dynamics, we must give preference to two-box sifters, to such types besides, which have the balance-wheel with the counterweight set between the boxes, and the distance between the horizontal planes of the centre of gravity of the sifter and of the balance-wheel equal to nought or very small.

In selecting sifters with mechanisms preventing wandering, those should be chosen where this is effected by means of two driving cranks which absolutely prevents running off.

4. *American Sifters*

In the development of sifter construction, just as in the building of roller mills, the Americans chose a route totally different to that of the Europeans. A characteristic peculiarity of their sifters is the inclined, zigzag-shaped arrangement of the sieves. Having observed the inequilibrium of motion in the single-box sifters with one counterweight, the American engineers were the first to solve the problem of equilibrium. The first (A. Wolf's) type, designed to obviate the running off of the sifter during operation, also belongs to the Americans.

These considerations, as well as the ignorance not only of the Russian but of the European technicians too, of the constructions of American sifters,[1] induced us to devote a separate chapter to them.

Noye's Zigzag Sifter.—Figs. 360 and 361 show us the longitudinal section and the perspective view of Noye's sifter. The box of the sifter consists of two divisions for sieves, between which there passes the driving crank-shaft *v* carrying two hand-wheels with counterweights *q*. These counterweights may be moved closer to or further from the axis of rotation by means of a screw *r*. The lower hand-wheel is cast in one

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[1] Only in Pappenheim's work is there a general description of the sifter built by the works of Nordyke & Marmon Co.

piece with the driving belt-pulley *s*. The shaft rests on the step-bearing *t* and is held in a vertical position by two bearings *o* set in the cross-bars of the frame *A*. The bearing *p* driven by a crank shaft is fixed in the bottom of the sifter box, which is suspended on four rods *a* with ball bearings. The product is fed in through *S* and falls on the sieve 1, which delivers its overtails (break semolina, middlings, or bran) through the spout s_1, while the throughs drop on to the cloth 1_1, which passes it to the sieve 2. The sieve 2 has the large tailings discharged from the sifter and passes the throughs to the sieve 3, which, together with the tails of the sieve 4, carries the product to the last sieve 5. The throughs from the sieve 4 are sent out of the sifter by the cloth 4_1 together with the throughs of the sieve 5 by means of the cloths 5_1. Thus the sieves 3, 4, and 5 yield flour as throughs into the spout *I*, the sieve 5 in its lower part gives dunst as throughs to the spout *II*, the sieve 1 large tailings into spout *III*, and the sieves 2, 5, and the cloth 6_1 tailings of mixed middlings into the spout *IV*.

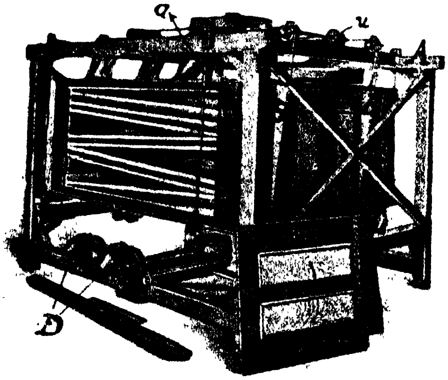

FIG. 360.

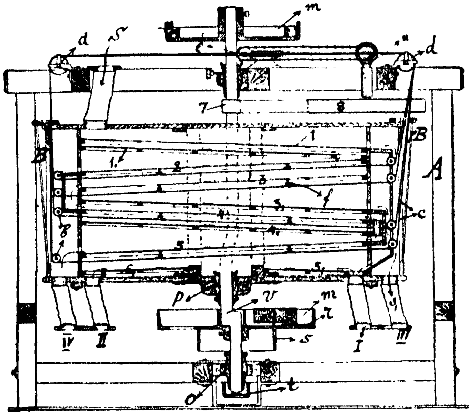

FIG. 361.

The cleaning of the sieves is performed by brushes brought into operation by a rather complicated device. On the wires *c* thrown across the guides *b*, there are fixed the brushes *f*, which run under the sieve forwards and backwards. The wire tracking *c* after the guides *b*, doubling over the idlers *d*, all join together at *c* with the chain of the gearing, which is brought into operation from the shaft *v* by the pulleys 7-8 and by the conic toothed gear *n*. To prevent the flour from escaping, the openings in the box for wire tracking are covered with casings *B*. For guiding the driving belt there are the loose pulleys D.

Nordyke & Marmon Co.'s Sifters. — The balanced two-box sifter from the Nordyke & Marmon Co. works, with a zigzag arrangement of the sieves, is shown in Figs. 362 and 363. The boxes *A* are joined to their foundation frames by cast-iron parallel guides *I* and cross-heads *T*, in which the bearings of the driving shaft *V* are fixed. The boxes are suspended on four cane rods *E* : *M* is the driving belt pulley, *O* the guiding loose belt-pulleys, which are fixed on brackets *Q* adjusted by means of screws *G*. Above and below the boxes there are counterweights *S* set on the shaft *V*: *H* and *R* are the oil boxes feeding the top and the bottom belt-pulleys. The rods are fixed to the thick ceiling board *J*, set across the ceiling beams *K*.

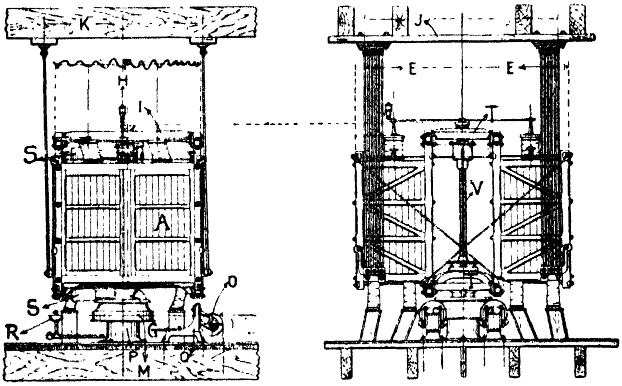

FIG. 362.

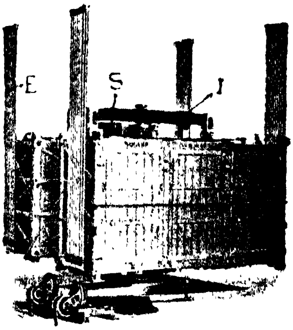

FIG. 363.

A longitudinal section of the sifter box is given in Fig. 364. The bolting trays 1, 2, 3, 4, and 5 are arranged in zigzag manner with different inclines according to the size of the product, the greater incline corresponding to the first sieve, which bolts the coarser product. Owing to the different inclination of the sieves, we obtain correspondingly different velocities of motion of the product treated. This very important condition of an even sifting of the coarse and fine product is not taken into consideration by European engineers. For feeding the throughs to the following sieves there are the inclined timber plates 1_1, 2_1 ,3_1, 4_1 and 5_1. The sieves are cleaned by means of brushes *a*.

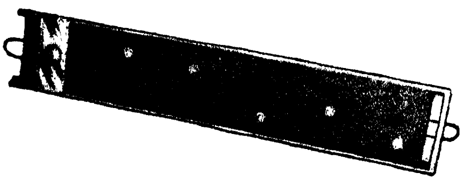

FIG. 364.

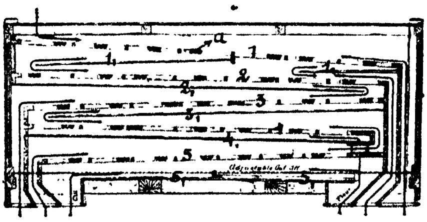

FIG. 365.

Into the box of the sifter, through the side, are inserted the bolting trays, the perspective view of which is illustrated in Fig. 365, and in section in Fig. 366, where it may be seen that each tray is clothed with a working sieve on the upper side, and an open wire tissue for the brushes from below. The tray is divided by transversal timber cross-pieces *a* to limit the area of operation of the brushes and to prevent their meeting.

An ordinary arrangement of counterweights is shown in Fig. 367 (the bottom counterweight), which likewise gives an idea of the transmission of motion to the boxes. The cast-iron belt-pulley has a large hub *B* in which there is an adjustable bearing *A* for the shaft. This bearing is adjusted by means of a set screw on one side and a tension spring *D*. The counterweight *E* can be moved in the guiding parallels by turning the set screw *F*. In the counterweight there are cylindric holes, in which in case of need the supplementary weights *G* are put, and fixed from below by bolts passing through holes in them.

Fig. 366.

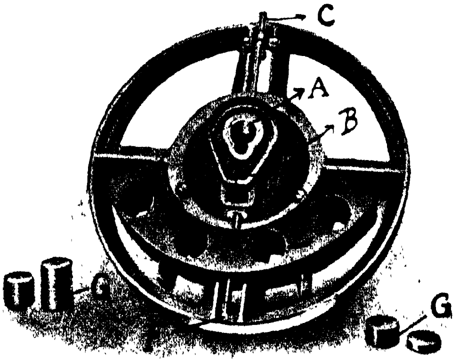

Fig. 367.

Sifters made at Wolf's Works.—We have already partly become acquainted with one of the makes of Wolf's sifters. Figs. 368 and 369 represent a longitudinal and a cross-section of one half of the sifter, operating for two products. In this sifter, as almost in all American types, the sieves are set in a zigzag line. The sieves are placed into the box from the side, and held by means of cast-iron planks *a* fastened by thumb-screws *b*. The motion is communicated to the sifter, as we have seen earlier (p. 372, Fig. 358), by means of two driving cranks and balance-wheels with counterweights brought into rotation by conic toothed gears. The number of bolting trays, five, is the same as in the preceding construction, with a similar flow of the product.

This sifter does not wander, but its run is not balanced, therefore the vibration (force X, p. 366, Fig. 347) of the shafts v, communicated to the floor through the bearings d, tends to shake the mill.

A section of Wolf's balanced sifter is shown in Fig. 370, and its different parts and disposition of sieves are shown in Figs. 371, 372, and 373. The drawing of Fig. 370 shows us that the counterweight Q is set inside the box A, so that its centre of gravity lies in the plane of the centre of gravity of the box. The crank-shaft is not made in one whole piece, but consists of two parts, v and v_1, connected by joints at o. The top part of the shaft rotates in ball and socket bearings of the cross-heads b connected with the box of the sifter as shown in Fig. 372. Owing to a special construction of the junction at o, the sifter can fluctuate in the inclined plane, passing from position 1–1 to 2–2. Let us examine more minutely the driving mechanism shown in Fig. 371.

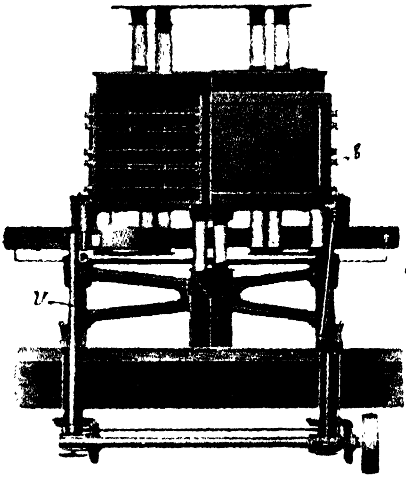

Fig. 368.

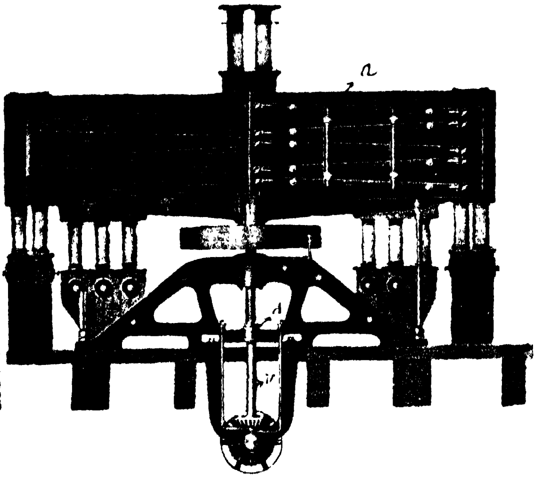

Fig. 369.

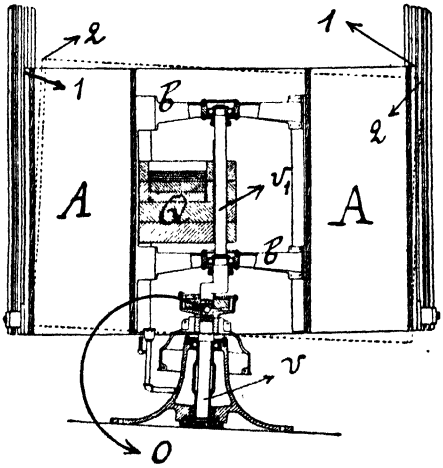

Fig. 370.

The lower part of the shaft v is set on a ball-collar thrust bearing a and held in a vertical position by two ball bearings c. On the top part of the shaft v there is set a split belt-pulley S on the hub P of the cup T. The upper crank part of the shaft v_1 has at its lower end a cavity for the finger of the ball bearing *o*, which enters into the steel shoe of the top end of the shaft *v*. The inner arms of the cup *T* and the cross-head *m* fixed to the end of the shaft v_1 form a cross-head coupling of the shafts *v* and v_1, resembling the junction of driving irons in stone mills, owing to which the rotation of *v* is communicated to v_1, and consequently to the sifter. The shaft v_1 is also held in two ball and socket bearings. The counterweight *Q* is bolted to the shaft by bolts *n* : such fixing of the counterweight allows of easily raising or dropping it when necessary. By means of cross-heads *b* and set squares *d* the whole system is coupled with the box of the sifter. This balancing arrangement totally obviates the possibility of vibration, since the centrifugal forces of the sifter box and the counterweight run in one plane.

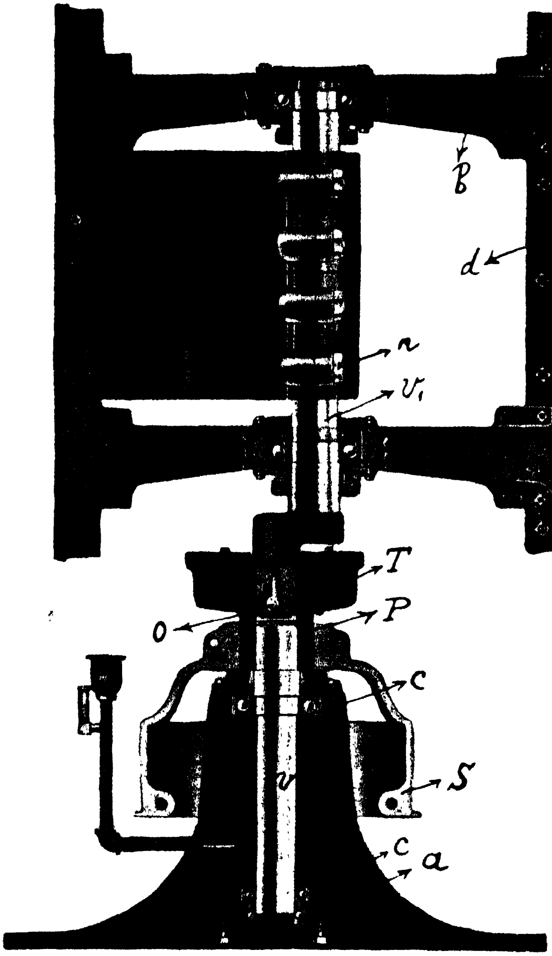

FIG. 371.

In Fig. 372 is shown a horizontal section of the sifter box above the counterweight. The sifter can bolt four or eight distinct products; in the latter case the sifter is divided into two floors.

The box is suspended on brackets *k* for the cane rods. The wire sieves are cleaned by means of heavy tappers *t*, and the silk ones by thin steel chains *p* attached with their ends to the frame of the sieve.

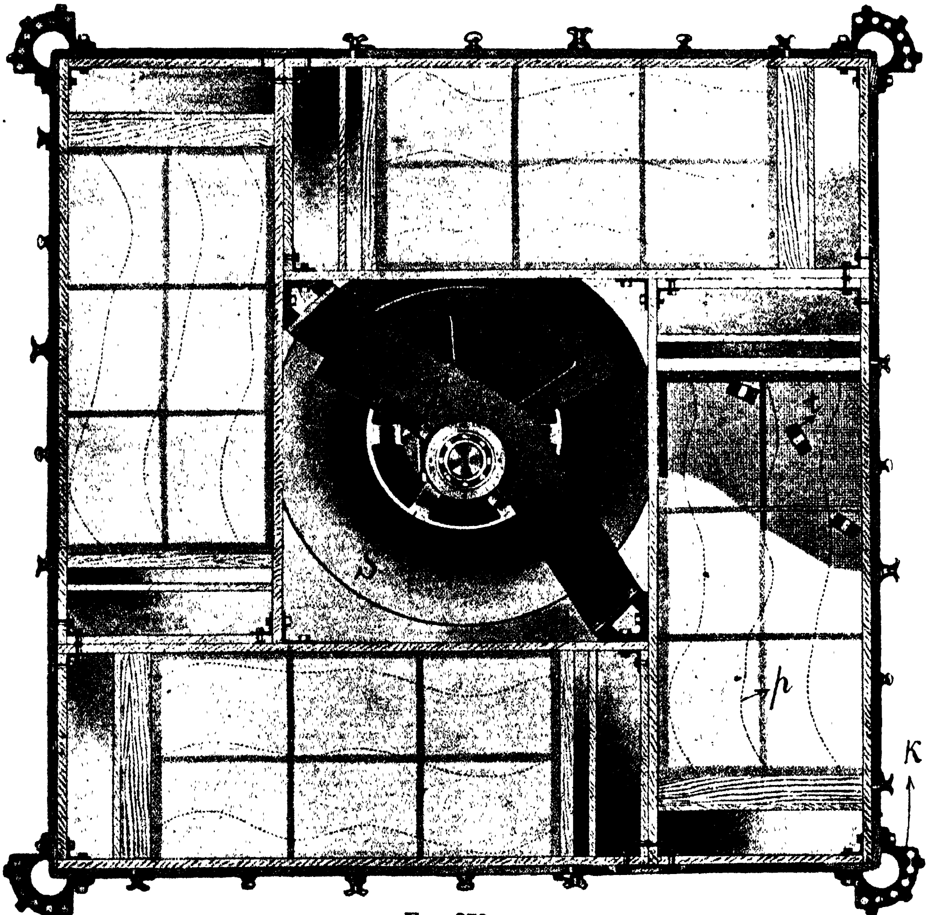

Fig. 372.

A longitudinal section of the sifter is shown in Fig. 373. Here one part of the sieves is given in longitudinal section, and one in cross-section. The sifter we are examining is built for eight products, *i.e.* each section operates independently for two products. For each product there are six bolting trays, every one of which has its own cloth. The tray 1 gives break *I* as tails, the tray 2 middlings *II*, trays 3, 4, and 5 yield flour as throughs, and the sixth tails over fine middlings and gives dunst as throughs. The lower floor of the first section differs in that the second semolina tray is substituted by one for flour.

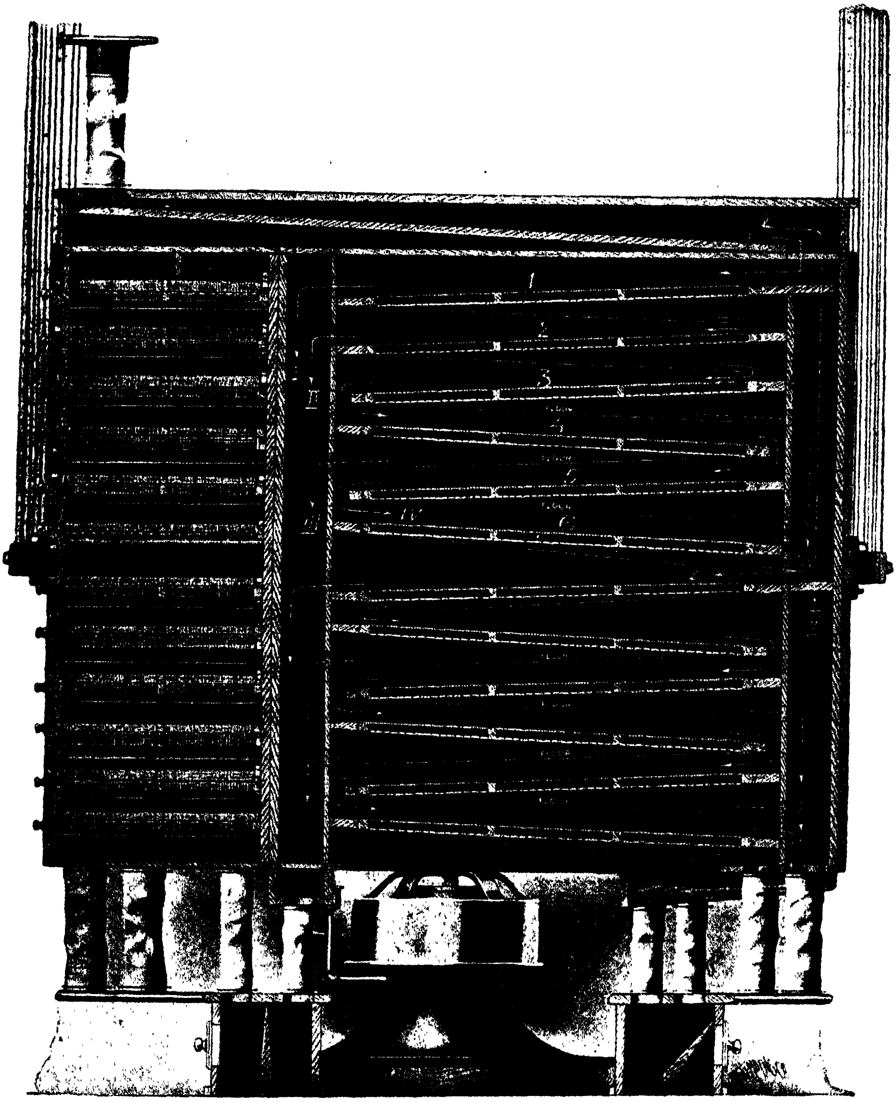

FIG. 373.

This sifter serves for a mill having four breaks and four reductions.

5. *Free Swinging Plansifters*

As we have seen already, both the single and the double box sifters have one sole defect from the point of view of their dynamics. They both wander, *i.e.* tend to revolve round the axis of the crank, particularly so at the start. However, this fault has been also obviated by the constructors at Robinson's in England, and Wolf's in America, with the aid of two driving cranks.

Thus, from the standpoint of dynamics, the sifter is a quite perfect machine at the present moment. But now a new problem has presented itself to the engineers—to simplify the relatively complex and heavy details, of which the crank driving the sifter-boxes and the balance-wheel with the counterweight are considered to be the parts most open to criticism.

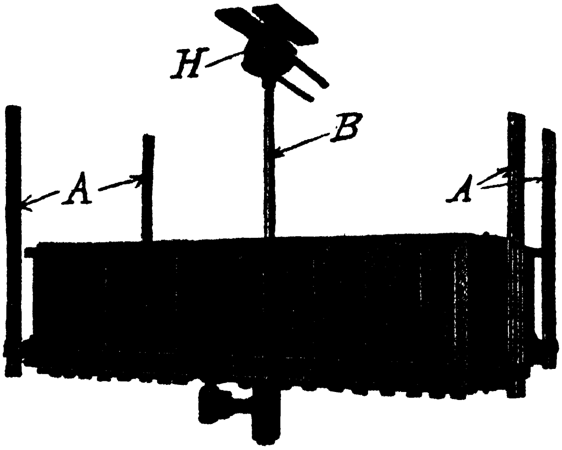

Fig. 374.

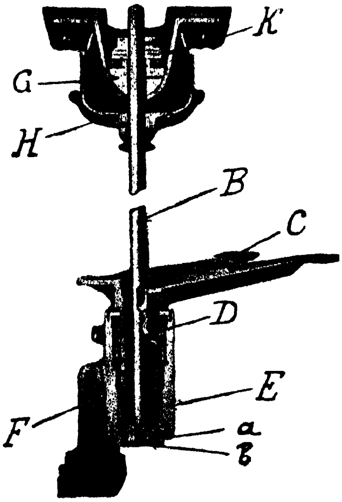

Fig. 375.

This question was worked at by American and European constructors, and finally, at the end of 1911, there appeared several patents, first in America and then in Europe, for so-called " self-balancing " sifters.

Before giving an estimate of these sifters from the point of view of dynamics and of other circumstances characterising the merits and defects of the new machines, we ought to make the student acquainted with their construction.

The classification of the new machines must be based on the character of the driving mechanism. In this respect there are known two kinds of drives, rigid[1] and flexible. Both types of construction totally obviate the crank method of obtaining the gyrating rotary motion.

Fig. 374 illustrates a perspective view of the sifter from "The American Machinery Co." works, which brought out this new type of machine as early as November 1911. The new construction is a two-box sifter suspended on four sets of canes *A*. It is brought into rotary motion by the shaft *B*, which is coupled to the sifter and the driving belt-pulley as shown on Fig. 375. The steel cross-head *C*, ending in a hollow finger *D*, couples the sifter boxes. On the finger there is loosely fitted the bush *E*, to the base of which the shaft *B* is joined, by means of a screwed-on nut *a* covered by a box washer *b*. This bush carries a weight *F*, which rotates freely on a joint. The top end of the shaft is supported by a ball bearing *G* entering into the filbore of the drop-hanger frame *K*. The belt-pulley *H* is set on the shaft *B* so that its centre line lies on a plane with the centre of rotation of the ball bearing.

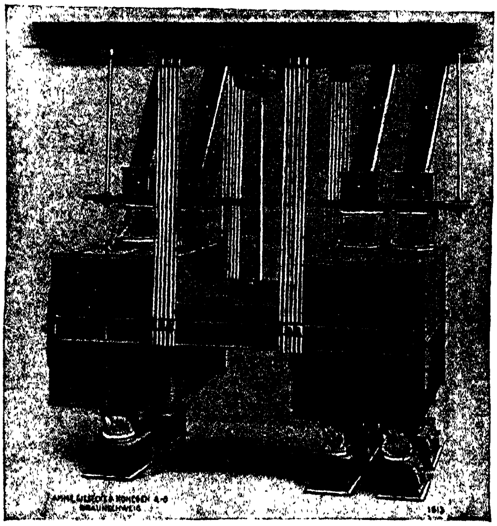

Fig. 376.

When starting the sifter the belt-pulley *H* receives its motion from the driving-belt and brings the shaft *B* into rotation. The ball bearing *G* glides in the filbore of the drop-hanger frame. At first the bush *E* glides over the finger *D* without bringing the sifter into operation. But in proportion as the number of revolutions increases, the weight *F* develops a centrifugal force; it rises and carries the finger *D* aside with it.

In this manner the gyrating rotary motion of the sifter is obtained owing to the centrifugal force of the weight *F*. This system of driving the sifter we call "rigid," to distinguish it from another construction which will be examined later.

After the type of the American sifter, also with a rigid drive, a new construction (Fig. 376) has recently been evolved by the works of Amme, Giesecke, and Konegen in Brunswick.

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[1] So we shall conventionally name the drive from a rotating shaft.

The idea of a free swinging sifter attracted the constructors so much that almost all more or less large European works, one after the other, began supplying the market with machines of that type. One may say that the works were seized by an epidemic of constructing sifters to work on the principle of utilisation of the centrifugal force.

The works "Erste Landwirtschaftliche Maschinenfabrik," in Budapest, and those of J. Prokop in Pardubitz, Austria, almost simultaneously put on the market free swinging sifters with flexible drives. Besides that several patents more were claimed for similar sifters, of which the most typical in its idea is Karl Gillesheimer's construction, shown in Fig. 377.

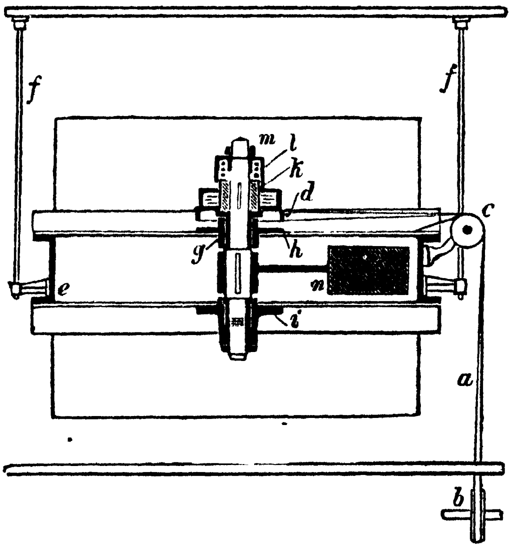
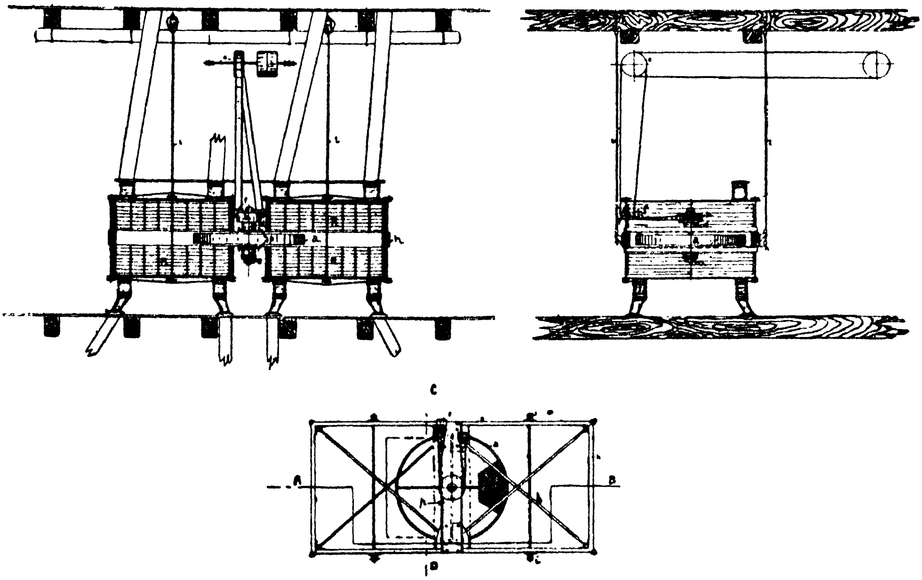


Fig. 377.

The essence of the construction of Gillesheimer's sifter consists in the following. The sifter box is suspended on four rods *f*. The fast pulley *d* is made to rotate from the shaft *b* by means of the belt-drive *a* guided by two jockeys *c*, fixed on the box of the sifter. The belt-pulley *d* is set on the shaft *g* to which the weight *n* is fastened. The shaft *g* rotates in bearings *h* and *i* coupled to the frame *e*. An important part of the mechanism is the friction coupling. The top part *k* of the friction clutch is keyed on the shaft, and the bottom part is formed by the belt-pulley *d* freely rotating on the shaft *g*. On the upper end of this shaft is fitted a spring *l*, the tension of which is adjusted by a nut *m*. By altering the tension of the spring, the pressure of the friction disc *k* can be altered, owing to which the force of friction of the clutch alters, and a modification in the magnitude of the moment rotating the box is thus attained. When started, the belt-pulley *d* at first glides over the friction disc *k*, and then gradually the force of friction forms a moment of sufficient magnitude, which brings the sifter into a gyrating rotary motion, and when the number of revolutions reaches the normal the gliding motion ceases. According to the inventor's idea the friction gear must at the same time be the regulator of the number of revolutions, since, in case of increase or decrease of the number of revolutions of the belt-pulley *d*, and consequently of the counterweight *n* as well, there springs up a force of friction between the disc and the belt-pulley, which either acts as a brake (if the number of revolutions increases), or drives the pulley *d* along with it.

The Voll and Mertz free swinging sifter with a flexible drive is given on Fig. 378.

The gyratory rotating motion of Voll and Mertz's sifter is based on the principle we have already examined. The weight *g* is set in the fly-wheel *a* in the same manner as the counterweight is set in the crank sifters. This fly-wheel is fastened on the shaft, which is supported by a ball-collar thrust-bearing *c* and a ball-bearing *d*, fixed to the cross-bar *p* of the frame coupling the sifter boxes. On the same shaft as the fly-wheel there is set the receiving belt-pulley *b* driven by means of a belt, which is carried to this pulley by means of jockeys *f* stationed on the sifter boxes.


Longitudinal section of the Sifter through *AB*.

Cross section of the Sifter through *CD*.

Plan of the Sifter without Sifting Trays.

FIG. 378.

All the constructions examined show that the gyrating rotary motion of the sifters is attained owing to the action of the centrifugal force, first of the weight, and next of the sifter itself.

Passing by a more minute estimate of the constructive details of free swinging sifters, which, doubtlessly, will be still more perfected, we shall direct our attention to the fundamental merits of the new machines, which are ascribed to them by their inventors.

1. A free swinging sifter requires no bulky setting of the crank shaft, which makes the machine, as well as its erection, heavier, more expensive and complex.

2. From the dynamic standpoint the free swinging sifter is an ideal machine, giving no shocks to the mill building.

As concerns the first point, *i.e.* the simplification and reduction of weight of the construction, this may be acknowledged as true, but only to a certain degree. The bulky mounting of the crank shaft is indeed discarded, but the rigid as well as the flexible drives have several defects.

Firstly, the American rigid drive has a complex ball drop-hanger frame, which will hold the oil badly. Also its belt-pulley performs, besides the ordinary rotatory, a conic motion, which causes unequal tension of the edges of the belt. Secondly, the flexible drive is far from perfection, because the guide pulleys have a gyratory motion, owing to which their middle plane falls out of its normal position, and causes the belt to be drawn off the pulley and the angle of contact to alter. These circumstances must lead to an irregularity in the work of the belt-drive.

However, the defects pointed out are not very considerable and may easily be avoided. For our own part, we would advise the constructors to pay serious attention to the electromotive transmission of motion to the sifters, retaining the principle of utilising the centrifugal force. If a friction clutch or a chain wheel were to be set on the shaft carrying the weight, as in the case of the American sifter, or on the fly-wheel with the weight, as Voll and Mertz's sifter has it, and bring it into rotation from the electromotor,[1] then the complex ball drop-hanger frame, driving belt-pulley, guide-pulleys, &c., become quite superfluous. To the motor of the sifter there will be only wires running from the ceiling, which will totally obviate the inconveniences of belt-drive, which work here under unfavourable conditions.

6. *Capacity of Plansifters*

The capacity of sifters, like that of other bolting machines, is characterised not only by the quantity of product sifted through a unit of bolting surface, but also by the quality of that work, *i.e.* the accuracy in separating the product according to size. If the overtails contain particles of product, which, judging by their size, should have passed through the

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[1] The great number of revolutions of the motor prevents a direct transmission from it to the fly-wheel.

meshes of the sieve, the work of the bolting machine is unsatisfactory, the machine is overloaded. When testing the capacity of bolting machines we suppose the quality of the work to be defined with an accuracy of up to 5 per cent., *i.e.* the tails contain not more than 5 per cent. of the product which should have passed through the sieves.

The capacity of plansifters, as also of reels and centrifugals, is best determined by experiment, but a theoretical elucidation of that question, in the shape given to it by Professor Zworykin, deserves attention.

First of all it is interesting to define the general bolting area for a given bulk of product, regarding the latter as the capacity of the mill in question.

We have seen that the capacity of roller mills is expressed in kilograms thus :

$$Q = \varepsilon l v \delta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

where l is the length of the rolls, v the velocity of passage of the product through the rolls, δ the distance between the rolls (average size of the product) or the thickness of the sheet of product, and ε is the practical alterable coefficient.

Professor Zworykin takes the bolting capacity proportionate to the area of the sieve and approximately proportionate to the square of the size of the product. By this reason Q obtained from the rolls and to be bolted now, is expressed by the formula :

$$Q = \varepsilon_1 A \delta^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2),$$

where A is the bolting area, δ largest size of the product, and ε_1 practical alterable coefficient.

From (1) and (2) we obtain :

$$\varepsilon_1 A \delta^2 = \varepsilon l v \delta,$$

and hence the A sought for :

$$A = \eta \frac{lv}{\delta} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

In this formula $\eta = \frac{\varepsilon}{\varepsilon_1}$.

The capacity Q of stone mills is formulated thus :

$$Q = \varepsilon_2 \pi d v_0 \delta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4),$$

where v_0 is the radial velocity of the product discharged, δ the average dimensions of the product.

On the other hand

$$Q = \varepsilon_1 A \delta^2.$$

Consequently,

$$A = \eta_2 \frac{d v_0}{\delta} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5).$$

If for rolls, both grooved and smooth, we accept the velocities v to be constant, as v_0 for millstones, the magnitude of the areas of sieves will be :

$$A = \eta_0 \frac{l}{\delta} \quad . \quad . \quad . \quad . \quad \text{for roller mills,}$$

$$A_1 = \eta^1{}_0 \frac{d}{\delta} \quad . \quad . \quad . \quad . \quad \text{for millstones.}$$

These formulæ are useful only if we have succceeded in deducing a series of values for η_0 and $\eta^1{}_0$ from practice, which requires serious experimental work on a large scale. At the present moment we are obliged to make use only of the data concerning the capacity of plansifters given by the works, correcting them after the results of practice.

Comparing the capacity of different bolting machines, Professor Zworykin gives the following table (Table XXXVIII) :

TABLE XXXVIII

System.	Capacity of 1 square metre bolting surface per 1 hour.
Polygonal reel . . .	up to 15 klg. of flour
Centrifugal	,, 70 ,, ,,
Haggenmacher's sifter .	,, 100 ,, ,,

In other terms, centrifugals have a capacity 4·5 times greater than reels, and the plansifters 6·5 times.

According to F. Kick's researches, 1 square metre of working surface in Haggenmacher's sifter has a capacity only four times as great as that of the reel.

Below we give a table (XXXIX) of the more up-to-date results as regards the capacity of reels, centrifugals and sifters according to Baumgartner and Notovitch.

TABLE XXXIX

Product to be Sifted.	Area of Sieves in Square Metres for Boiling 36 lb. of Product per 1 Hour.			
	Polygonal Reels.	Round Reels.	Centrifugals.	Plansifter.
1. Break Chop . . .	0·123sq.m.	......	0·110 sq.m.	0·025sq.m.
2. Fine Chop (midds etc.)	0·350 ,,	0·230 sq.m.	0·140 ,,	0·070 ,,
3. Reduction 50–60 per cent. of flour and 50–40 per cent. of dunst . .	0·50 ,,	0·330 ,,	0·160 ,,	0·100 ,,

When calculating the number of sifters required for the given capacity of the mill, Table XL may be used, where the capacity of two-box sifters with two, three and four sections having different numbers of bolting trays is given.

TABLE XL

Number of		Dimensions of Bolting Trays.		Capacity of the Sifter in Cwts. per 1 Hour.			Consumption of Power.	What Part of the Sifter.
Section	Bolting Trays in each Section.	Length in mm.	Breadth in mm.	Wheat.		Rye.		
				Break Chop.	Rebreak and Reduction Stock.	High Grinding.		
2	...	...	...	53·0	27·3	33·6	From 0·3 to 0·5 horse-power to a sifter.	Whole sifter
3	10	1400	865	26·2	13·6	16·8		½ of sifter
4	...	...	...	13·0	6·5	7·8		¼ ,,
2	...	...	...	63·5	31·2	40·0		1/1 of sifter
3	12	1400	865	31·0	15·6	20·0		½ ,,
4	...	...	...	14·7	7·2	9·5		¼ ,,
2	...	...	...	50·0	22·0	27·3		1/1 of sifter
3	6	1600	925	25·0	11·0	13·6		½ ,,
4	...	...	...	12·0	4·8	6·1		¼ ,,
2	...	...	...	55·8	27·3	33·6		1/1 of sifter
3	8	1600	925	27·9	13·6	16·8		½ ,,
4	...	...	...	13·4	6·1	7·8		¼ ,,
2	...	...	...	67·4	33·6	41·5		1/1 of sifter
3	10	1600	925	33·7	16·8	20·8		½ ,,
4	...	...	...	16·3	7·8	9·8		¼ ,,
2	...	...	...	79·0	40·0	49·2		1/1 of sifter
3	12	1600	925	39·5	20·0	24·6		½ ,,
4	...	...	...	19·0	9·5	11·9		¼ ,,

The capacity of round sifters of the Bunge type is given in Table XLI.

TABLE XLI

Number of Trays.	Diameter of Bolting Trays in mm.	Working Surface in Mt.^{2}	Number of Revolutions per Minute.	Capacity of Sifter in Cwts. per Hour.		Power Consumption, H.P.
				Break Chop.	Reduction Stock.	
4 trays	1000	3·1	150	12·2	7·4	0·12
	1300	5·2		21·0	12·2	0·15
	1500	7·0		28·5	16·2	0·20
	1700	9·0		36·5	20·3	0·25
5 trays	1000	4·0	150	14·8	9·0	0·15
	1300	6·6		24·3	14·8	0·20
	1500	8·8		32·4	18·7	0·25
	1700	11·3		40·5	24·3	0·30

In spite of this table showing the capacity of round sifters to be almost the same as that of rectangular ones, in reality it should be regarded as much smaller (up to 25 per cent.), taking into consideration the quality of work, which is incomparably lower than the work of rectangular sifters, where it is performed on six trays at least.

In comparing the quantity of work done by plansifters and the other bolting machines, we see that the sifter stands considerably higher as regards capacity. But the quality of work of the sifter is also higher than that of polygonal and round reels. Experiments prove that at the bolting of the products (reduction of middlings) some 50 per cent. of flour is tailed over, together with fine middlings and dunst, which makes a complementary bolting indispensable, in its turn requiring a considerable increase of the working surface of the sieves.

Since there are no investigations of the quality of work performed by sifters and reels of a later date, we shall give the results of experiments made by I. Wingert, the president of the German Millers' Society, who tested Haggenmacher's sifter and the reel, and published the results of his investigations in *Die Mühle,* 1889, No. 6. The experiments were performed on the bolting of the product of middlings reduced on French stones. The results were as follows :

	Sifter.	Reel.
Flour . .	74·52 per cent.	43·83 per cent.
Middlings .	25·36 „	54·46 „
Offal . .	0·12 „	1·71 „
	100 per cent.	100 per cent.

Thus, more than a half of the flour and dunst, which could have been discharged with the flour, were separated as middlings on the reel (54·46 per cent.), whereas the sifter yielded 25·36 per cent. of pure middlings unmixed with flour.

The advantage of plansifters in comparison to other types of bolting machines needs no proofs now. And if the reels are not generally supplanted as yet, they are retained only in primitive mills, where the quality of the flour is of no importance, or this flour has to compete with flour of unsifted grinding, as in peasant windmills, or water-mills of the Caucasian type.

CHAPTER VI

GRADING THE PRODUCT ACCORDING TO SPECIFIC GRAVITY

I

GRADING MIDDLINGS AND DUNST ACCORDING TO SPECIFIC GRAVITY

SINCE the flour-milling technics evolved the system of high grinding, the sorting of the intermediate product according to its specific gravity has been undoubtedly one of the most important stages in the milling process. Indeed, from the moment he has separated the middlings and the dunst according to the quality, the miller proceeds to define the grades of flour.

The removal of the branny and colouring particles of grain from the valuable starchy middlings, which give high grades of flour, is no easy task. A solution of this problem was being sought by flour-milling engineers for a whole century, and only now is it solved almost to perfection.

Although the repeated milling (*mouture économique*) is an invention of the French, who practised it 150 years ago, the character of the wheat—soft, with comparatively moist integument—never suggested to the French flour-millers the idea of grading the middlings according to quality. In the old French process of repeated milling[1] the elastic coverings of the soft wheat very successfully resisted reduction when passed through grinding machines, and gave a comparatively insignificant percentage of bran reduced to flour. A considerable part of the integument therefore was easily removed with the aid of bolting apparatus. The result of a repeated milling of hard wheats is totally different. The dry shells are reduced to fine bran, which it is impossible to separate from the meal by bolting machines. The fine bran imparts a darker colouring to the flour and lowers its quality and market value.

The French repeated milling, widely spread in Europe, with the aid of which an excellent flour according to the standard of the time was obtained, proved to be unsuited for hard Hungarian wheats. With a view to attaining the same results in milling as with the soft wheats

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[1] As a type of such milling, the rye milling of to-day may be taken, with the sole difference that roller mills are substituted in the place of grindstones.

the Hungarian flour-millers thought of damping the wheat, so as to moisten the bran, and in this manner make it more elastic. The imperfect damping processes, however, offered great inconveniences, in so far that the wheat was moistened too copiously, the moisture penetrated into the kernel of the wheat, the flour obtained was " damp," and could not stand long storage or export.

Thus the first impetus was given to the Hungarian millers to direct their inventive faculty towards other ways of freeing the flour of branny admixtures. In the first place, Ignatz Paur, a flour miller, introduced a slight improvement into the French repeated milling, by greatly altering the distances between the working surfaces of the grinding stones, and thus making the first steps towards modern high-milling (Hochmühlerei is derived from Hochmühle, showing that the runner stands high over the bed-stone in the first passage), and then, winnowing the blue flour away from the heavy semolina by means of hand bellows, the primitive shape of a special type of purifiers, which, however, took no root in practice.

Owing to this improvement Austria-Hungary first sent to the market a granular flour for bread of the highest grade and semolina for immediate use. That semolina, very much resembling our " manna," was called Wiener Gries, *i.e.* Viennese semolina.

Thus, the hand bellows gave Ignatz Paur the idea of sorting the product according to quality, *i.e.* specific gravity. In 1810 he invented the first purifier which is known in the history of the development of flour milling under the name of " The Viennese purifier." From that date the milling process is richer by a very important stage—grading of middlings according to the quality.

For the period of a century flour milling has seen hundreds of constructions of purifiers, but the fundamental principle of their action has remained the same. For this reason, before proceeding to review the purifiers in their historic succession, beginning with Ignatz Paur's, it is necessary to dwell on the theoretic foundation of the chief principle of action of every purifier.

If we compare the weights of equal bulks of cleaned and uncleaned middlings, both kinds being of equal size, we shall see that the impure middlings are less in weight. This weight is lost at the expense of the grains of middlings, which have one of their facets covered with the integument of the kernel, because the bran in specific gravity is much lighter than the inner starchy parts of the wheat or rye. Further, the weight of uncleaned middlings is less owing to the splinter-like particles of the bran, which pass as throughs or overtails from one and the same sieve together with the good middlings. In this manner after sifting we have a mixture of particles equal in size but unequal in weight. It was that difference in the weight of separate particles that the constructors availed themselves of, to separate the light particles, *i.e.* bran and middlings with integumental elements, from the heavy or, in other terms, rich product.

It is evident that if two falling grains of product, equal in size but different in weight, should be subjected to the action of an air-current, the lighter particle of grain will be carried further than the heavier one. But for the constructor of a machine sorting the middlings according to quality, it is important to know not only this obvious fact, but also the law of motion of the particles influenced by their gravity and the constant force of wind fanning the product to be graded. And only when that law of motion has been defined, is the constructor enabled to start working out a rational type of machine confidently, and without groping about for a rational type of machine.

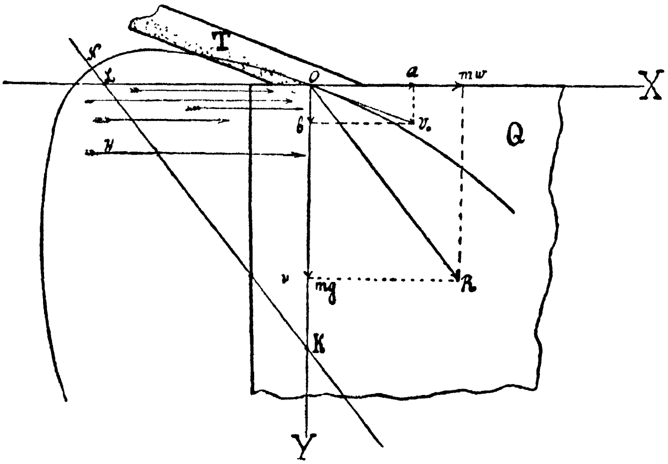

FIG. 379.

H—Direction of the wind.

Thus, we are to solve the following problem: to define the law of motion of a particle subjected to the action of two constant forces.

We shall first examine a general case, when the particle falls into the sphere of action of the draught with a certain initial velocity v_0. For simplicity's sake let us imagine (Fig. 379) we have an inclined spout *T*, down which the product flows into the chamber *Q* with that same initial velocity v_0. On leaving the spout the particles of middlings undergo fanning by a horizontal air-current.

We suppose O, where a particle of the stock m is on passing from the spout in Q, to be the beginning of rectangular co-ordinates, of which OX coincides with the direction of the draught, and OY with the vertical, *i.e.* with the direction of action of the gravity. The velocities a and b are components of the initial velocity v_0.

On marking the force of the draught mw, where w is the acceleration of motion along OX, we obtain the following equations of motion for the particle of stock m:

$$\left.\begin{array}{l} m\dfrac{d^2x}{dt^2}=mw \\[2ex] m\dfrac{d^2y}{dt^2}=mg \end{array}\right| \text{ or } \begin{array}{ll} \dfrac{d^2x}{dt^2}=w & \quad . \; . \; . \; . \; . \; . \; . \; (1). \\[2ex] \dfrac{d^2y}{dt^2}=g & \quad . \; . \; . \; . \; . \; . \; . \; (2). \end{array}$$

To define the laws of motion along OX and OY, we must evidently integrate these equations. Then, bearing in mind that $\frac{dx}{dt}=V_x$, we obtain:

$$\int\frac{d^2x}{dt^2}dt=\int\frac{dV_x}{dt}dt=\int dV_x=\int wdt=V_x+C=wt.$$

To define the constant C we suppose $t=o$, *i.e.* we define V_x at the initial moment of motion. Then, naturally $C=-a$ from $V_x+C=O$. Consequently, the law of velocity is:

$$\frac{dx}{dt}=V_x=a+wt \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; (3).$$

By integrating a second time, we obtain:

$$\int dx=\int adt+\int wtdt$$

or

$$x+C_1=at+\frac{1}{2}wt^2.$$

But since $t=o$, we have $x=o$, consequently $C_1=O$. Thus the law of motion along OX is:

$$x=at+\frac{1}{2}wt^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; (\text{I}).$$

Having done the same with the differential equation of motion (2) along the axis OY we obtain:

$$y=bt+\frac{1}{2}gt^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; (\text{II}).$$

Now, to define the trajectory of motion of the particles, we must exclude t out of (I) and (II). By reducing these equations to the same denominator, multiplying I by g, II by w, and subtracting the second from the first, we obtain :

$$\begin{array}{c|c} 2x=2at+wt^2 & g \\ 2y=2bt+gt^2 & w \\ \hline \multicolumn{2}{c}{2(gx-wy)=2(ag-bw)t} \end{array}$$

Hence we define $t=\dfrac{gx-wy}{ag-bw}$ and substitute it into the second equation. Then we have :

$$2y=2b\left(\frac{gx-wy}{ag-bw}\right)+g\left(\frac{gx-wy}{ag-bw}\right)^2$$

After reducing x and y to the same denominator and arranging them according to degrees, we obtain the equation of the curve :

$$g^3x-2g^2wxy+gw^2y^2+2bg(ag-bw)x-2ag(ag-bw)y=0.$$

Consequently, we obtain a curve of the second order of the following shape :

$$Ax^2+Bxy+Cy^2+Dx+Ey=0.$$

The absence of the constant term F shows that the curve passes through the beginning of the co-ordinates, as it should. The term B^2-4AC, after the substitution of corresponding coefficients ($A=g^3$, $B=-2gw^2$, and $C=gw^2$), is equal to 0. Hence it follows that our curve is a parabola, one branch of which passes through the point O.

Now the position of the axis of the parabola remains to be defined. For the equation of the axis of the parabola in general outlines we have the following formula : [1]

$$\frac{B}{2}\left(Ax+\frac{B}{2}y+\frac{D}{2}\right)+C\left(\frac{B}{2}x+Cy+\frac{E}{2}\right)=0.$$

Having substituted the corresponding coefficients A, B, C, D, and E we obtain the following equation of the axis :

$$-g(w^2+g^2)x+w(w^2+g^2)y-(ag-bw)(bg+aw)=0,$$

or

$$-\frac{x}{\dfrac{(ag-bw)(bg+aw)}{g(w^2+g^2)}}+\frac{y}{\dfrac{(ag-bw)(bg+aw)}{w(w^2+g^2)}}=1 \quad . \quad . \quad . \quad \text{(III)}.$$

In this way the axis of the parabola lies crossing the axis Y below the point O and the axis X to the left from the beginning of the co-ordinates, because we see from the equation of the parabola axis that the segment it strikes off the axis X has a negative magnitude. The direction of the parabola axis will be defined in accordance with the angular coefficient,

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[1] *Analytical Geometry*, Briot and Bonquet, p. 148.

which will give us a very simple formula for the equation of the axis we have obtained :

$$tg\varphi=\frac{g}{w}.$$

If we define now the direction of the resultant of two component forces mw and mg we obtain from the triangle ORS :

$$mg=mwtg\varphi,\text{ whence } tg\varphi=\frac{g}{w}.$$

Consequently, the axis of the parabola is parallel to the direction of the resultant force. The summit of the parabola is, evidently, higher than the axis of X is, for instance, at the point N. It is possible to find the summit of the parabola and the equation (III) of its axis.

We have thus solved the problem in its general form. The formula $tg\varphi=\frac{g}{w}$ defines the direction of the axis of the parabola, which is very easy to construct. Since w, the acceleration of the particle through the force of the draught, depends on the shape of the particle, and the force of the draught expressed by the product of the mass by the acceleration mw, it is clear that for particles of different quality and shape we shall have different directions of motion, *i.e.* shapes of parabolas ; the trajectories of motion will be different for particles of unequal quality and form of their surface. It follows hence that we can set the receiving hoppers for particles of various quality accurately and correctly, once the trajectories of motion are designed.

Besides that general problem, special cases are possible. Firstly, the particles having an initial velocity, developing, for instance, from the centrifugal motion, are exposed to the effect of the draught at an angle of 0° to the direction of the gravity ; secondly, the force of the draught is directed at an angle of 180° to the gravity. Both in the first and in the second cases we have the simplest problem in parabolic motion. The summit of the parabola coincides in both these cases with the beginning of the co-ordinates.

Let us turn now to the first purifier, invented by Ignatz Paur as early as in 1807, and patented in 1810.

In its original form this purifier (Fig. 380) was a timber box of a parallelopiped shape $9\times2\frac{1}{2}\times1\frac{1}{2}$ ft. in size. Generally the chamber of the purifier was divided into three nearly equal parts, D, E, and F, working independently of each other. As may be seen in the longitudinal section (Fig. P) of the purifier, its box is divided into three chambers by air-conducting channels C and B directing the air to the product to be

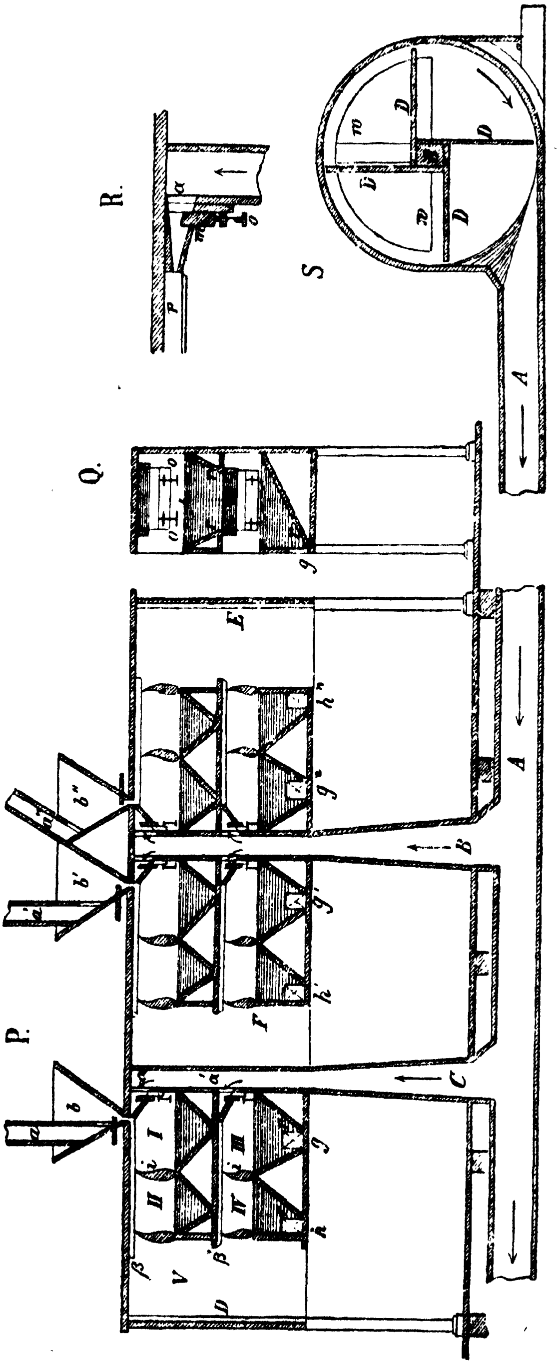

FIG. 380.

graded. Each chamber of the purifier was supplied by the spouts *a*, *a′*, and *a″*, through hoppers *b*, *b′*, and *b″* with product which was previously graded on a flat sieve, likewise of Paur's construction. The operation in all the chambers being perfectly alike, it is sufficient to examine one section, *D*.

The product in passing through the outlet of the hopper *b* into the hopper *I* was subjected to the effect of an air-current blowing through the opening *a* out of the air-conductor *C*. The branny and light mealy particles were carried away to section *V*, the heavier ones fell into the hopper *II*, and in this way, on the top floor of the purifier, the first separation of the product into three classes according to the quality was effected.

When running from hopper *I* to *III* and from hopper *II* to *IV* the stock underwent fanning for the second time by a draught impelled through the opening a_1. The product was consequently subjected to a double aspiration, and then delivered through outlets *g* and *h* into sacks. Thus, three products were obtained on Paur's purifier; two grades of middlings of different quality and light refuse.

To have done with that purifier we must complete the description of its construction. As we see in Fig. P, the hoppers *I*, *II*, *III*, *IV*, and *V* are separated by swinging partitions *i*, by means of which the area of cross-section of the air-current could be altered, and thus the velocity of the passage of air regulated, which allowed of adapting the purifier to treat products of different size and quality. Fig. Q illustrates the cross section of the purifier where the hoppers *I* and *III* and the screws *o* to the gate *m* (Fig. R) are seen, which regulates the influx of air from the air-conductors *C* and *B*. On Fig. S is given a rather primitively constructed fan which was generally set somewhere apart in a convenient place, and communicated with the purifier through the main air-conductor *A*. This air-conductor with two channels, *C* and *B*, branching off, one of which, *B*, works for two chambers *E* and *F*, protrudes beyond *C* to show that it supplies with air other purifiers as well. The Fig. R gives an idea of the nozzle conducting the air into hoppers *I* and *II*. In this drawing the gate *m* regulating the influx of air by means of the screw *o* is clearly seen.

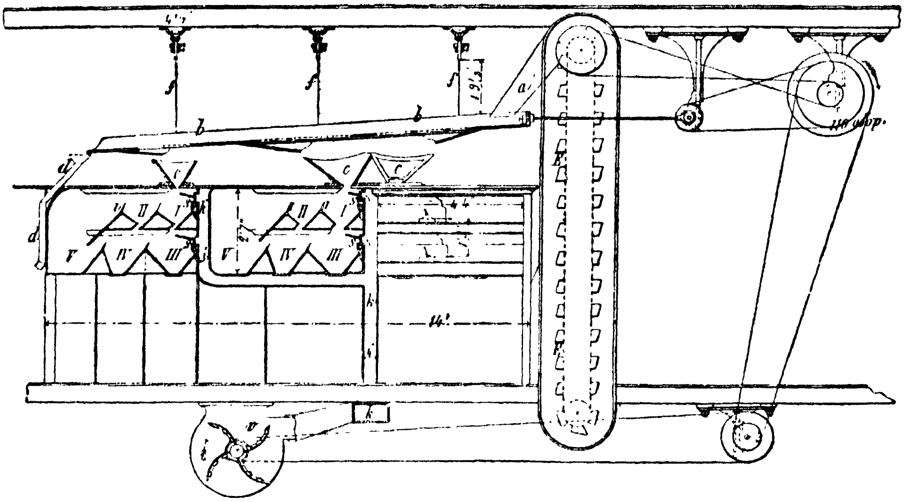

FIG. 381.

A few years later Paur brought out a more perfect construction of a purifier (Fig. 381), which constituted one block with the fan *v* and was combined with a vibrating sieve *b* and an automatic elevator *E*. We shall say no more of this purifier, because it is clearly enough described in the preceding.

Paur's purifier and other machines of the same type, and built on the same principle, were in use in mills for sixty years. Having spread all over Europe, they were called "Wiener Griesputzmaschinen mit Stosswind," or simply "Wiener Stossmaschinen." This "Stosswind," *i.e.* the air forced into the machine, caused the flour millers no small annoyance, as the mill was filled with clouds of flour dust, which freely escaped from the purifier driven by the impelled air. Naturally, there was a series of attempts to obviate this inconvenience, but they all were constructive half-measures which brought no satisfactory results.

But, in 1867, J. Woerner's purifier made its appearance, and immediately drove out the machine with the Stosswind that blinded the mill with flour-dust. The new machine differs from the machines of the Paur type in that, instead of a blast fan Woerner adopted an exhaust one. In this way the fan not only does not fill the mill with dust, b on the contrary cleans it.

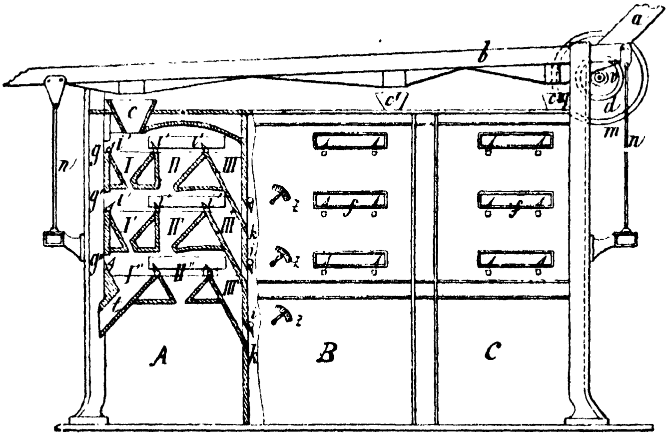

FIG. 382.

Woerner's purifier (Fig. 382) was a box of about the same size as Paur's machine, also divided into three chambers *A*, *B*, and *C*. Over the purifier there was the sieve *b* to which a vibratory motion was imparted with the aid of a crank shaft *v* receiving its motion from the ceiling drive through the belt-pulley *d*. On the same shaft *v* was a hand-wheel *m* adjusting the reciprocating movement of the sieve, which was swinging on rods *n*. The air conductors *kk* communicate with the general air-channel running to the aspirating fan.

The product, graded according to size into three grades, flows into separate chambers of the purifier through hoppers *c*, *c'*, and *c''*. The process of grading according to the quality in the chamber *A* is carried out in the same order as in *B* and *C*. From the hopper *c* the semolina falls into divisions *I*, *I'*, and *I''*, undergoing a triple fanning by a draught aspirated through the opening *g*. The lightest particles of bran and dust pass into division *III*, and are carried out through the air trunk *kk* driven by the fan into the dust chamber; the second grade of middlings falls into division *II* and is subjected to a twofold fanning. By this method here, too, as in Paur's purifier, three products are obtained, with the sole difference, that the light refuse of Paur's purifier covered the mill with dust, while here they could collect in the dust chamber, or at least be discharged into the open. As we see in the drawing, in the purifier the velocity and the quantity of air employed could be regulated by means of the swinging gates *i*. The purifier was covered on the sides by a timber casing in which windows *f* were made for inspecting the operation.

On this new principle of the "Saugwind," *i.e.* on the principle of operating by means of a current of aspirated air, there sprung up a series of more or less successful types of purifiers, still working with a flat vibrating sieve outside the purifier itself.

Of these purifiers, of a slightly simplified type worked in comparatively simple mills, we should mention Arndt's machine, which made its appearance in 1869. As may be seen in the drawing (Fig. 383), the middlings fell through the hopper *T* upon the sieve *C* which was given a vibratory reciprocating motion (up to 200 vibrations) by a crank mechanism *b–i*. The end of the sieve was laid on rolls *g*. There were only two products here: the throughs which ran into the feeding hopper *Q* and spout *a*, and the refuse which was discharged. The fanning of the product was performed by draughts impelled through tubes *a*, *d*, and *c*; the air was sucked in by fans *V–V* ending in tubes *f* with bags tied to them for collecting the flour dust and the light branny refuse. The highest quality middlings passed into *c* and those of a second quality into the side spouts *d*. At the ends of spouts *c* and *d* there were set bosses *p* and *q*, having side openings for letting the air out; to these bosses, which could be lowered and raised to regulate the inflow of air, there were bags attached to receive the cleaned middlings. The tubes *f* were furnished with windows *e* covered with a bolting or linen frame to leave a passage for the air and prevent the meal dust and particles of bran from escaping.

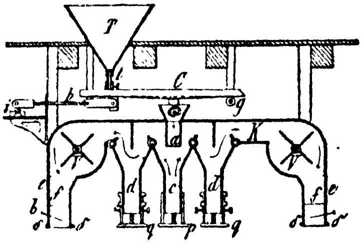

FIG. 383.

For a period of ten years after Woerner's purifier was invented, this type of machine was being perfected, mainly in the direction of a multiple aspiration and the increase of the number of grades of middlings.

The most successful and characteristic machines in that respect are the purifiers of Millot and of Karl Haggenmacher, which appeared almost simultaneously (the first in 1879, the second in 1878).

Millot's purifier, shown in a longitudinal and in a transversal section in Figs. 384 and 385, was designed to give a multiple fanning to the product which poured into the hoppers through the sieves *TT′* (Fig. 384) and passed through the funnel *m* to be graded. The sieve with the hoppers was fixed on four elastic stands *t* and vibrated from the eccentric rods *s* operating from the shaft *o*, which carried the intermediate belt-pulley *O* to the fan pulley *O′*. The stock was conveyed (Fig. 384, right-hand side) by the channel *d* to the first sieve *c* through which the air-current passed. The refuse off the sieve *c* flowed down an inner channel to be further aspirated, while the throughs fell on an inclined receiving board, down which it rolled on to the other sieve *c* similar to the one preceding. This reiterated process of fanning one and the same product was continued until the cleaned middlings reached the receiving spout *d′* and were discharged into the sack. The particles of bran and the meal dust, on passing the grates *E*, were blown by the fan *V* into the dust chamber, whereas the heavier particles, dropping to the bottom, left the purifier through the chamber *D′*. In this manner only two grades of middlings were yielded by this purifier, but these were well cleaned.

For regulating the force of the draught there were apertures *F*, the opening of which allowed a passage for the air and reduced the rarefaction in the chambers *D*. Besides that, there were automatic valves *F′*, which opened by themselves as soon as the rarefaction in the chambers *D* exceeded the set limits. On Fig. 385 is shown the chamber *G* into which there passes a part of the fanned air, cleaned by filtering through linen tissue *g*. Through this chamber *G* the air was directed by gutta-percha sleeves *r* under the sieves *T* and *T′* and cleaned their blinded meshes by pressure.

From this description we may judge how thoughtfully this machine was constructed. In the construction of Millot's machine all the fundamental principles of a purifier were foreseen : manifold aspiration, regulation of the air pressure, and cleaning of the sieve. Still Haggenmacher's purifier was a more perfect type of the machine, in so far that it afforded the possibility of obtaining three grades of middlings. Altogether, it must be noted that K. Haggenmacher is one of the most eminent

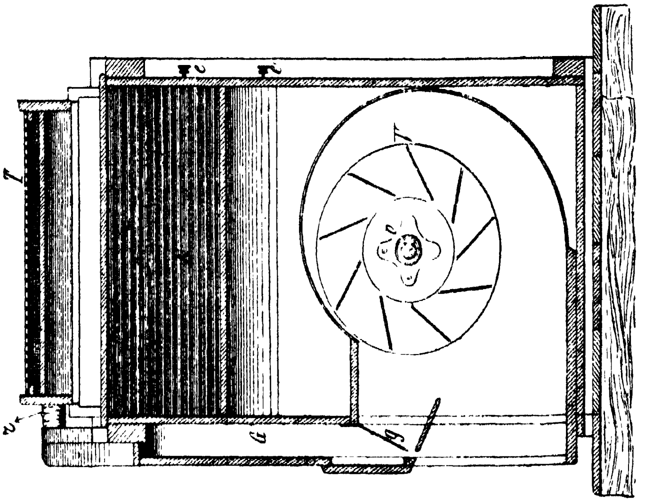

FIG. 385.

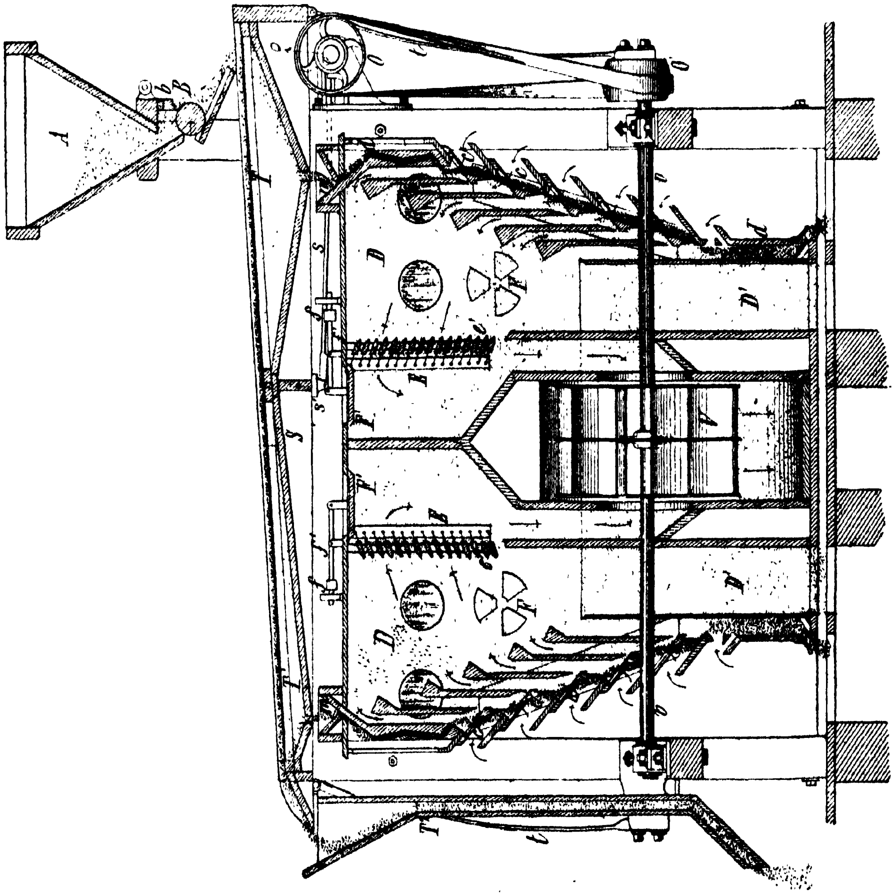

FIG. 384.

constructors of mill machinery, justly occupying a place of honour in the history of the development of flour milling. We shall, therefore, meet his name more than once again, when studying the constructions of machines.

Haggenmacher's purifier is shown in Fig. 386. Here we see the same scheme of vibrating sieves *a* and *a′*, delivering their throughs to the hoppers *d* (two on the right and two on the left-hand side of the purifier), and the refuse into the hoppers *b′* and *b*. The middlings of the highest quality after a quadruple exhaust pass to the spout *p*, those of medium to *q*, and finally, the lower grade to *r*. The meal dust and particles of bran on passing through the fan *V* are conveyed by the air-trunk *B* to the dust chamber. The outer air flows in through the openings s_1 and s_2, which are furnished with lids on hinges; these lids may be raised by the pressure of the outside air, thus closing the openings, and drop under their proper weight. But the rarefaction of air in the chamber of the purifier may be also effected by the windows 1, 2, 3, and 4, through which the desired quantity of outer air is let in, as these windows may be opened more or less by rack gates *m*.

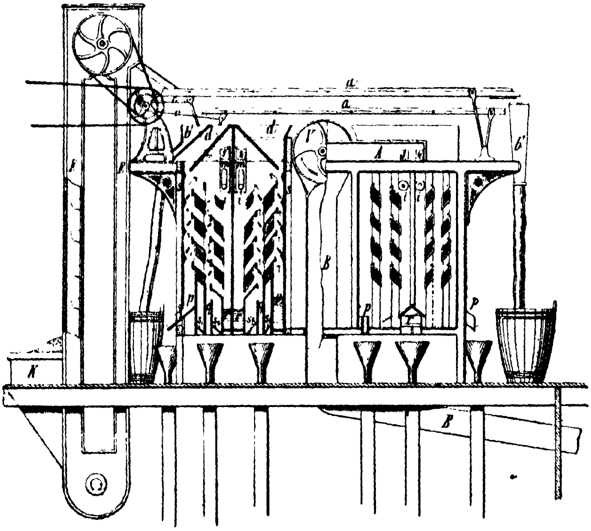

FIG. 386.

In the beginning of the eighties the construction of this purifier was altered, so that it could yield up to five grades of middlings. A general installation of these purifiers is seen in Fig. 387. The sieves *ab* here are placed outside the machine, and the stock, graded according to size on the sieve, is delivered to the purifier by an automatic elevator *E*. The fans are likewise set outside the purifier and communicate with them by means of aspirating air conductors *o* (collector) and *o′* (branches off to the purifiers). The graded product runs to the ground floor to be packed.

The further improvement of Haggenmacher's purifier stands in connection with the invention of plansifters. But substantially the last types of these machines remained purifiers with many aspirations, in which the sieves form a separate independent machine. We shall return again to the latest types of these purifiers, and turn our attention for the present to a new group of machines for grading middlings.

The fundamental principle of action in the machines of the first group was the aspiration of stock falling because of the force of gravity. In the seventies, however, there appear machines in which, besides the force of air currents and gravity, an attempt was made to introduce centrifugal force.

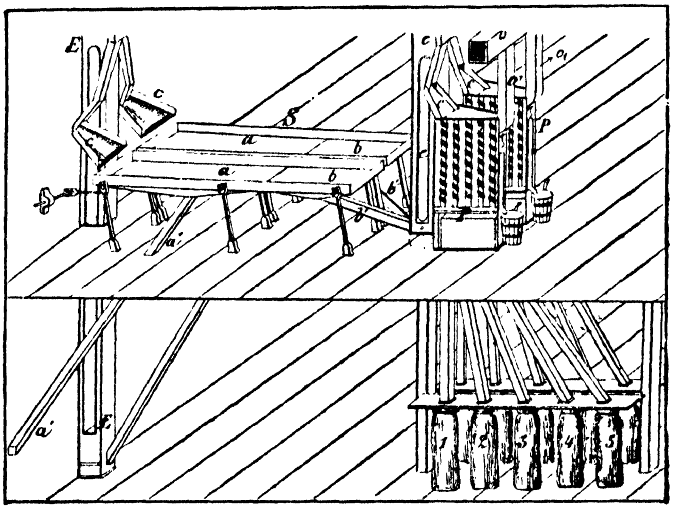

Fig. 387.

In 1876 such a machine (one of the first) was patented by Buchholtz. The action of this machine (Fig. 388) was as follows. The stock flowing through the hopper *a* upon the rapidly rotating disc *c* is spread out through the effect of centrifugal force and fanned. The heaviest particles fall into the chamber *n*, the medium ones into *m*, and the bran and meal dust into the air-trunk *d*, which communicates with the suction fan. The boss *b* with a hand-wheel may be raised or lowered (screw thread), which allows of regulating the flow. From *n* and *m* the product is removed by scrapers, or runs down the inclined hopper to the spout.

Another machine, constructed by two Englishmen, F. Thomson and W. Williamson, in 1880, is based on the same principle, but a repeated aspiration of the stock is introduced by this time. Through a funnel *z* (Fig. 389) the stock is poured upon the rapidly rotating disc *t*, from which it is flung off by the action of the centrifugal force and subjected to aspiration. Successively, according to its quality, the stock falls into k_3, k_2, k_1, while the offal is carried away through the tube *r* to the dust-chamber. The number of middlings grades here is three, and the number of fannings two, though four to six floors of *k* could be made, and then four to six aspirations would be obtained.

The theoretic problem of motion of the particles for this type of purifier is most simple, but the introduction into the machine of a constructive device in the shape of gyrating discs rendered it considerably more complicated; that type of purifier is therefore quite extinct now.

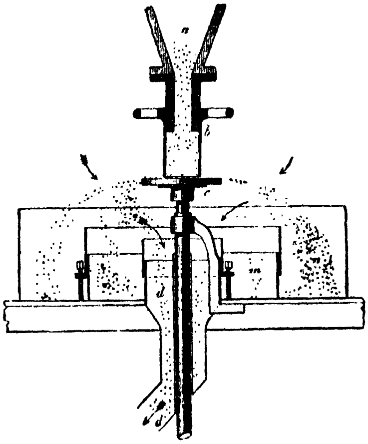

FIG. 388.

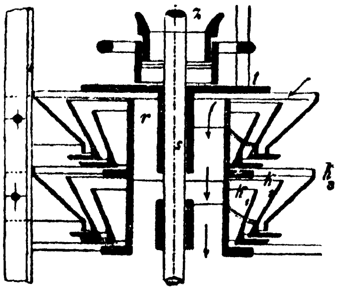

FIG. 389.

With this the history of the first period of development of purifier may be concluded. Beginning with the eighties of the last century, the machines for grading the stock according to quality begin to develop into another type.

II

MIDDLINGS- AND DUNST-GRADING MACHINES OF TO-DAY

After the series of modifications in the constructions of machines for grading the middlings and dunst according to quality recorded above, modern technics fixed upon two types of machines. One of these types retained the principles of Haggenmacher's first purifier, which in Professor Zworykin's terminology was called "self purifier";[1] the other is a machine, in which the product moves over the sieve. The air passes through the sieve and lifts the light particles of stock. This type of machines Professor Zworykin names the "sieve purifier."

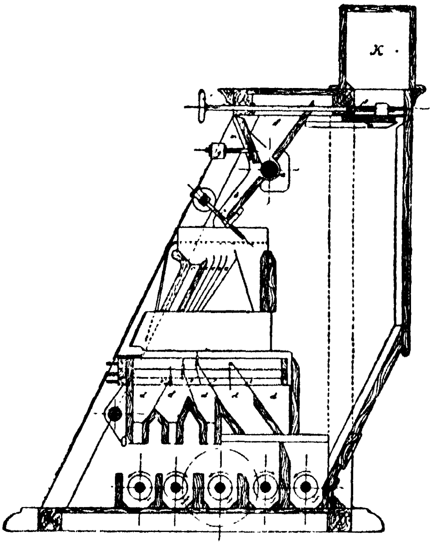

Fig. 390.

Haggenmacher and Voll's Gravity Purifier.—The latest construction of Haggenmacher's gravity purifier, patented jointly with Voll in 1907, is designed mainly for large and partly for medium middlings. This gravity purifier is always set to work in conjunction with the middlings grading sifter, and is, therefore, also named "the group."

The middlings, graded according to size by the sifter into from eight to sixteen grades (Figs. 390 and 391, eight grades of middlings in all), pass into the hoppers *A*, the outer wall *m* of which is a self-adjusting gate with a weight *g*. The feed roll *a* feeds the stock in an even stream to the spreader board *b*, in sliding over which the particles of middlings, equal in size but unequal in weight,

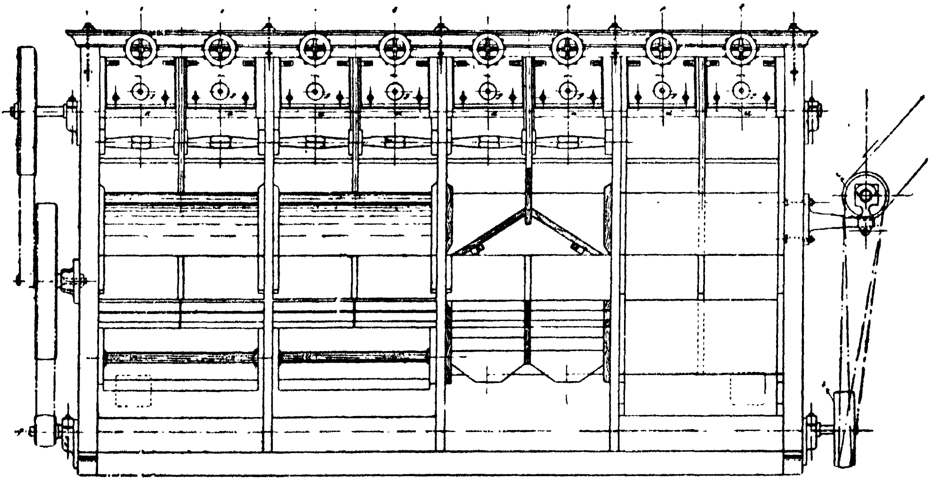

Fig. 391.

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[1] In England this machine is known as the "gravity purifier," in contradistinction to the "sieve purifier." This term will therefore be employed in the text.

acquire different velocities of motion. Running off the spreader board, these particles have various speeds, and therefore, when meeting a current of air, give different deflections from their initial direction. Falling in accordance with their quality into the bottomless feeding boxes *c*, the middlings pass through them into the chamber space, where they undergo a second fanning, after which the cleaned product drops into hoppers *d*, divided according to quality. Over these hoppers adjustable valves are placed, and may be moved to the right or to the left, according to the force of the draught from the fan and the size of the stock graded. From the hopper *d* the graded product runs to the worms and is discharged by them from the machine.

The Double Gravity Purifier.—In Figs. 392 and 393 is shown a double gravity purifier, also built by Haggenmacher and Voll. The stock falls first upon the top sieve *S* feeding the throughs to the second sieve and the tails for discharge. The second sieve *S′* passes the smaller throughs from the right-hand side half to the corresponding part of the purifier. The bolted product runs into the hoppers *A*, whence it is delivered by feed rolls *a* to the spreader boards *b*. On the way from the spreader boards *b* the stock is aspirated, and drops to the bottomless boxes *c*, from which it is directed into boxes *d* in streams separated according to quality and size, and undergoes fanning once more on its route. The boxes *d* have adjustable valves *e*, which are regulated in accordance with the size of the stock to be graded. From the boxes *d* the graded product flows to the discharge spouts *f* for further treatment. Between the divisions of the purifier there is the fan chamber in which the suction fan *h* is set.

The Haggenmacher and Voll's machines we have examined are described according to specimens built by the works of Dobrovy and Nabholtz, but the same type of machines of similar principle are made by other works also, such as Daverio, Luther, Amme, Giesecke and Konegen, &c.

Smith's Sieve Purifier.—Smith's sieve purifier was originally invented in America, and under the name of "Reform" was evolved by the works of Seck Bros. It is constructed on a different principle of action to that of Haggenmacher's gravity purifier, which originates in Ignatz Paur's first sieve purifier.

The principle of action of that sieve purifier is as follows (Fig. 394): If we compel the stock to travel over the sieve *a–a* in the direction pointed by arrows *b*, and at the same time impel a current of air of a sufficient force under the sieve, the state of the flowing product will be similar to that of boiling. Its light particles will be lifted over the sieve and carried

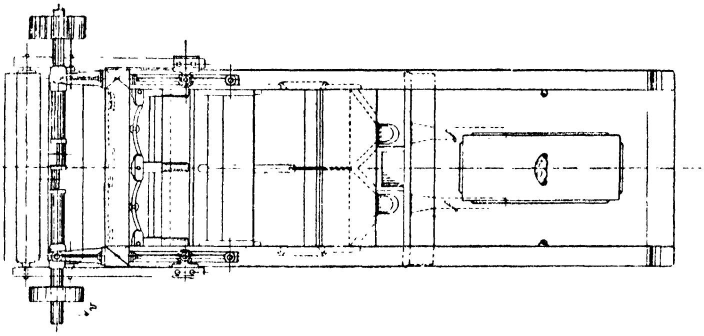

FIG. 393.

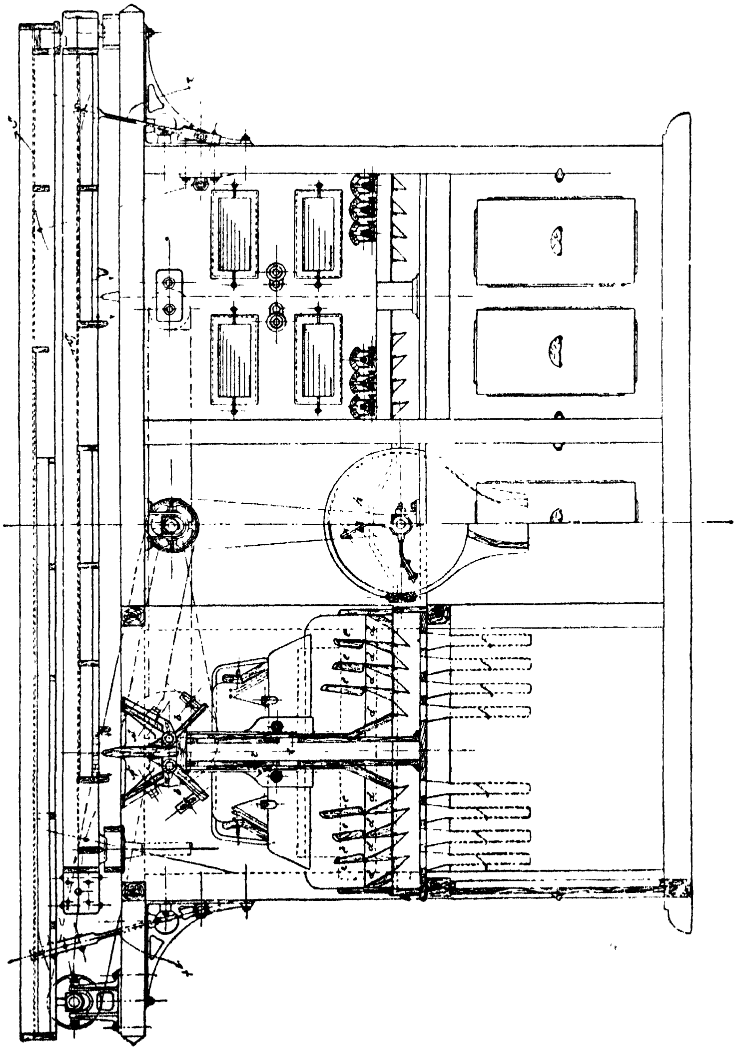

FIG. 392.

by the draught upwards. Part of that light refuse will be sucked out towards the fan, the rest, consisting of heavier offal, will collect in boxes over the sieve, into which it will drop owing to the abatement in the velocity of the air, which expands on leaving the canals between the boxes.

In this way, the air-current here lies at an angle of 180° to the direction of bolting, and at an angle of 90° to the direction of motion. The light particles are lifted off the sieve and separated as light or heavy offal. The heavy product passes through the sieve, and the tails consist of the large, generally less heavy product, because the largest-sized middlings, the conditions of reduction of the kernels being equal, always consist of the integumental particles of grain.[1]

The principle of this machine has remained unchanged up to the present day, and on this principle the machines are designed in Europe as well as in America. In some constructive minutiæ the works of Seck Bros. have altered their "Reform" purifier from their first model, and in its present shape it is given on Figs. 395 and 396. The stock to be treated flows into the hopper *a*, and is then fed in an even stream by the feed roll *b* to the surface of the sieve *c*, performing a reciprocating motion. Above the sieve, at no great height, are set similarly to fire-grates sheet-iron channels *d*, with their ends inclined to the longitudinal channels *f*. The sieve being placed in a closely shut up chamber, the whole of the air sucked in by the fan *e* must pass through the bolting cloth. The light refuse is carried away by the fan to the dust collector, the heaviest falls into the sheet-iron channels *d* and the side worm (Abstoss der Aspiration), and the medium refuse upon the inclined planes lying over the channels *d*. The refuse collecting inside the chamber generally

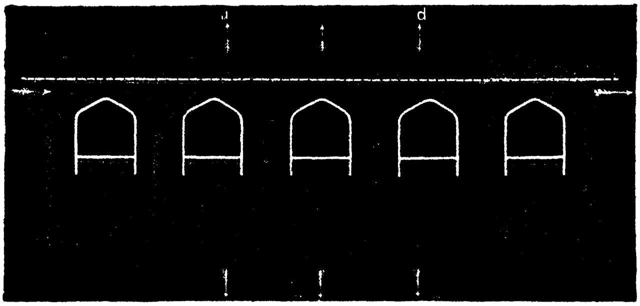

FIG. 394.

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[1] In one and the same break or rebreak passage the coloured middlings, *i.e.* the particles covered with bran, are always larger than the pure ones. This is due to the fact that the middlings with offal are more elastic, and, consequently, offer greater resistance to reduction than middlings out of the pure endosperm.

mixes together, whereas the offal settling in the worm separates, being the heaviest obtained in fanning the refuse off the sieve *c*.

The cleaning of the sieve *c* is performed by means of brushes fastened to endless chains. The transmission of motion is sufficiently clearly illustrated by the drawing.

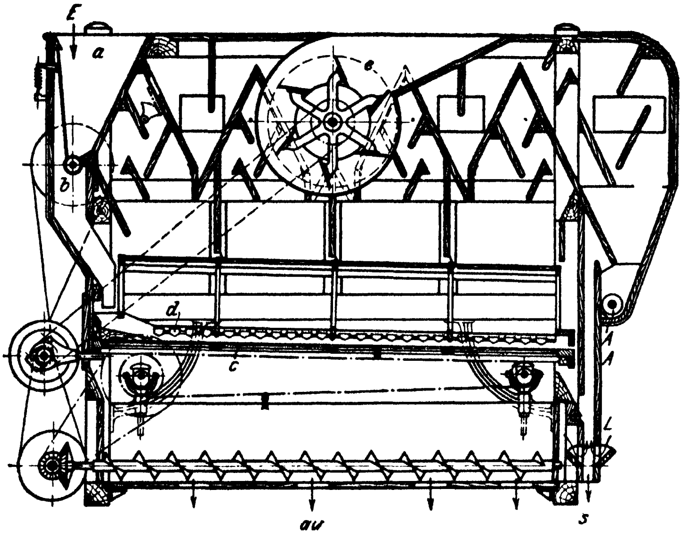


FIG. 395.

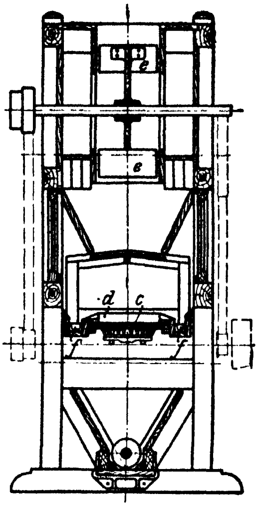


FIG. 396.

E—Inlet. *A*—Refuse from ventilation. *L*—Inlet of air.
S—Overtails of sieve. *au*—Outlet of middlings.

This type of machine operates well in cleaning different sized middlings, also coarse and fine dunst. A perspective view of the machine is shown on Fig. 397.

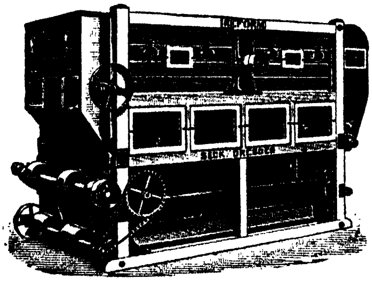


FIG. 397.

Robinson's Sieve Purifier. — The English sieve purifier constructed by Robinson (Fig. 398) is also a modification of Smith's purifier, but in its principle of action it remains unchanged, as do also the sieve purifiers of other works.

I illustrates the longitudinal section of this purifier, *II* a cross-section, and *III* and *IV* are the plans. Figure 1 indicates the frame of the oscillating sieve, 2 its bolting surface, 3 the deflecting boards V-shaped at their base. The air, directed upwards and aspirated by an ordinary fan 6, lifts out of the stock on the sieve 2 the light particles in such a way, that they fall upon the deflecting boards and are rejected to the sides of the bolting tray, where the greater part of them land on the deposit platforms 7. When several trays 3 are used with spaces in between them, the air-current passing through the sieve 2 is equal in force in all parts of such a sieve. The trays are made with gravels 8 for the sake of greater lightness, and, owing to their channelled shape, serve for collecting the heavy refuse, which has a tendency to falling back on to the sieve. It is best to fix the trays 3 with their ends to the frame of the sieve 1, so that, when swinging, the dust in the grooves 8 and on the side channels 7 would travel to the lower edge and fall into the dust-collecting box 9. Figure 10 indicates the spout conveying the stock into the working space, 11 the spout for overtails, 12 a hopper for the throughs, 13 the frame of the machine. If the air-current, on passing by the deflecting trays 3, were to run directly to the fan 6, part of the offals would not settle on the side channels 7, but would be carried to the fan. To avoid this, the direction of the draught blowing by the trays 3

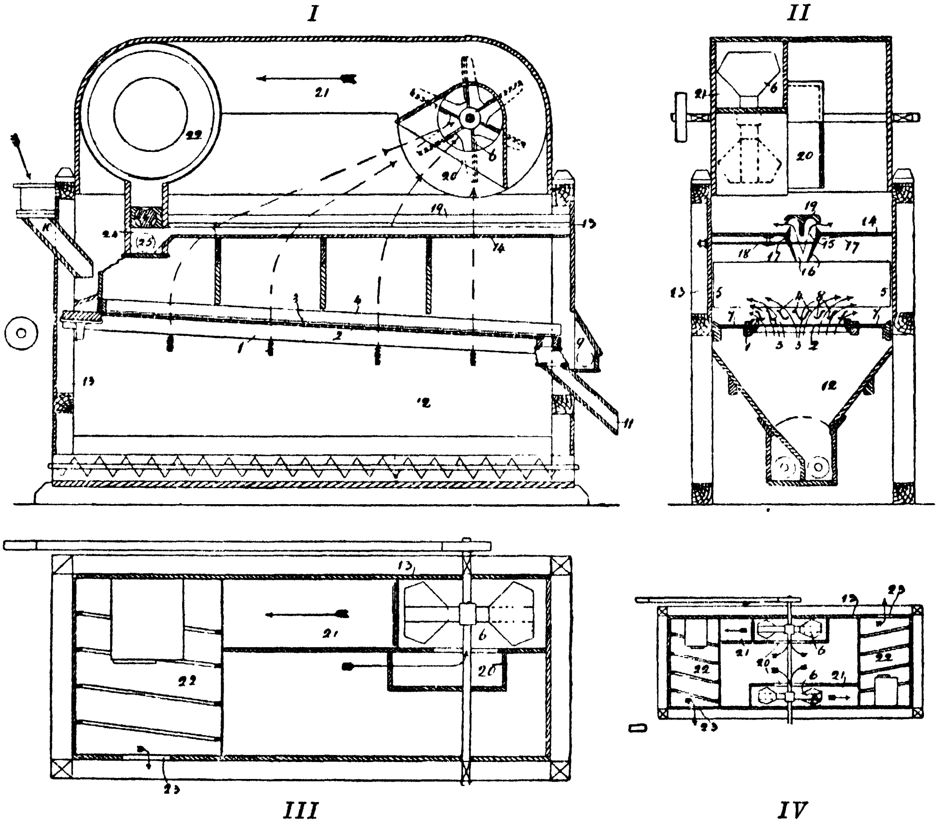


FIG. 398.

is sharply altered by means of the baffle plate 14 attached to the frame 13. In the centre of the baffle plate 14 there is made a long and narrow hole 15, parallel to the spaces between the deflecting trays 3. Thus, all the air passing between the trays is deflected to the opening 15, and the greater part of the offals settle on the side channels 7. With joints 17 under the hole 15 there are attached adjustable gates 16, the free edges of which may be brought closer to or further from each other by means of rods 18 or some other contrivance for regulating the width of the opening. With figure 19 is indicated the deflecting cap over the opening 15, which compels the remaining particles of dust, owing to the centrifugal force they develop, to settle on the top side of the baffle plate 14, whence they may be removed by a running brush or in some other way. Having passed the baffle plate 14, the exhausted air goes through the passage 20 to the fan 6. This fan impels the air along the passage 21 to the expansion chamber separator 22, which is of the centrifugal type. In the expansion chamber the air circulates spirally and makes its exit through the outlet 23. The rest of the dust deposited by centrifugal force on the casing collect in the dustbox 24, whence by means of the worm 25 it is

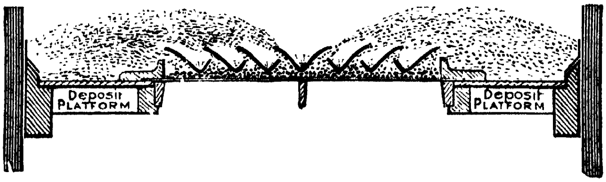


FIG. 399.—Cross Section of Sieve and Channel Cowl.

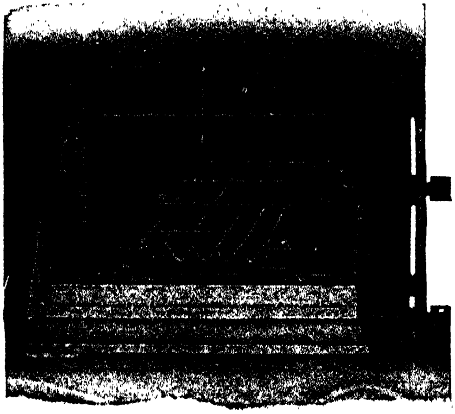


FIG. 400.—Perspective View of Channel Cowl in Working Position.

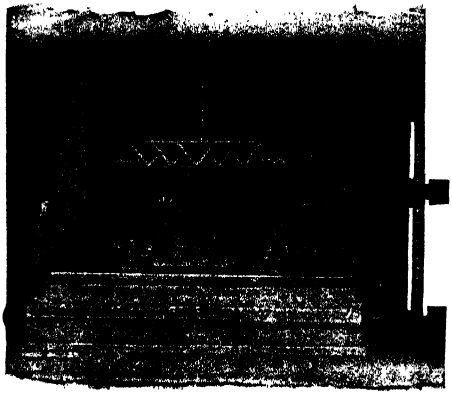


FIG. 401.—Channel Cowl raised for Cleaning of Sieve.

taken out of the machine or conveyed to one of the side channels 7. Several fans and separators may be employed. Fig. *IV* illustrates on a reduced scale the plan of a machine, similar to the one examined, but with two fans 6 and two dust collectors 22.

For convenience sake when using the sieve purifier for coarse product or for two kinds of stock with a stronger current of air, the sieve is divided in two parts, and the stream of product is guided separately to each half. Both the air-currents are directed into the centrifugal separator and the fan, as in the former case. In Fig. 402 is given the longitudinal section of such a sieve purifier. The parts corresponding to parts *I*, *II*, and *III* are marked with the same figures. The sieves 2 face each other at an incline. For each of the sieves there is a separate feeding spout 10. Number 11 indicates the deposit platforms for refuse, and 9 an ordinary worm for refuse rejected by deflecting trays and the side deposit platforms of both the sieves. The dust collector 22 is furnished with two inlets adjusted by the valves 26, so that through both the sieves there should pass air-currents of equal force. In this case the air is not impelled through the collector, but drawn through it by the fan 6 stationed by the outlet 23. The offal from the box 24 goes to the worm 25,

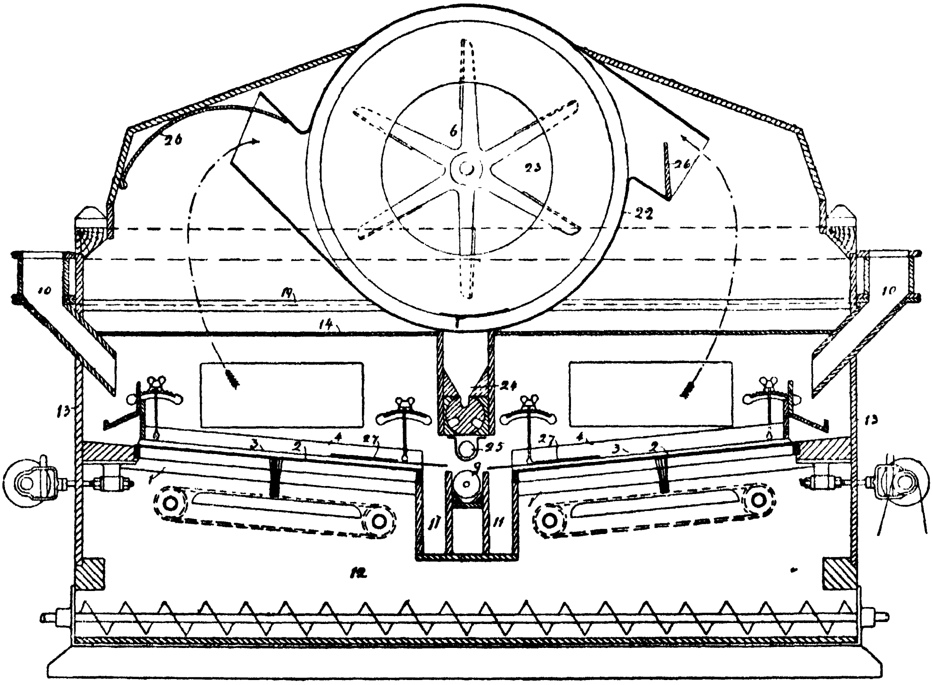


FIG. 402.

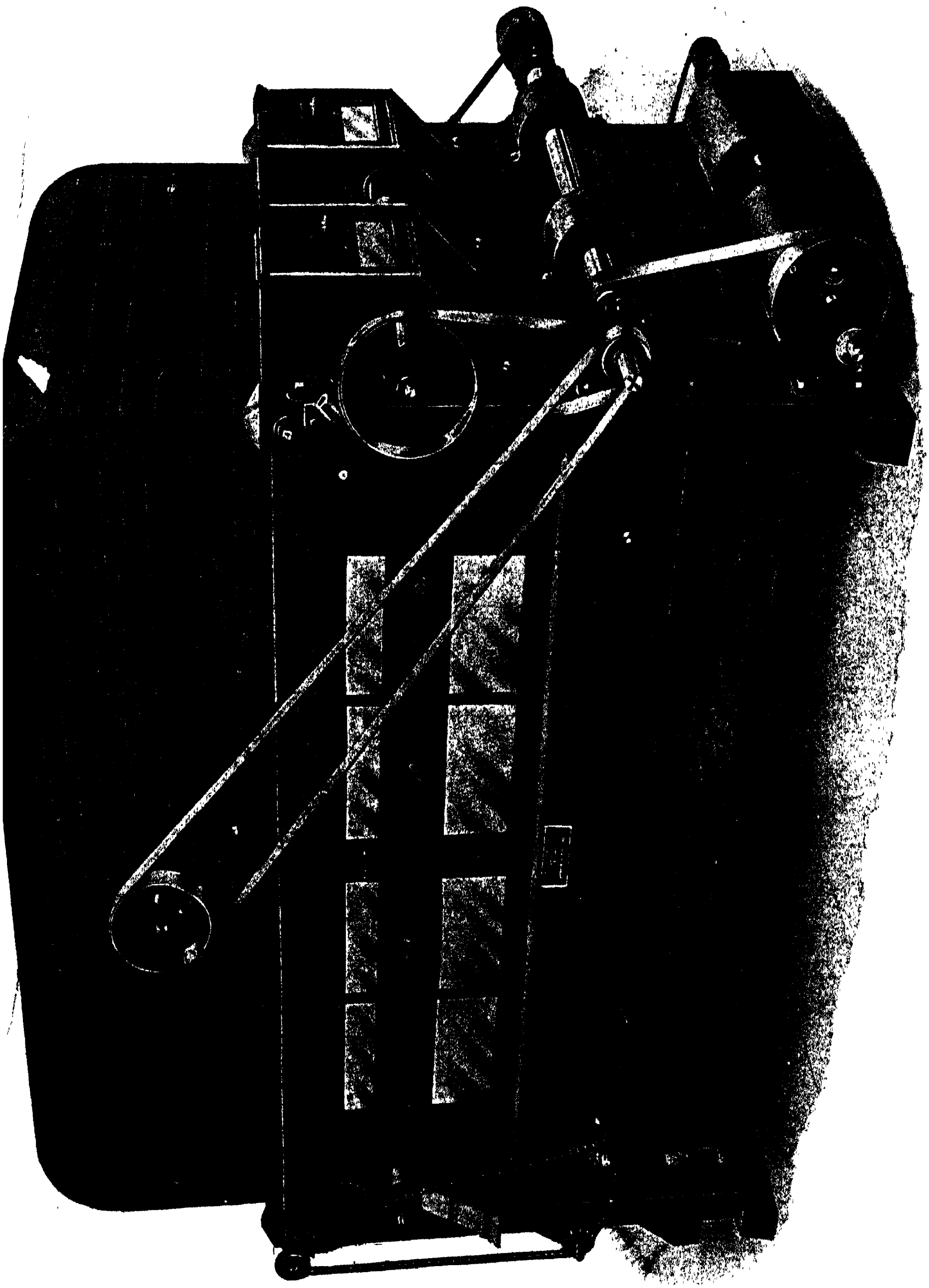


FIG 403.—Perspective View of Robinson's Sieve Purifier.

which conveys it out of the machine. Over the divisions of the sieve there may be set boards 27 to reduce in case of need the air-current which passes through the sieve at this point, where the strength of the draught is the greatest.

A perspective view of the sieve purifier is given on Fig. 403.

Schneider, Jacquet & Co.'s Sieve Purifier.—A characteristic peculiarity of the Schneider, Jacquet & Co. sieve purifier is that, firstly, it requires no dust-collector for the fan offals, and secondly, it operates with one and the same volume of air, which moves in the machine in a locked current.

On Figs. 404 and 405 may be seen the longitudinal (the middle part of the machine is cut out) and transversal sections. The action of the machine is as follows.

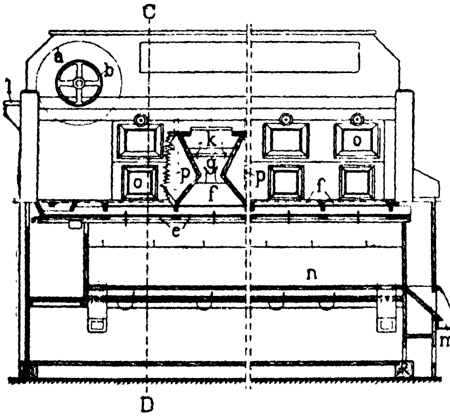


FIG. 404.

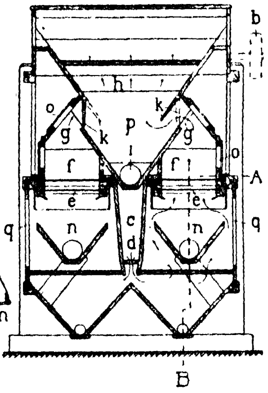


FIG. 405.

The air in the chamber of the machine is brought into motion by the fan *a* with an outside driving belt-pulley *b*. From the fan the current of air passes down a vertical spout to a horizontal channel *c* (Fig. 405). Then it travels as indicated by the arrow through the longitudinal bottom opening *d* of this channel to the working chambers under the sieves and returns to the fan. On its way the air passes through vibrating sieves *e*, on which the stock to be purified lies. The lighter particles are carried off the sieve by the air-current, to pass through the chambers *f* and openings *g* into the separating space *h*. In travelling from the sieves *e* down the chambers *f*, the current, owing to their decreasing transversal section, becomes narrower. The velocity of the draught here must therefore increase; it attains its largest magnitude when the current passes through the openings *g*, and then it all at once drops to its minimum, so that the light particles carried away, losing their kinetic energy, drop into the chamber of the worm *i*. The increase in the velocity of the air-current when passing through the chambers *f* is an advantage, in so far that the light particles separated from the stock on sieves *e* cannot fall back. Owing to the expansion of air in the collecting space, the light particles settle down, and are thence carried away by means of the worm conveyor *i*. The air chambers *f* are so arranged, that the openings *g* can be adjusted by the valves *k*.

Each machine has several chambers *f* arranged in rows. For the stock under treatment to be evenly cleaned, it is indispensable that the air should pass through all the chambers at an equal pressure. The pressure of the current leaving the fan and running into the channel *c* decreases when passing down this channel. Because of this difference in pressure, the outlet *d* running below along the channel *c* is made wider behind (from the fan) than in front, and has, in this manner, the shape of a trapezium. Expelled through this opening in the channel, the air flows out with an even pressure at every point of the passage, and, owing to the backward increasing width of the openings in the sieves *e*, blows through the working chambers with different force. This will be clearly explained by the following.

By passing through the outlet in the channel *c*, the air acts upon the reverse surface of all the sieves *e* with equal pressure. Since the stock to be purified lies in a large mass on the first sieve, which is finely meshed, the purifying draught of air cannot pass through this layer of product as easily as through the more open back sieves where the layer of product has already been partly bolted, and is consequently not so thick. The quantity of air passing through the front sieve is therefore the least, and in proportion as we approach the last sieves it increases, since the resistance to be overcome by the air-current in passing through a successive row of sieves with decreasing numbers gradually diminishes. Thus the grading air-current penetrates all parts of the machine with equal pressure, but through the working chambers *f*, owing to the diminishing resistance, the air passes in different quantities. Owing to this, the process of purification is performed evenly in all the air chambers, because the draught penetrates into them with equal pressure.

Down the inlet boss *l* (Fig. 404) the stock to be graded runs in a manner required to the vibrating sieves *e* in the machine, over which it travels in a longitudinal direction. At the boss *m* the coarser parts which have not passed through the sieve meshes are tailed over. The middlings which passed through the meshes into the box *n* are carried away by worm conveyors. To allow of the frequent inspection of the purification during operation, in the chambers *f* there are windows *o* adapted especially for that purpose. The even distribution of the air-current in the whole machine down the channels *c* and *h* has this advantage, that the fine light particles are not carried by the draught to the chambers, but settle in a special compartment. The chief chamber for the precipitation of the light particles *h*, which also runs down the length of the machine, is to this end divided by suitably adapted partitions *p* into a certain number of sections, so that each two opposite inlets of the chambers *g* open into one such section. The partitions do not cut off the chamber *h* in its full height, so that the light particles of product settling in all the sections may be discharged by means of a common worm conveyor *i*.

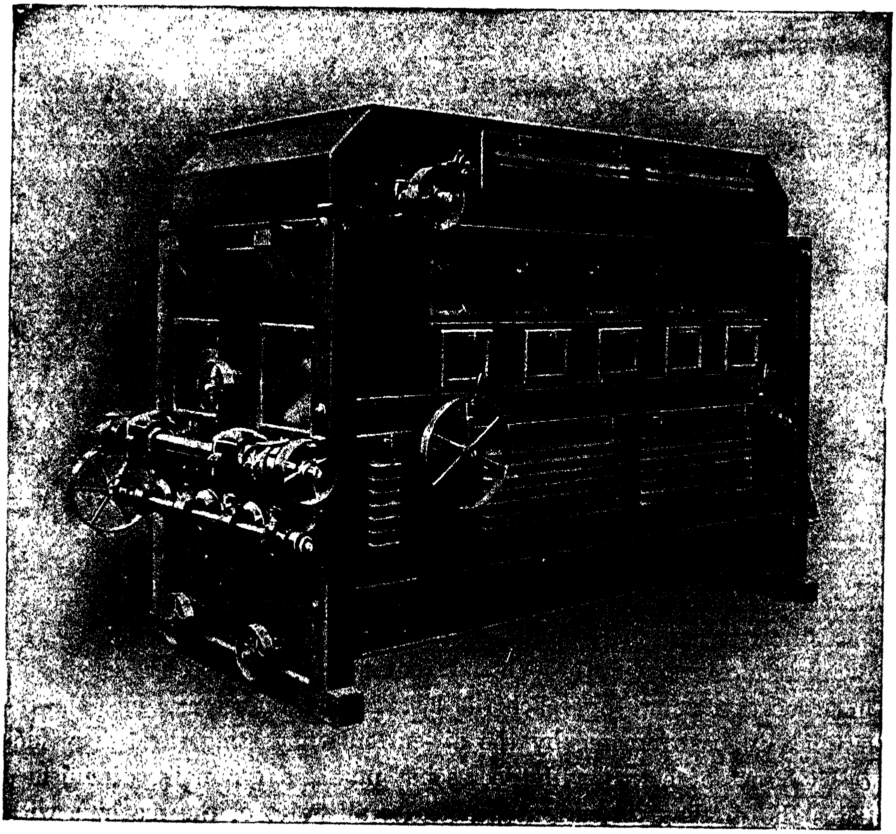


FIG. 406.

The surfaces on which the particles separated from the stock precipitated are so arranged that these particles cannot remain settled anywhere, and are constantly delivered by the machine as heavy offal.

Thus the peculiarities of this middlings and dunst purifying machine consist in that under the chamber *h* for collecting the light particles of product passing down the full length of the machine there is arranged a channel *c*, for the passage of air, which also runs through the length of the machine. The longitudinal bottom opening *d* of this channel is arranged to correspond to the decrease in pressure in such a manner that the air-current passing out of it enters all the working chambers at an equal pressure.

The chamber *h* for the light particles is divided by partitions into several sections, the number of which corresponds to the number of double chambers *f*. This is done to prevent the formation of strong air-currents in the narrow part of the chamber *h* about the inlets *g*.

Fig. 406 illustrates the perspective view of the sieve purifier.

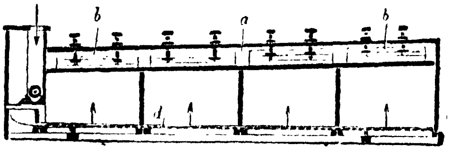


Fig. 407.

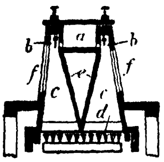


Fig. 408.

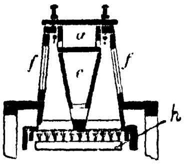


Fig. 409.

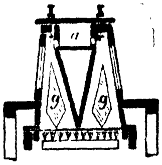


Fig. 410.

II. Brunner's Purifier.—In his recently patented machine Brunner aims at a simplification in the construction of the types we have examined, attempting to discard the collecting plates and worms from the purifier. His point of departure was the principle that with the decrease in the cross section of the passage of air over the sieve, the velocity of motion of the offal increases and their falling back on the sieve is an impossibility In all the constructions illustrated in Figs. 407–410 the air from the chamber *a* occupying the full length of the sieve is drawn out by a suction fan. Through the openings adjusted by gates *b* the air passes out of the chamber *c*, which is divided into several parts. The space *c* containing the rarefied air contracts after this, beginning immediately from the sieve *d*, owing to which the air-current is evenly distributed over the full breadth of the sieve. In Figs. 408 and 409 the contraction of the space *c* is attained by having the walls *e* and *f* raised in the shape of a cone upwards from the sieve. In Fig. 410 are illustrated the intermediate partitions *g* built into *c*, which also assist in making that space rapidly narrower, so that directly it leaves the sieve the air-current acquires a greater speed and the light particles lifted are carried away to the outlets *b* and through their openings pass into the chamber *a*. The bottom of the chamber *a* may be slanting, and then the heavy refuse will run out of itself; or the draught may also be left there of such force that it would be able to carry these particles out of the chamber with it. In the second case the heavy refuse can be collected by the dust-collector or in some other way.

III

CAPACITY OF PURIFIERS

In his book Professor Zworykin gives the capacity of the purifiers in accordance with the length of the working air fissure.

Let us name the capacity of the machine Q, the length of the fissure b, the velocity of motion of the product v, and the width of the fissure (the thickness of the stream of product) e. Then we obtain:

$$Q = abev,$$

where a is the coefficient of proportionality.

If we name the finished stock Q_0, it may be expressed through Q by introducing the coefficient of proportionality k, which is the number of passages required for cleaning the product:

$$Q_0 = \frac{Q}{k} = \frac{abev}{k} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1).$$

But k, the number of passages, is proportionate to the thickness of the sheet of product fed in and inversely proportionate to its average dimensions. Therefore

$$k = \frac{\beta e}{\delta},$$

where β is the coefficient of proportionality. But k, the number of passages, will diminish with the increase of the number of fannings n. Therefore:

$$k = \beta_0 \frac{e}{n\delta} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2).$$

By substituting k from (2) into (1), we obtain:

$$Q_0 = \frac{a}{\beta_0} nb\delta v.$$

Since practice shows that almost in all constructions of purifiers the velocity of the feed is a constant quantity, we finally obtain:

$$Q_0 = Ab\delta n \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (3),$$

i.e. the capacity of the purifier is directly dependent on the length of the fissure, the size of the stock treated, and the number of fannings.

Experiments show that 1 cm. of total length of the draught fissures produces from 1 to ½ klg. per hour or 54 to 27 lb. per day (24 hours) of pure semolina, depending on the size of the product.

These data refer to Haggenmacher's type of purifier. As to the purifier of Seck's type (" Reform ") this calculation is useless, for the air-current operates through the sieve. For the sieve purifiers it would be necessary to reckon the cross section of the bolting cloth, lowering it by a certain coefficient, because the stock passing through the sieve blinds the meshes of the cloth for the moment.

In calculating the number of purifiers one may use the data of the works, which deserve full confidence. The compound Table XLII of the capacities of the " Reform " type sieve purifiers, from practice, gives results almost similar to the data of the catalogues of the German works.

TABLE XLII

CAPACITY OF SIEVE PURIFIERS

Dimensions of Machine Nos.	Working Surface of the Sieve on an Average (for Different Works) in Square Metres.	Capacity per Hour in Cwts.		Number of Vibrations (Double) of the Sieve per Minute.
		Middlings.	Dunst.	
1	1·200–1·400	11·8–16·0	7·8–9·6	500
2	1·000–1·200	10·0–13·2	5·9–8·2	500
3	0·800–1·000	8·1–11·0	4·8–6·0	500
4	0·500–0·640	5·9–7·8	3·2–4·5	500
5	0·350–0·400	3·6–5·1	2·1–3·0	500

On an average it may be reckoned that 1 square metre of the sieve purifier cleans 10 cwt. of middlings and 6 cwt. of dunst per hour.

In closing the section on grading the product according to the quality, we must point out that a gravity purifier of Haggenmacher's type may be employed for semolina, and sieve purifiers of the " Reform " type are preferable for cleaning fine middlings and dunst, these machines being of a more delicate structure.

CHAPTER VII

ACCESSORY APPLIANCES AND MECHANISMS

COMPARATIVELY recently, to the fundamental mill machinery there have been added a series of appliances and mechanisms of an accessory character, without the assistance of which the milling process would be impeded or would produce unfavourable results in respect to the quality of the product as well as the health of the staff operating the mill.

The development of automatic grinding required an improvement in the transportation service at the mill, and the necessity for keeping a certain standard of flour on the market compelled millers to employ machines and apparatus with the aid of which the influence of the inconstancy in the quality of wheat upon the outward appearance of the flour might be neutralised to a certain degree.

The most essential necessity for a mill is the ventilation of the machines. By means of exhausting the grain-cleaning machines, as we saw when studying their construction, the removal of dust and screenings is attained, which is indispensable not only for the machines, but for the mill building as well, since the penetration of dust into the parts in contact with the machine is injurious to them, not to speak of the danger of explosions, fires, and injury to health.

In the mill proper the ventilation of machinery is of still greater importance, because not only dust but evaporation occurs here. In fact, owing to the heat generated by grinding, the water contained in the grain turns partly to steam, especially in the milling of soft kinds of rye and wheat. The heated air, saturated with steam, comes in contact with the cold walls of the machines and bedews them. This phenomenon is identical to the sweating of cold window panes when they are breathed upon. In the winter, the formation of dew in the machinery of the mills with badly arranged ventilation is so great that the water pours down the inner walls of the roller mills in thin streams.

Besides the machines, the spouts, elevators, worm conveyors, and bins suffer from the warm, damp air. The timber parts rot, and the iron rusts. The flour turns to paste, clots of dough block the spouts, find their way into the elevators, and thence into the bolting machines, the sieves of which become blinded by the paste, and the capacity of the mill often drops 50 per cent., and sometimes the spouts and the elevators are so badly choked that it is necessary to stop the mill and give the machines, spouts, and elevators a general cleaning.

The damp air, however, has a detrimental effect not only upon the machines, but upon the meal too. The moisture contained by the flour imparts a dark colouring to it. If the flour contains a great quantity of moisture, a spirituous fermentation often sets in, and reduces its rising and baking qualities.

Thus, the aim of ventilation is to remove the dust and the warm, damp air from the machines.

In classifying the accessory appliances and mechanisms in the mill we may divide them into two groups :

I. Ventilation of the machinery and the mill.
II. Transportation, blending, and improvement of the product.

The first group gives the following two sub-divisions :

1. Mechanisms and apparatus for improving the intermediate products.
2. Dust-collectors.

The second group has four sub-divisions :

3. Transportation of the stock.
4. Apparatus for blending the flour and packing.
5. Apparatus for calculating the quantity of stock.
6. Apparatus for bleaching the flour.

In this order we shall now proceed to examine the construction of the accessory mechanisms and apparatus.

I

PURIFICATION OF THE INTERMEDIATE PRODUCTS

Robinson's Cyclo-pneumatic Separator.—This separator is placed after the break rolls for the first four or five breaks. We know that a certain small percentage of bran is reduced to meal dust and stripped off the berry in the shape of small beeswing on the grain being passed through break rolls. In addition, part of the remaining beard is torn off, and broken up. The integumental dust darkens the break flour, the offal mixes with the middlings, and the hairs of the beard blind the meshes of the meal sieves and make sifting difficult. To separate the bran powder, offal, and beard, it is well to employ apparatus through which the break product can be passed and subjected to cleaning. Robinson's separator

(Fig. 411) is such an apparatus. It is a cyclone and an aspirator combined. The break product runs from the rolls into the feed tube *D* and through it on to the rotating disc *A*, which flings the product up fanwise. On its route from the space *E* to the hopper *F*, the product is subjected to the action of an air-current which carries away the dust, offal, and beeswing. Out of the hopper *F* the cleaned break chop flows down the spout *G* into the sifter for further grading.

The aspiration is effected in the following manner. The fan *W* sucks the air out of the cyclone into the space *E* and drives it down arrows *S* into the chamber *B*. When the air is passing out of the right-hand side part of the chamber into the left under the dividing partition *L*, the heavier particles of integument develop a centrifugal force and fall into the worm *P*, and the air with the lighter dust particles flows into the cyclone. The centrifugal force presses these light particles of dust against the walls of the cyclone, and they roll down arrows *S* into the worm, while the pure air is again drawn up to the space *E*. In this way the work is performed by a constant quantity of air. The offal from the chamber *B* and the cyclone collects generally in a common worm, and is discharged as indicated by arrow *l*. The dust offal contains also a part of break flour, which is then separated away on a sifter. To prevent any circulation of air, there are leather partitions set in the worm.

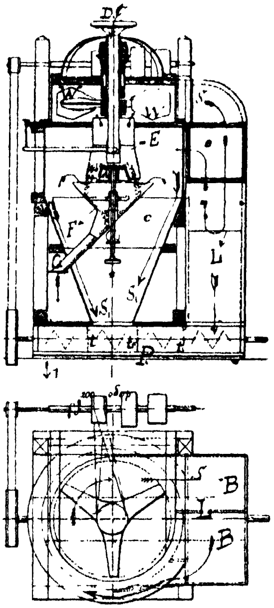


FIG. 411.

The Schneider, Jacquet & Co. Apparatus.—A more simple apparatus for cleaning the break stock is the chamber illustrated on Figs. 412, 413, and 414.

This apparatus is stationed before the break rolls, and separates the offal from the break semolina. If the break process has high breaking and eight breaks, it is well to set the apparatus for the semolina from the first (after the high breaking) six breaks and for the rebreaks (for the first two of the three).

Fig. 412 gives the longitudinal and half of the transversal section of this apparatus, which consists of a rectangular timber cupboard, through which there pass the worms *a* and a_1 for the removal of the more or less heavy offal. The break semolina flows down the spout *A* on to the inclined plate *B*. On this plate there are set the distributors *b*, which break up the narrow stream of product into a broad sheet, which descends as shown by the arrow c to the outlet into the box D over the roller mill. On its route of descent the product is subjected to the action of an air-current x streaming in through the crevice between the adjustable gates d and d_1. Besides the regulation of the width of the crevice between the gates d and d_1, the force of the draught may be altered by the gate O. The air is aspirated by a fan through the spout E.

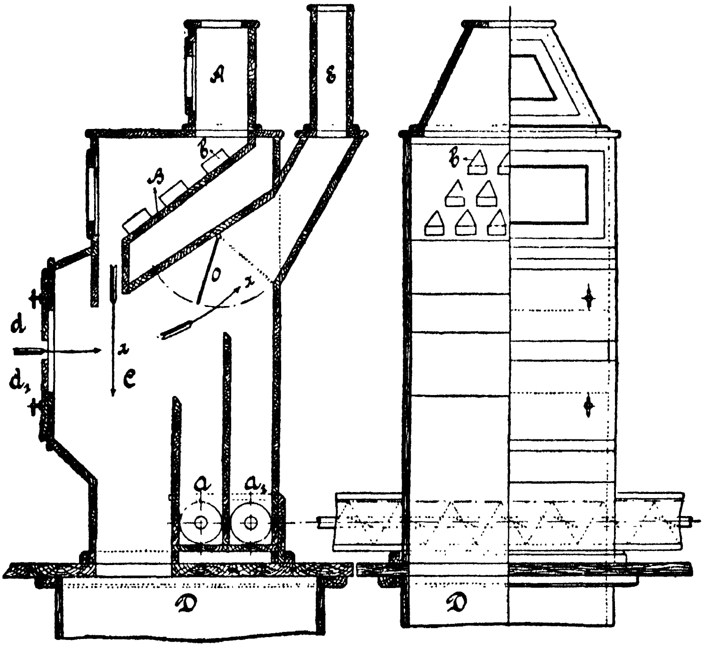


Fig. 412.

The longitudinal and the side view of the installation of eight machines is shown on Figs. 413 and 414, where it is seen that the offal passes into the aspirated worm A, whence it is conveyed to the sack or to the bolting machines.

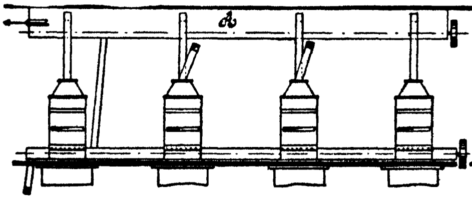


Fig. 413

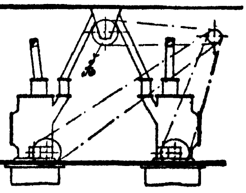


Fig. 414.

The Briddon & Fowler Pneumatic Scalper.—Attempts have often been made to arrange the cleaning of the break chop in the roller mill itself, but with no good result. Of the latest attempts, a construction of the Briddon & Fowler works in Manchester (Fig. 415) deserves attention.

This has been made the foundation of a system (patented) of milling. It is the outcome of experiments made by Fowler in a Yorkshire mill. He found that a pronounced natural separation takes place in break stock coming from the nip of diagonal rolls. The heavier stock, *i.e.* partly broken wheat, semolina and heavy middlings, are thrown farthest from the roll, while the break flour, finest middlings and dunst are thrown down on the inside. An adjustable division board, under the nip of the rolls, effects, without any mechanical agency, an immediate separation of the heavy and the branny particles from the floury stock and fine dunst. Thus contamination of the break flour or the production of inferior attrition flour is obviated, and the colour and granularity of the break flour are improved. Currents of air—working as in a gravity purifier—assist the separations. The system is working most successfully in many of the largest British mills, and is regarded as one of the most successful innovations of recent years.

FIG. 415.

II

DUST-COLLECTORS

Dust-chamber.—The simplest kinds of dust-collectors are dust-chambers or dust-bins. Their arrangement is very simple. A free corner of the mill is partitioned off by a timber frame clothed with canvas (a simplified chamber is clothed with old flour sacks), thus forming a dust-bin. The dusty air is driven out of the machines by fans into this chamber, and oozes through the canvas walls of the bin, leaving the dust on them. In proportion as the dust collects on it, the canvas is shaken, the dust falls on the ground, and is removed when the fan stops working. Sometimes the dust-bin is made with an inclined bottom and discharge spout with a sack fitted to it to receive the dust.

This simplest kind of dust-collector is arranged in small mills with the means about them. The dust-chamber occupies much room, but its filtering area is insignificant.

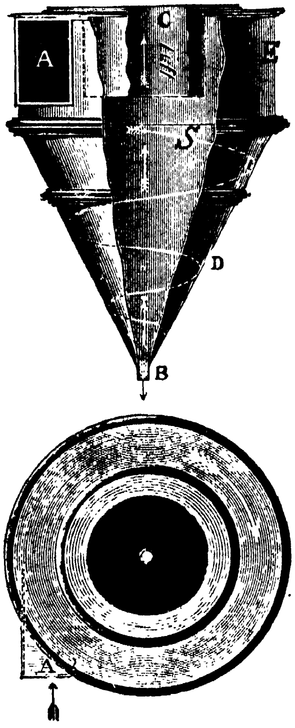


Fig. 416.

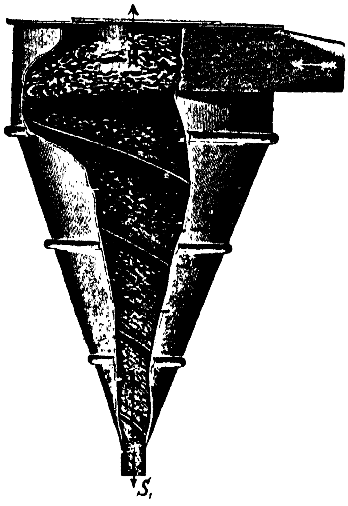


Fig. 417.

Cyclones.—The cyclone apparatus invented by the Americans is a more perfect dust-collector. On Fig. 416 is shown an ordinary kind of a cyclone, its partial section and the view from the top. The dusty air flows into the feeding tube *A*, passing into the ring space between the cylindric part *E* of the cyclone and the outlet tube *C*. This ring space is covered over with a lid, in consequence of which a rotary motion is imparted to the air in the ring closed on the top, and it travels in a helical direction downwards along the arrow *S*. With the increase of resistance to motion the air-current in the narrowest part of the cone is impelled in the direction of least resistance, *i.e.* upwards, and passes out through the tube *C*. Owing to the spiral motion of the air the particles of dust develop a centrifugal force and press against the walls of the cyclone, down which they slide to the exit *B* influenced by their gravity. Thus, the air emitted through *C* is perfectly pure and free of dust.

Such is the action of all cyclones. This apparatus is very simple, its action is satisfactory, but it is comparatively bulky.

Wishing to improve the action of the cyclone, Howes' works in America suggested a more complex construction of an apparatus with a compulsory spiral motion of the air and dust in the chamber (Fig. 417) by furnishing it with helical arms. This complication in the construction, however, does not improve the action of the cyclone, but the contrary, for the arms have very little influence on the direction in which the air travels, and at the same time retard the delivery of the dust.

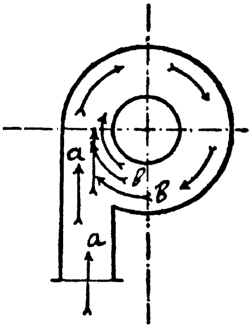


FIG. 418.

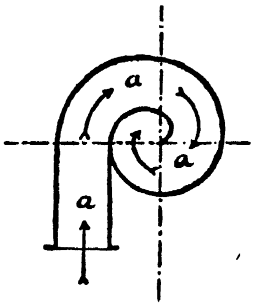


FIG. 419.

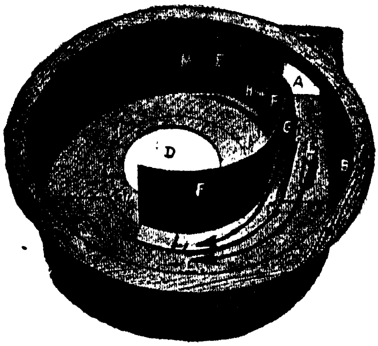


FIG. 420.

The Knickerbocker Co. Cyclone.—The cyclones we examined have the defect that quite a considerable part of the pressure is lost because of meeting at a fairly large angle, as we see in Fig. 418, the air flowing into the cyclone and gyrating there. To avoid any intersection of the air-currents, the celebrated American cyclone works, the Knickerbocker Co. (Jackson, Michigan), which invented the first cyclone, suggested in 1905 a new principle for a cyclone, in which a spiral motion is immediately communicated to the inflowing air, as it is shown in Fig. 419. Here the axis of the efflux of the air does not coincide with the axis of the cyclone. The meeting of the air-currents is obviated in the cyclone of such a construction.

On Fig. 420 may be seen the cylindric part of such a cyclone. The air runs into the receiver *A* and along the arrow *L* passes spirally to the partitioned-off section of the chamber *J*. The spiral direction is communicated to the current by the walls *E* and *F*. The first wall is closely fitted to the wall *M* of the cylinder, while between it and the wall *F* there is a clearance *H* through which the superfluous amount of air can pass out along the arrow L_1. The current of air *L* acts partly as in the deflector in respect to the chamber *J*, consequently the streams *L* and L_1 do not cross each other, but coincide. And if the air travelling under the walls of the chamber *J* has not separated away the whole of its dust and offal, then, in passing again into the fresh supply chamber, it can be totally freed of admixtures. The exhaust air passes out through the opening *D*, eccentrically made in the lid of the cyclone. The position of the opening *D* may be altered, since the ring *K* is eccentrically set in the lid. This is of consequence for a correct setting of the air outlet. The cyclone construction we have just examined is the best of all existing types of these dust-collectors.

Filters.—The most generally used dust-collector is the tube filter, which has almost totally driven out the cyclone in European mills. The tube filter is convenient in this respect, that occupying little space it gives a large working surface.

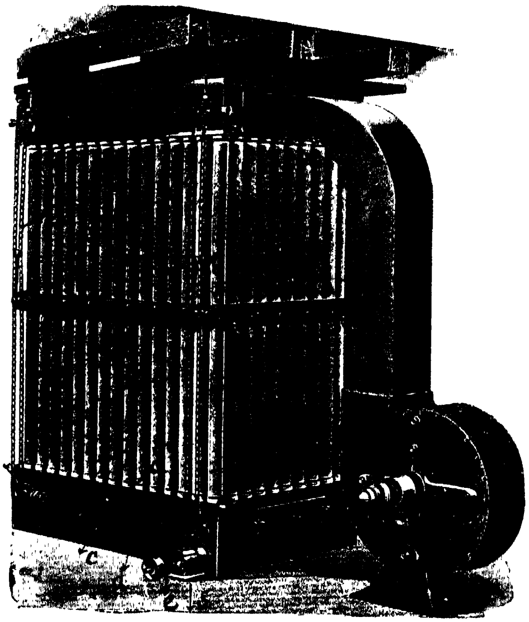


FIG. 421.

On Fig. 421 we have a pressure tube filter. It consists of two, generally timber, boxes, *A* and *B*, the chambers of which communicate with each other by linen tubes. The dusty air carried by the fan *C* out of the ventilated chambers passes into the top chamber *A*, whence it is distributed to the tubes and filters through the cloth, leaving the dust on its inner surface.

From off the tubes the dust is shaken by means of a frame *D*, which has a wire running from one side to the opposite on every one or two rows of tubes. The distance between the wires being less than the diameter of the tubes, the latter are compressed. The frame *D* runs up and down uninterruptedly, and in this manner shakes off the dust, which falls into the bottom box *B*. The frame *D* rises and falls by means of four chain drives, it being suspended on the chains *a* by means of straps *b*. The dust fallen to the bottom of the box *c* is scooped away by scrapers *d*, which run down the full length of the box and are brought into action by a chain drive *g* inside it, and is thrown into the worm *e*, whence it is delivered through the outlet spout as indicated by the arrow *s*.

Fig. 422 illustrates the suction filter, which differs from the preceding in that it is enclosed in a common box. In the first case the fan should be placed between the aspirated machine and the filter, in the second after the filter. In this manner the fan sucks the air out of the box *A*. The dusty air which is conveyed into the top box by the air pipe from the machines precipitates into the tubes and filters through their cloth, owing to the air in the box *A* being rarefied. Consequently, through the fan there passes pure air.

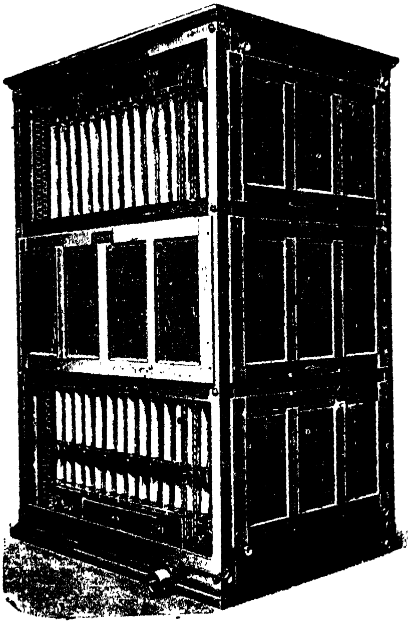


Fig. 422.

In comparing these two types of filters, we must speak in favour of the first one for cheap plants, seeing that firstly its construction is more simple, secondly it requires 15 to 20 per cent. less power, there being no such resistance to the outflow of the exhaust air as we see in the suction filter; thirdly and lastly, its operation is easily supervised, whereas in the suction filter the shaking frame is hidden in the hermetically closed box *A*. The latter circumstance could be obviated in the suction filters, if a glass inspection window were to be made in *A*; but for some reason or other none of the works do it, though this would be very useful. Among the defects of the pressure filter we may count the fact that the exhaust air, not always free of dust, passes directly into the mill, whereas in the suction filter it is discharged by the fan into the open, and the mill does not remain free of dust if the filter works unsatisfactorily.

On Figs. 423 and 424 may be seen the American tubular filters made by S. Howes' works. The first one is a type similar to the European construction, differing from it only in the greater ease it affords for inspection of the lower working box, the lid of which may be lifted. The second filter, likewise sectional, is more simplified, the scrapers here being discarded and a bin with a worm below placed, into which the shaken-off dust falls out of the outermost tubes down the inclined walls of the bin.

The star-shaped forcing filters are much more popular in America. Fig. 425 shows such a filter, made in Europe by Luther's works. The filter consists of a stationary cylindric casing with longitudinal or round holes. Over this casing is fitted another similar one, but rotating with the aid of a ratchet wheel gear. On the rotating casing there is set a series of tubes stretched by springs on either end of the plank, which is also connected with each tube. The driving belt-pulley is the large one on the left; it operates the whole mechanism, in which the lever pawl turns the filter one or two cogs, while the hammers on the axle hit the tubes approaching them from the top. Since the stationary cylinder is divided into two parts, of which the lower one receiving the dusty air communicates through the holes with the tubes, and the top one containing the worm is isolated from dusty air, the dust which remains after the air has passed through the cloth of the lower tubes falls out of the top ones, when they are hit with the hammers, to the lower part of the casing, and is discharged by the worm.

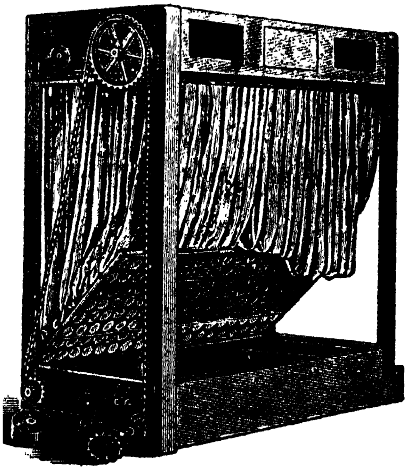


FIG. 423.

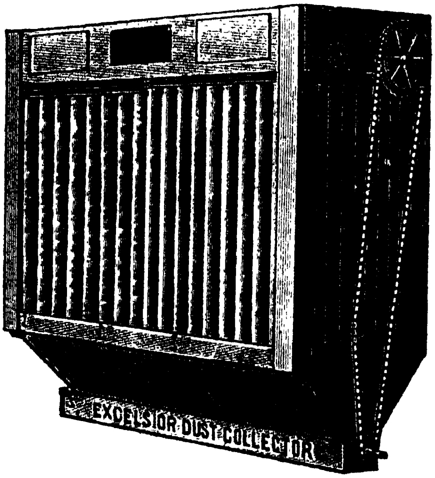


FIG. 424.

In spite of the comparative complexity of the mechanism these filters are very widely used, owing to their being more compact than the European tubular filters. They have made their appearance in Europe, too, of late.

We shall end the chapter treating of filters with a description of one of the latest types of Seck's suction tubular filters. Fig. 426 illustrates the longitudinal and the cross section, and Fig. 427 a perspective view of this filter. It consists of an iron cylindric chamber *b* containing the filtering tubes *c* closed at the top, and attached by their edges to the bottom of the chamber and open for the discharge of dust. With the aid of an aspirating air pipe *k* the chamber *b* communicates with the fan. The dusty air from the exhausted machines passes through the air pipe *i*, whence it runs into the tubes *e* and filters out, free of dust, into the chamber *b* owing to the rarefaction of space between the tubes and the casing of the chamber. The tubes are suspended to the lever *d*, which rises and falls owing to the operation of the ratchet wheel *e* on the shaft *f*. Simultaneously with the dropping of the lever *d*, during which the tubes receive a shake, the valve *l* also

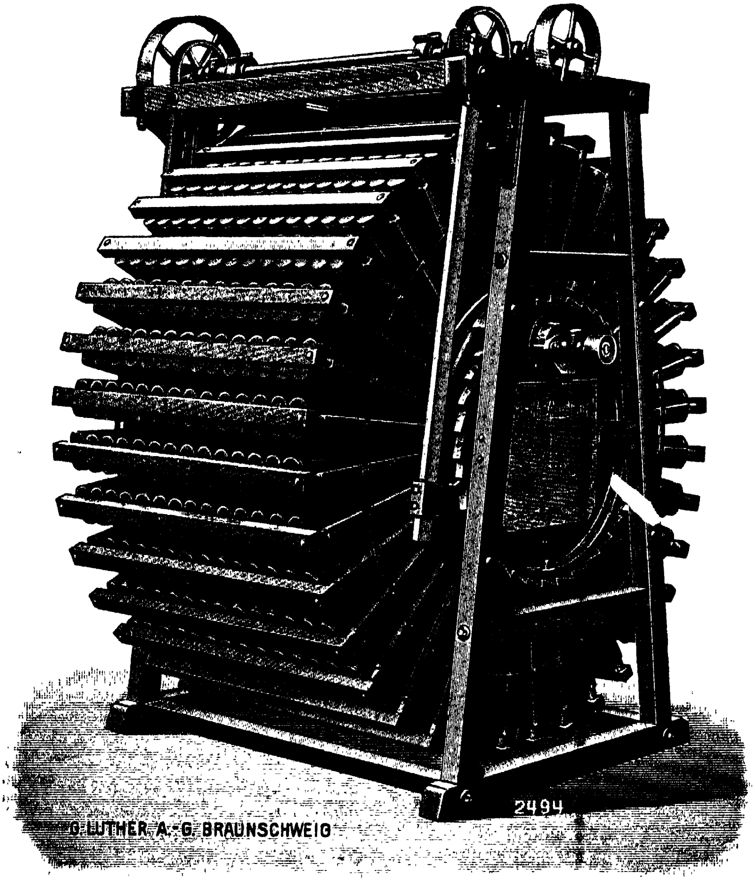


FIG. 425.

closes automatically, so that the suction of the air out of the filter is discontinued for the moment of the shake. The dust descends to the box *g*, whence it passes into the worm. The heavy offal drops into the worm when the air flows into *g*, because owing to the sharp curve the current performs the offal develops a great centrifugal force and is flung down.

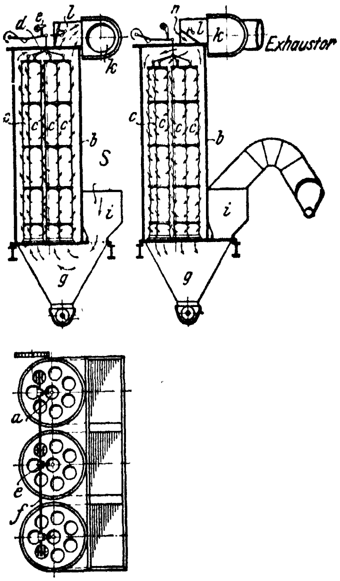


FIG. 426.

n—Recurrent of air.
S—Dust-laden air.

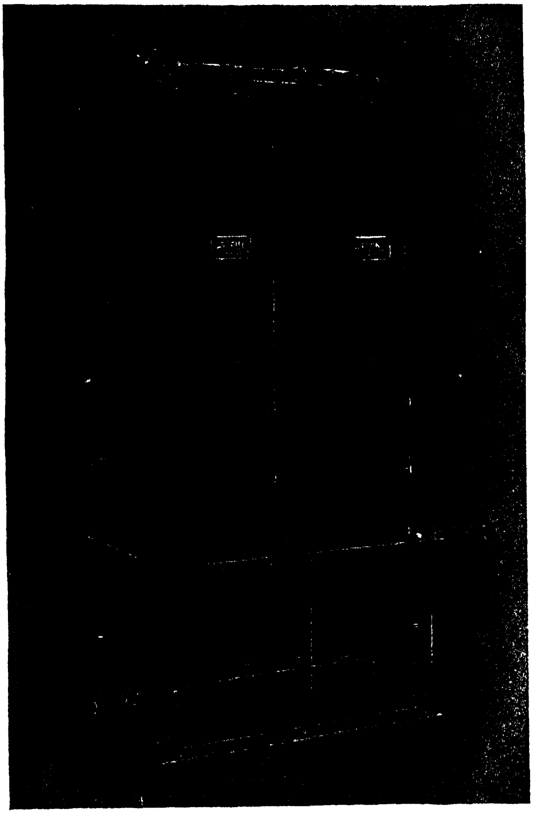


FIG. 427.

Generally the suction filter plants have two chambers at the very least, as in Fig. 427. But more often three or four chambers are joined together. This guarantees continuous work of the filter also, because when one of the filters is being cleaned, *i.e.* the suction tube *k* is closed with the valve *l*, the others at the same time are open, the ratchets *e* being brought into action by turns.

III

EXHAUST SYSTEMS

1. *Group Exhaust Systems*

Ventilation of Roller Mills.—The removal of the bran powder and flour dust, as well as the cooling of the rolls and of the heated product, is the aim of ventilation for roller mills. There are two ways of exhausting the rolls. The first is based on the principle of counter-currents, when the draught is directed opposite to the motion of the product; the second, when the direction of the air and the stock coincide. In most cases the first method is accepted by the works, by reason of the dust being easily separated from a thin sheet of product with an air-current. But the condensation of steam in the cooler top part of the mill chamber and the formation of paste on the walls of the frame are to be reckoned among the defects of this method. The absence of condensation owing to the constant temperature in all the parts of the chamber speaks in favour of the second method; to its defects may be referred the smaller capacity of the air-current to remove the particles of dust and shells from the compact mass of stock travelling down the spout or the worm. However, the defects of both the first and the second methods are avoidable. If the mills are not overloaded and the product is not heated much, the difference in the temperatures will be insignificant and there will be no condensation. In the second case, when the air-current crosses the sheet of product, the particles of dust are extracted out of it and do not mix in the spouts with the rest of the stock.

Fig. 428 represents an American ventilating plant on the principle of counter-currents. The product is fed in at *S*. The air flows into the chamber of the mill through the windows *A*, which are covered with cloth or a metal screen, traverses the sheet of product flowing out at right angles, and passes out as indicated by the arrow S_1 into the common trunk *B*, carrying the dust with it. The fan *C*, in sucking the air out of *B*, forces it into the star filter.

On Figs. 429 and 430 we see Seck's system of exhausts, in which the direction in which the product travels coincides with the route of the air. In the case when the incline of the spout *A* is sufficient for the product to run down of itself, the plant in Fig. 429 may be used. The product leaving the mill flows down the spout *A* to the elevator. The air is aspirated through the trunk *B*, which directs it to the worm *C*, doing service for several rolls, and whence the fan sucks the air through the trunk *D*. In the spout *A* there is a freely suspended valve *a*, which does not allow the air to pass into the ventilated worm out of the elevator ; in the bend of the trunk *B* there is a valve or a gate *b*, with the aid of which the intensity of the exhaust in any particular mill may be regulated by opening it wider or less. The heavy offals carried away by the air-current

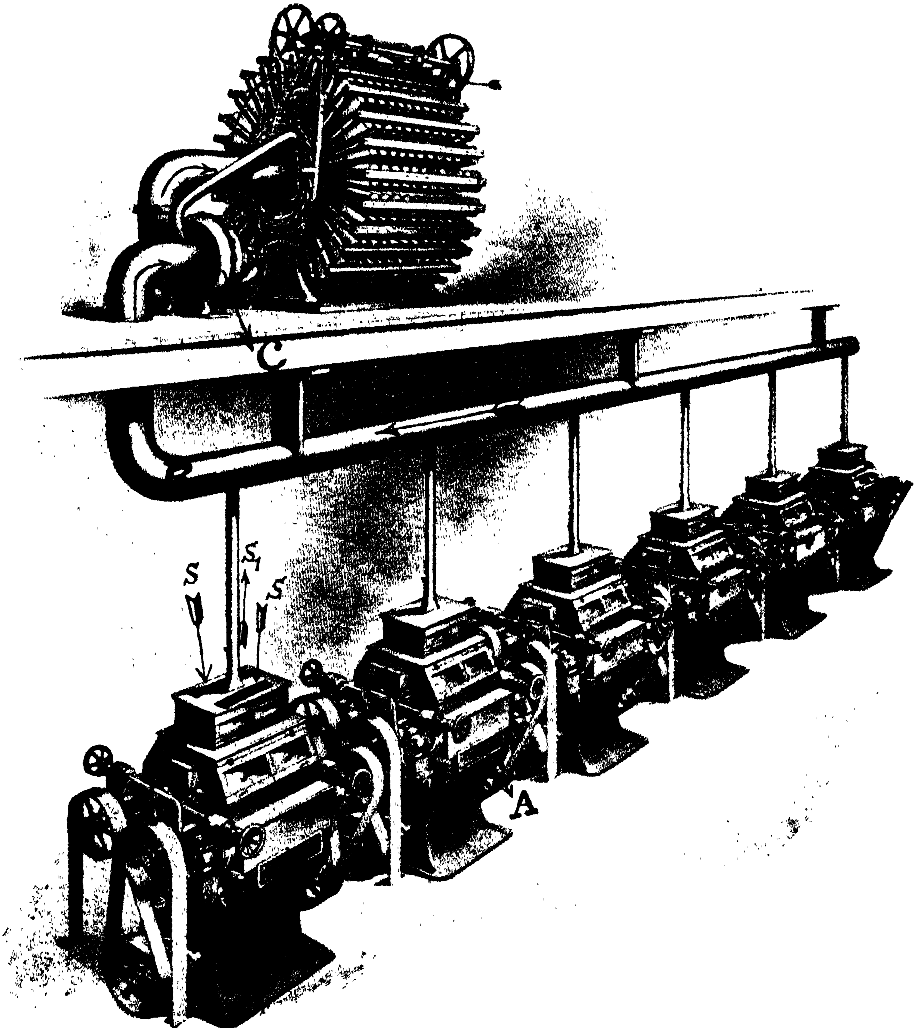


FIG. 428.

out of the stock drop into the worm and are conveyed by it into the open, while the light dust runs down the trunk *D* to the filter, where it collects.

In case the elevators have to be stationed far from the roller mills, and the stock cannot flow to them of itself, the exhaust arrangement shown in Fig. 430 is employed. Here is set the worm *E*, out of which the air is aspirated by a similar trunk *B*. In the remaining part of the plant there is no difference.

We have been examining here the exhaust systems of the most important machines, the roller mills. Before proceeding to a description of general systems of exhaust we must set several general rules for a rational construction of the plants.

How important a correct calculation and construction of exhaust is we may judge by the example of a German mill, which being driven by a 260 H.P. steam engine consumed 110 H.P. for ventilation, *i.e.* 43 per cent. of the power used by all the milling machines. Such enormous consumption of power for the exhausts was caused solely by bad construction and incorrect calculations.

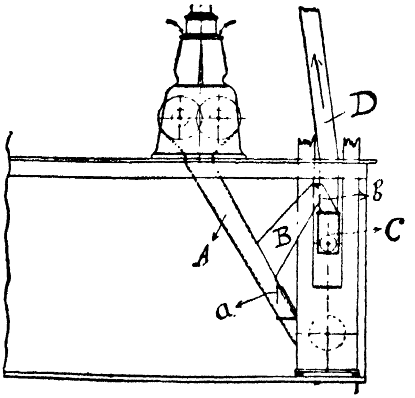


FIG. 429.

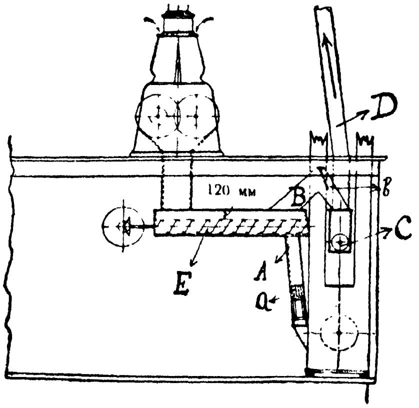


FIG. 430.

One of the main details of an exhaust plant is the air trunk, down which the dusty air is driven out of the machine to the dust-collector by means of a fan in the machine itself or a fan outside it. The separate air trunks communicate with the main trunk, on which generally the main fan is set.

In constructing and reckoning out the ventilation, the following general rules should be borne in mind :

1. A correct computation of the general quantity of air required for the plant given, *i.e.* the selection of suitable fans.

2. The sections of the air trunks should be so calculated as to have an equal quantity of air passing in their different sections, where the velocities may be different.

3. The coupling of the air trunks should be such as to involve no loss of air pressure.

4. The dimensions of the chambers, cyclones, and filtering surfaces ought not to cause any superfluous pressure, which requires a greater consumption of power.

Rules 2, 3, and 4 give the ground on which a correct choice of the fan can be made, and we shall therefore speak of them more in detail.

If we have two equal machines placed at unequal distances from the fan, we cannot use air trunks of equal sections. Obviously the air trunk of the further machine will offer greater resistance to the motion of air, being the longer of the two. To have both the machines placed in equal conditions of ventilation, it is necessary to make the trunk of the further machine larger in section, taking its dimensions in accordance with the length, which defines the loss in pressure.

In no case may trunks of an equal section be used for equal machines, when this section is calculated from the air consumption and the pressure of the machine farthest removed. In that case the machines lying nearer to the fan will be subjected to a more energetic exhaust than is needed, and the regulation of the air trunks by means of valves or gates will incur an extra consumption of power.

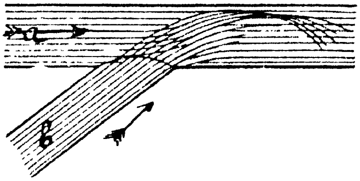


Fig. 431.

The absence of sharp bends in the trunks and their joints is of great importance. The greater the number of bends, especially at right angles, the greater is the loss in pressure of the exhaust plant.

The coupling of air trunks must in no case be at right angles, as we have it on the American plant, which serves as an example of the worst kind of coupling for air trunks. If we have a coupling of two air trunks at a certain considerable angle, about 45° (Fig. 431), for instance, then the air-currents *b* entering into the main air channel intersect with the currents *a* and thus hinder each other, mutually reducing the general pressure. It is necessary to have these streams almost coincide in their direction of motion. The practice of to-day has fixed the largest angle formed by the axes of the coupled air pipes at 5°.

As to the size of dust-collectors (chambers, cyclones, and filters), in selecting them such dimensions should be taken as will not cause any loss of the necessary pressure before the fan, owing to stoppage of the exhaust air passing out. Beyond these limits the dimensions of dust-collectors may be increased without harm to the plant if the space and the means allow it. Dust-collectors of super-normal size facilitate the work of the whole plant.

2. *General Exhaust Systems*

Ventilation of the Grain-cleaning Department.—Knowing the fundamental requirements of a rational ventilation of machinery, we can give

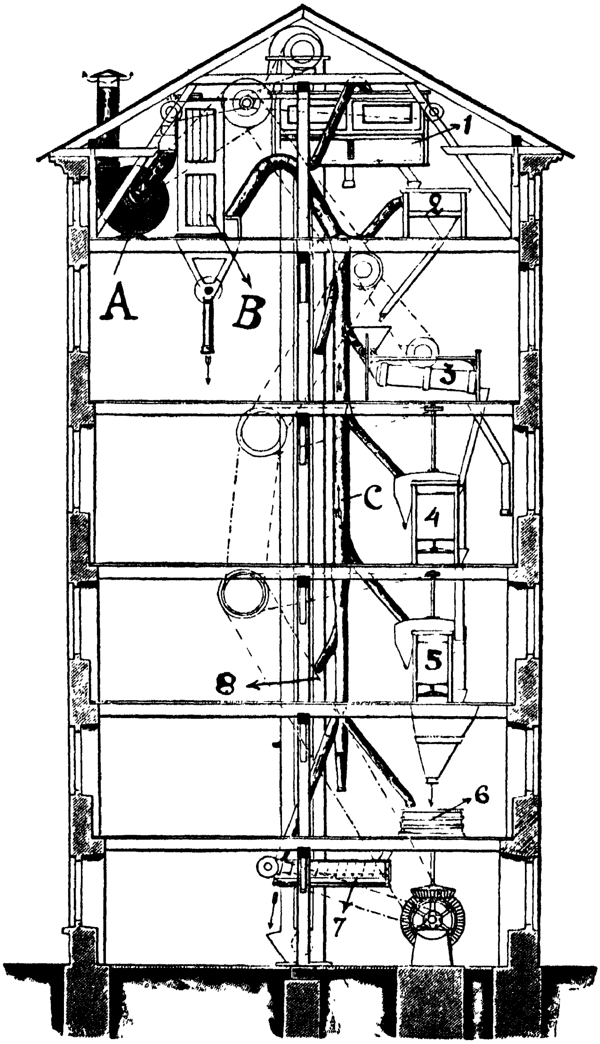


Fig. 432.

a general type, as a more complex one, of an exhaust plant for the grain-cleaning department of automatic mills, from which it is an easy passage to simple plants.

On Fig. 432 we have a cross section of the grain-cleaning department containing all types of machines. The ventilation is performed by means of

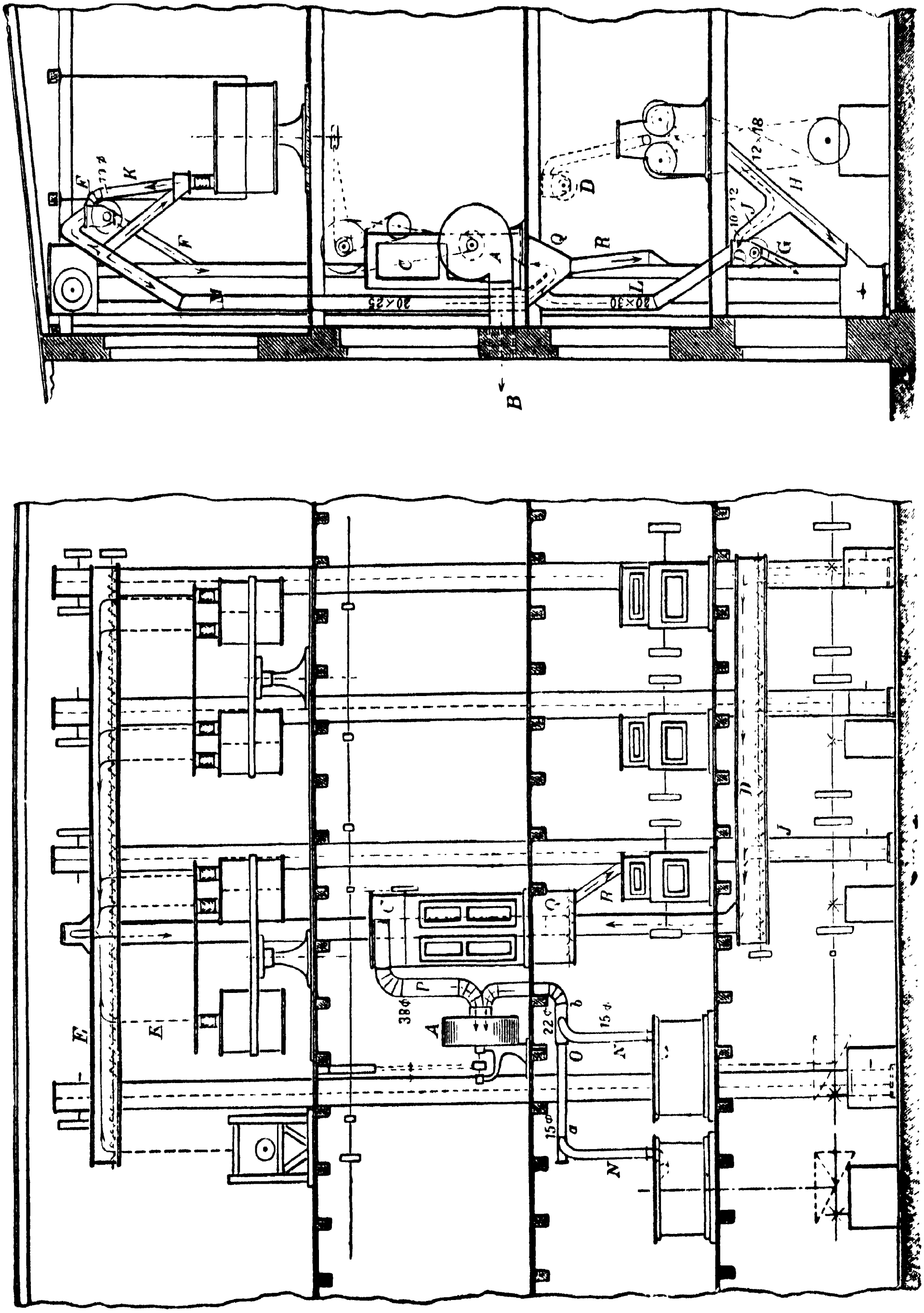


Fig. 433 and Fig. 434.

the fan *A* and the suction filter *B* of the Seck type we have examined. The main air channel *C* is disposed vertically, and tributary to it are the conveying air trunks from the dusting reel separator 1, separator 2, trieurs 3, scourers 4, brush machines 5, scouring millstones 6, clean reel separators 7, and lastly, from the automatic elevators 8 at two points. In this plant we see that the junction of the conveying trunks with the main channel lies at the least possible angle of their axes. The vertical position of the main channel is to diminish the quantity of harmful resistance, and the fan is set on the top floor, which allows of utilising the natural pressure of air in respect to the machines standing below.

Ventilation of the Milling Department.—In Figs. 433 and 434 we have a diagram of the exhaust system for the milling department of a rye mill of 100 sacks per day (24 hours) capacity. A fan *A* and a suction filter *C* operate for this plant.

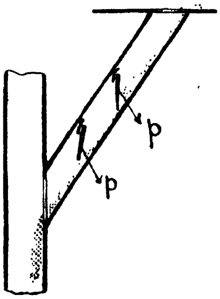


FIG. 435.

Speaking generally, the air trunks from the machine should be set at an incline allowing the heavy particles settling in them to run down of themselves. For the heavy offals to run down in this manner it is sufficient to have the spout inclined at an angle of 60°. In the plant given and those similar to it, however, the common channel for the roller mills had to be made horizontal, and therefore it contains a worm *D* for the discharge of heavy refuse. The necessity of grouping the sifters for general ventilation in a similar manner required a worm *E*. The ventilation worms differ from the ordinary ones in that their chamber is made considerably higher (the area of the cross section is 1½–2 times as large), to allow the air free passage.

In this plant we see that the air trunks *N* from the stone mills run directly to the fan, passing the filter by, as the millstones have their filters in the chamber of the casing.

The heavy offals and flour collected by the worms descend along the spouts *F* (from the worm of the sifters) and *G* (from the worm for the rolls) to the nearest elevators corresponding to the quality of offals, returning in this wise to the stock ; the light dust and offals, on the other hand, pass to the filter, where they collect in the worm for discharge.

In the plant we are examining there are shown two variations of exhaust for rolls : one variation, with a bottom worm with ventilation of the spouts *H*, connected with the ventilated worm *D* by the air trunk *I*, is the type accepted by Seck; the other the one most generally used, with a top collecting worm *D*, outlined in dots under the ceiling (Fig. 434).

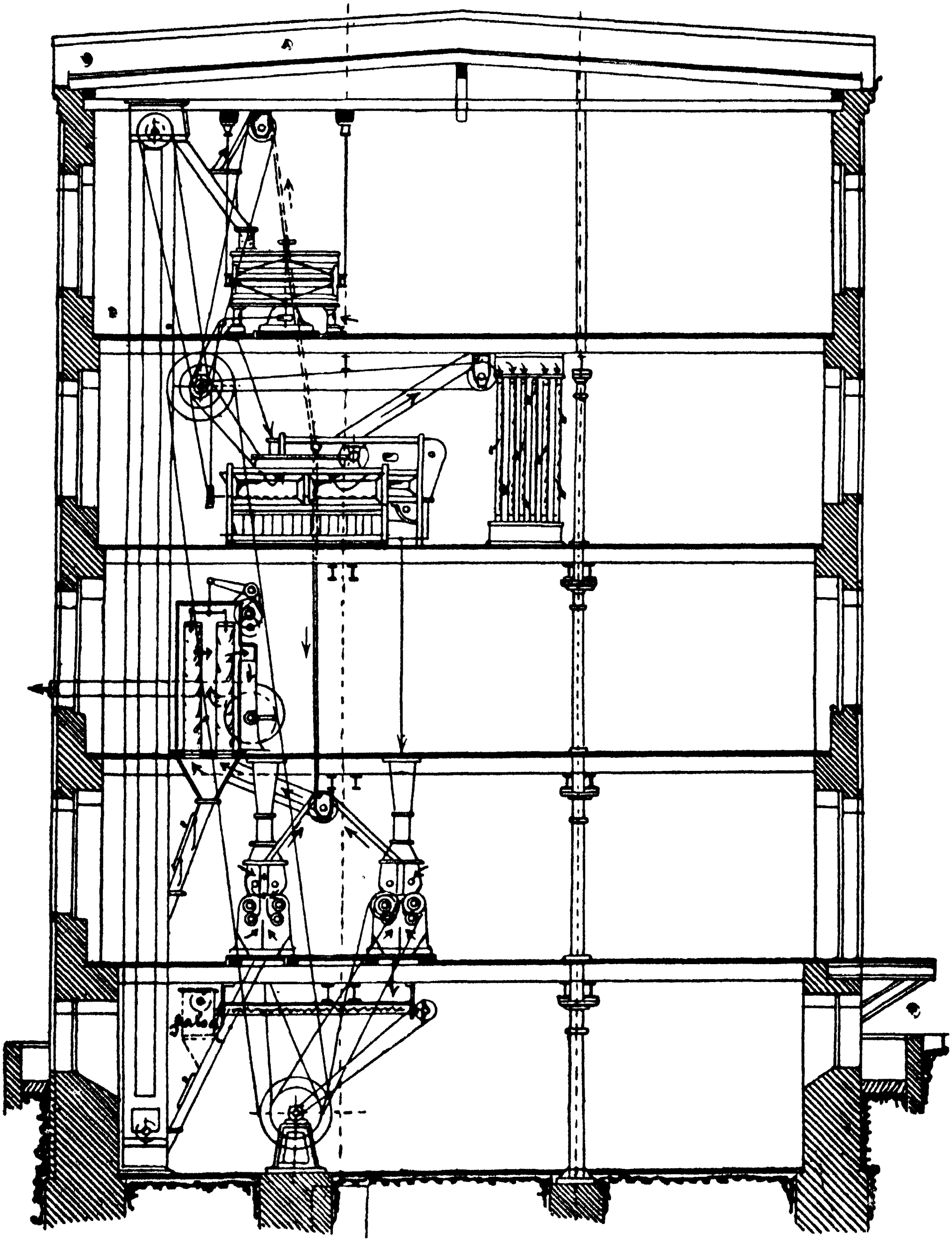


Fig. 436.

The comparative merits and defects of these two variations have already been spoken of.

Two common air trunks, *L* from the worm of the rolls and *M* from the worm belonging to the sifters, convey the dusty air to the filter, where it deposits the dust and is discharged by the fan through the trunk *B* leading outside the building.

The meal dust and light refuse discharged by the filters descend into the bin *Q* and a worm carries them out to the spout *R*, where they are admixed to the product going to the fifth break. The spout *R* can also deliver the filtered product to the centrifugal or directly into the sack. In any case this spout must have valves *p–p* (Fig. 435), which are opened by the pressure of the dust discharged and prevent the back draught of air into the filters, otherwise the action of the filters would be weakened.

Fig. 436 illustrates the exhaust plant of a wheat mill. In comparison with the preceding one there is an extra set of purifiers here, for which a pressure filter is installed. From the purifiers the dusty air is driven by their fans to the collecting worm, whence it passes to the filter. The sifters and roller mills are exhausted by the fan operating for the suction filter.

3. *Calculation for an Exhaust Plant*

To calculate the correct size of an exhaust plant it is necessary to know : (1) the quantity of air required to remove the dust and warm air from each machine ; (2) the area of the filtering cloth.

The Area of the Filtering Cloth.—It is more convenient to begin by determining the necessary area of filtering cloth, from which we shall pass to the calculation of the volume of air required for the given working effect.

Area of Filtering Surface for Machines of the Grain-cleaning Department.—

TABLE XLIII

CAPACITY 125 SACKS PER DAY (24 HOURS)

NAME OF MACHINE.	Area of Filtering Cloth in Square Metres.
Scales	20–25
Separator with one sieve	25–30
Separator of the zigzag type	30–35
Trieurs (cylinders)	12–15
Horizontal emery scourer.	30–35
Vertical emery (plate) scourer	30–35
Brush machine, horizontal	20–25
,, ,, vertical	20–25
,, ,, compound vertical[1]	20–25
Combined scouring machine of the Zolotukhin type .	40–45

[1] See Fig. 95, p. 103.

As regards the definition of the area of the filtering cloth, there is no possibility of any theoretical reckoning. One is obliged to make use of the practical data of the best foreign and Russian plants of to-day, which we shall append. These data refer to the filtering woollen tissue " malton " (German cloth) or to a Russian cloth of corresponding density.

The less limits of areas refer to the drier, and the larger limits to the damper grain.

Practice has proved that with the increase of capacity of the machine, the filtering area increases in proportion, but later diminishes by 10 to 15 per cent. For instance, if the capacity of a zigzag separator is 375 sacks, the filtering area for it will be :

$$3(3{\cdot}0-3{\cdot}5)-10{\cdot}3\frac{(3{\cdot}0-3{\cdot}5)}{100}=2{\cdot}7(3{\cdot}0-3{\cdot}5),$$

i.e. not 90–105 square metres, but 10 per cent. less.

The Area of Filtering Surface for Machines of the Milling Department.—The area of filtering surface for machines of the milling department is likewise defined from experimental data, which are expressed in the following figures :

To 1 metre of length of a pair of rolls for wheat	1·25–1·75 sq. mts.
To 1 metre of length of a pair of rolls for rye	2·5–3·0 ,, ,,
For a stone mill with stones 1 metre in diam. (wheat grinding)	1·35–2·0 ,, ,,
For a stone mill with stones 1 metre in diam. (rye grinding)	3·0–3·5 ,, ,,

For sifting machines 50 per cent. of the filtering area necessary for all reduction machines is required.

For purifying machines 125 sacks per day :

(*a*) Gravity purifier " Groupe "	10–15 sq. mts.
(*b*) " Double Pur. " of Haggenmacher and Voll	25–30 ,, ,,
(*c*) " Salgir " of Dobrovy and Nabholtz .	35–40 ,, ,,
(*d*) Sieve purifier of the " Reform " type .	35–40 ,, ,,

The quantity of air is more conveniently defined to 1 square metre of filtering area. Here practice has also established definite data. 7–8 cubic metres of air are required for 1 square metre of filtering surface.

To obtain a draught of exhaust air there are set, as we have seen, fans or separate fans for machines having no fans of their own. The pressures of the fans within the machines (scouring machines, separators, purifiers, &c.), or without, are generally not great, namely, from 40 to 120 mm. of the water column.

We must regard the capacity of fans given in Table XLIV as the normal, which should serve as a proving capacity for the catalogue data of different firms.

TABLE XLIV

CAPACITY OF FANS

Diameter of Wings, mm.	Diameter of the suction holes, mm.	Number of Revolutions per 1 Minute.	Volume of Air Delivered per 1 Minute in Cubic Metres.	Number of Horse-Power Required.
300	160	2100–2500	25–30	0·3–0·5
375	200	1650–2000	38–45	0·5–0·75
450	250	1400–1650	50–60	0·75–1·10
600	330	1050–1250	100–125	1·5–2·0
800	440	800–950	220–250	3·5–4·0
1000	550	650–750	350–400	5·0–6·0
1200	660	500–600	500–600	7·5–9·0

Once we have the above-mentioned data, the calculation of the details for any exhaust system may be undertaken.

For example, we shall reckon out the plant of the rye mill (Figs. 433 and 434) with high grinding we have examined, which has three double roller mills with rolls 800, 700, and 600 mm. long, two stone mills with stones 1300 mm. in diameter, two sifters, and one reel separator.

Suppose we are grinding rather damp rye. Then a larger filtering surface according to our data has to be employed.

Three mills require :

$$3 \text{ sq. mts.} \times 4{\cdot}2 = 12{\cdot}6 \text{ sq. mts. of filters.}$$

Two stone mills :

$$3 \times 2{\cdot}6 = 7{\cdot}8 \text{ sq. mts.}$$

Consequently, the reduction machines must have 20·4 sq. mts.

The bolting machines, 50 per cent. of 20·4 sq. mts. = 10·2 sq. mts.

The total is 30·6 sq. mts. The quantity of air necessary for ventilation is :

$$30{\cdot}6 \times 8 = 244{\cdot}8 \text{ cubic metres,}$$

which will need a fan with wings 800 mm. in diameter running at the rate of 960 revolutions per minute.

If we decide upon a common pressure tubular filter for all machines, millstones included, then the diameter of the tubes being 90 mm. (3½ inches), a filter with 56 or 60 tubes 2 metres long will be required.

The section of the air trunks may be calculated according to the consumption of air.

The general air trunk L for the roller mills must give passage to $12\cdot6\times8=100\cdot8$ cubic metres of air per minute, and $\frac{100\cdot8}{60}$ cubic metres per second. Accepting the velocity of passage of the air from the ventilated machines down the air trunks (Figs. 433 and 434) I, K, and N on the average to be 1–5 metres per second and 15–25 metres per second down the collecting spouts L, M, and b, it is easy to calculate the dimensions of the transverse section of the air-conducting trunks. As regards the shape of section of the trunks, round is best, as it offers less resistance to the motion of air. But trunks of rectangular section being more easily made, these may be used for a short travel.

IV

TRANSPORTATION OF STOCK

1. *Spouts and Elevators*

Modern industrial mills are almost exclusively automatic ; the whole travel of the stock, beginning with transportation of the stock to the storing bin and ending with the delivery of flour, takes place without any expenditure of manual work. Therefore the arrangement and a correct calculation of dimensions of the transportation devices is of vital importance. The transportation devices must be so constructed as to answer the given capacity (without any reserve for the enlargement of the mill) and consume the least amount of power. That will be the basis of our estimation of the transport constructions, which we are about to examine in this part.

All the modes of transportation may be divided into two groups :

1. Transposition of the stock from one height to another down from the top or the reverse.

2. Transposition of the stock within the bounds of one horizontal plane.

Delivery of the Stock Downwards : Spouts.—For the transmission of the product in a downward direction there are drain pipes, automatic dischargers, or, as they are more often called, spouts. The spouts generally carry the stock from the machine to the elevator or the reverse, from machine to machine, and, lastly, from the bin to the sacks for packing the finished product—the flour. In the first two cases the spouts have always to be set aslant, and in the third possibility and convenience allow the position of the spouts to be vertical, because the greater the speed of the flour flowing out of the bin, the faster and more compact will be the packing.

It is easy to deduce the condition under which the motion of the stock over an inclined plane is possible. If we have a spout (Fig. 437) inclined to the horizon at an angle α, and suppose the weight Q on a unit of area of the spout to be equal to G, and the coefficient of friction of the stock upon the surface of the spout f, the motion of the product is possible under the condition that :

$$T-Nf>O \quad \ldots\ldots\ldots\ldots \quad (1).$$

And since

$$T=G \sin \alpha \text{ and } N=G \cos \alpha,$$

by substituting the values T and N into (1), we obtain :

$$f<Tg\alpha.$$

In other terms, the motion of the stock in the spout is possible only in case the coefficient of friction of the product upon the surface of the spout is less than the cotangent of the angle of incline of the spout.

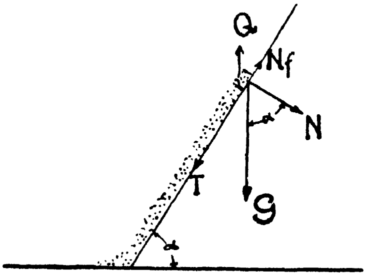


FIG. 437.

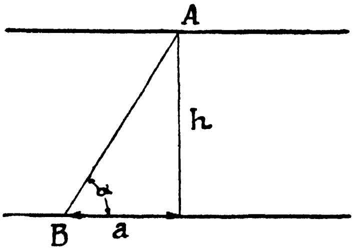


FIG. 438.

For wood spouts practice has established the following least values of the angle α for different products :

For grain	25–30 degrees
„ high break	40–50 „
„ low break	50–60 „
„ large middlings	45–50 „
„ medium middlings	50–55 „
„ dunst	55–60 „
„ bran	60–65 „
„ flour and dust	70–80 „

It will be well to give the limit values of the greatest horizontal transmission of the stock when it is delivered by the spout. If from the point A (Fig. 438) the product passes to the point B, the quantity sought for a is expressed in accordance with h thus :

$$a=h \, Ctg\alpha.$$

If $h=1$ (metre, yard, &c.) we obtain a for various products.

If $\alpha=25$—30—35—40—45—50—55—60—65—70—75 degrees, then a will correspondingly be equal to:

$a=2{\cdot}15$—1·73—1·19—1·00—0·84—0·70—0·57—0·47—0·36—0·27 mts.

Hence it is easy to define the value of a for different h, since a increases or decreases in proportion to h.

As to the constructive side of the spouts, they are either rectangular or round in their cross section. The spouts with a round section are made of iron or zinc sheet iron.

Spouts with a rectangular section are generally made of pine tree planks $\frac{3}{4}$ to 1 inch thick. The planks are joined by overlapping, *i.e.* by simply laying them on and nailing or coupling them with wood screws; or by covering as shown on Fig. 439, or by grooving and tonguing, Fig. 440. The last joint is the best, and the grooves may run in one direction a and at right angles b: the covering comes next, and the worst, the overlapping joint, should be avoided, as it is not hermetically closed against air, which reduces the efficiency of the ventilation plant.

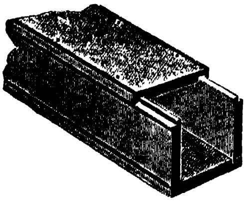


FIG. 439.

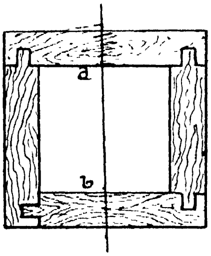


FIG. 440.

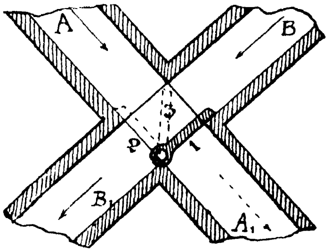


FIG. 441.

To lessen the friction, the lower part of the spout over which the stock travels is lined with sheet iron.

Sometimes the product has to be transferred from one spout to another. In such cases there is made a transfer valve, as illustrated on Fig. 441. When the valve lies in position 1 the products out of spouts A and B flow into one common spout B_1, if its position is 2; into spout A_1, if 3; out of B the product runs into A_1, and out of A into B_1.

The vertical spouts for the flour packing by hand end in bosses on which sacks are fitted. Fig. 442 shows various constructions of cast-iron bosses. Nos. 1, 2, 3, 4, and 5 have a gate valve to stop the flow, and No. 6 has a valve A which is turned by means of a handle B. No. 7 illustrates this valve in a half-opened position.

The diameters of the bosses are 250 to 350 mm.

The sack is fastened to the boss by a strap with a French clasp *A* (Fig. 443). The strap is suspended to the spout by means of " ears " *a*. When the empty sack is fitted on the boss, the clasp is coupled and the handle *c* turned as indicated by the arrow *b*, owing to which the strap tightly fastens the sack to the boss.

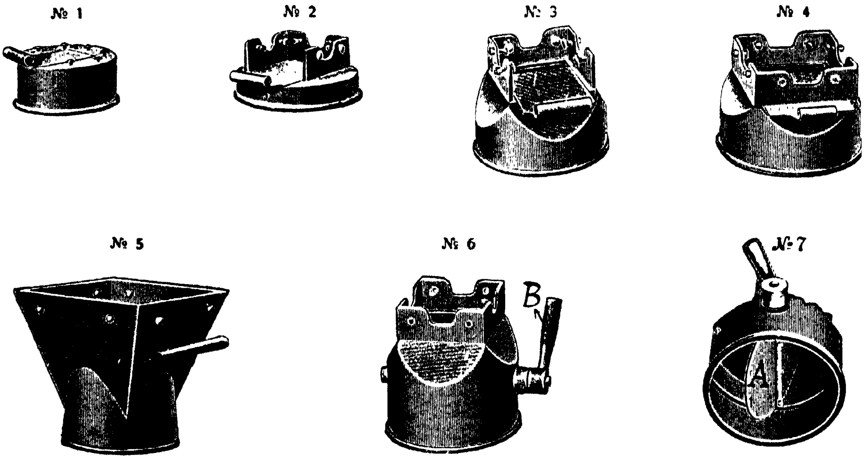


FIG. 442.

Transmission of the Product Upwards : Elevators.—The upward transmission of the stock in the mill is generally effected with the aid of elevators or automatic lifts, which consist of an endless belt with boxes (cups, buckets) attached to it and running over pulleys, one of which is set below, in the boot of the elevator, and the other at the top—in its head. On the same shaft with the top pulley is set the driving pulley to which the belt from the shafting runs. The belt with the buckets is enclosed in a timber or iron case or leg to avoid any loss or scattering of the product delivered. On Fig. 444 a wood elevator is shown.

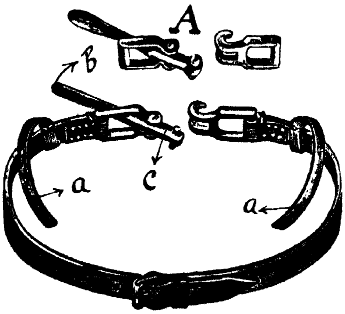


FIG. 443.

The elevators are always set vertically, and only very rarely, in case of extreme need, an incline is allowed of not more than $\frac{1}{8}$, because otherwise the sag of the belt on the right side compels it to slide over the left-hand inner wall of the leg, which damages the belt and incurs extra consumption of power, and the sag of the left side leads to the cups coming in contact with the leg, which results in extra work of friction and in the cups and leg being damaged.

The timber legs of the elevators should be built in the same manner as the spouts, *i.e.* by tonguing and grooving. Iron legs of small dimensions are made of iron plate with the bend of the grooves down the seams, and the large ones are joined with rivets.

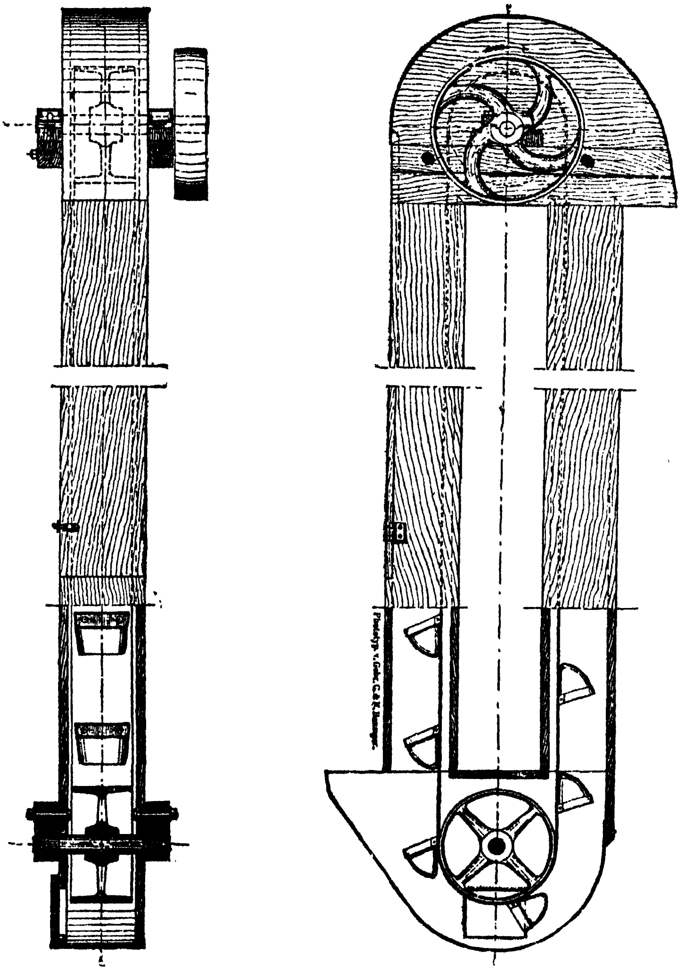


Fig. 444.

The belts are generally of leather or plaited of camel-hair.

The cups are made of iron, galvanised sheet iron, tinplate, or black iron plate. According to the manner of manufacture there are stamped cups with a bend of the groove, and riveted cups. In Russia there are used cups with the seams joined by overlapping with bent grooves. In Western Europe and in America these cups are being supplanted by those bossed of a whole piece, these being lighter. The riveted cups are used for heavy work, when they have to be of a large size.

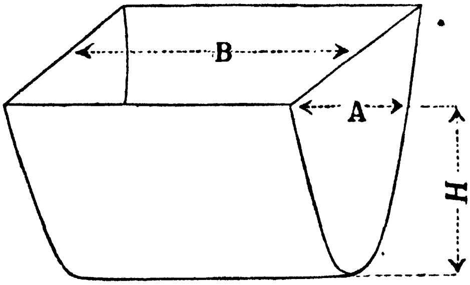
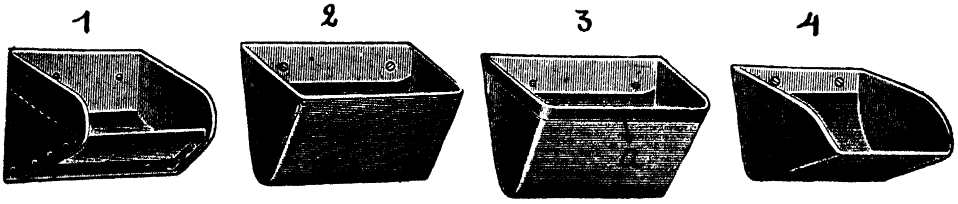


FIG. 445.

Every cup is characterised by three measurements (Fig. 445): width *B*, projection *A*, and height *H*. In the back wall of the cup there are made holes for fastening them on to the belt with special bolts.

Fig. 446 illustrates six different types of cups. No. 1 has a riveted bottom, Nos. 2, 3, 4, and 5 of medium size are bossed, and No. 6, a cup for large capacities, is manufactured of comparatively thick iron, up to 2–2½ mm., whereas the ordinary cups are made of tin plate or iron 1–1½ inch thick. Boxes of thin tin plate, as No. 3, have a cover plate *a* for strength and better resistance to wear. On Fig. 447 is shown the best shape for bolts with a flat head.



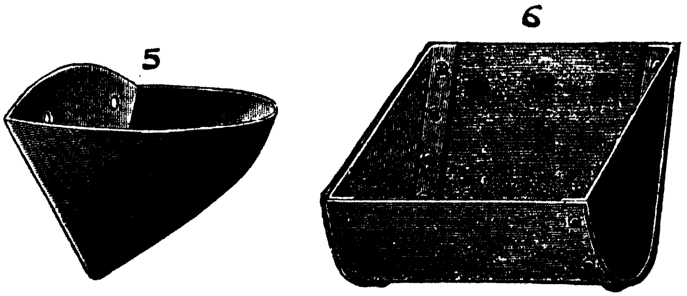


FIG. 446.

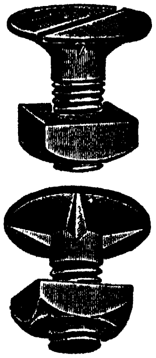


FIG. 447.

As regards the dimensions of the cups, for mill elevators they may be represented by the following figures (Schmidt's works in Würzen, Germany):

TABLE XLV

Nos. of Cups.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.
B—Width, mm. .	90	100	110	120	130	140	150	160	170	180	190	200
A—Projection, mm. .	85	90	100	105	115	120	125	130	135	140	145	150
H—Height, mm. .	65	75	80	90	97	105	115	120	130	135	145	150
V—Capacity (¾ full) litres . . .	0·20	0·27	0·35	0·45	0·55	0·67	0·80	1·00	1·20	1·40	1·65	1·80

Another manufacturer, Dietz in Leipzig, gives cups with a less variety of projections and heights, but with such a matching of these sizes, that the working capacity of the cup, ¾ full, is greater than Schmidt's.

TABLE XLVI

Nos. of Cups.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.
B	90	100	110	120	130	40	150	160	170	180	190	200
A	80	95	100	110	115	115	115	115	115	115	120	120
H	90	95	95	110	115	115	115	130	130	130	135	140
V	0·72	0·95	1·10	1·20	1·50	1·61	1·72	1·84	1·95	2·00	2·28	2·40

The filling *V* of cups of the mentioned constructions must not exceed ¾ of their capacity, otherwise, as has been proved by experience, the whole of the product will not be thrown out into the discharge spout.

The diameters of the belt-pulleys, the number of cups to one metre of length, and the capacity per hour in litres, are shown in the appended table.

TABLE XLVII

Nos. of Cups.	No. 1.	Nos. 2–3.	Nos. 4–6.	Nos. 7–8.	Nos. 9–10.	Nos. 11–12.
Diameter of belt pulleys	400–500	500–600	500–600	600–700	700	700–800
Number of cups to 1 metre . . .	12	12–10	10–8	8–6	6–5	5–4
Capacity per hour in litres . . .	12,500	15,000–16,000	20,000–25,000	30,000–40,000	45,000–50,000	55,000–60,000

To bring the constructive description of elevators to a close we must give an idea as to the arrangement of cups, cleaning of elevator legs, and the constructions of the boots and heads of the elevators.

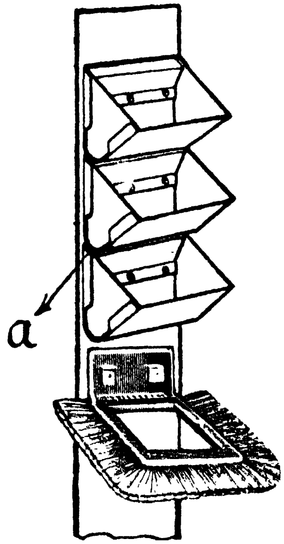


Fig. 448.

The preceding table shows us that the cups are generally set on the belt in such a manner as to leave a space of 10–65 mm. between them. But of late they are aiming at a total abolition of the distance between the cups, as is shown on Fig. 448, in order to increase the capacity of elevators without increasing the dimensions of the cups. In such cases the top part *a* of the cups is made so much wider that the bottom of the cup above may enter into the cup below, in which sometimes a notch of the top line *a* is made.

The construction of compact arrangement of cups just examined imparts greater rigidity to the belt, which demands a larger consumption of power to overcome the injurious resistances ; but in its final result the useful work of such an elevator is greater than with the cups set apart.

For freeing the elevator legs of dust there are brushes *b*, which touching the walls of the spout with their edges sweep the dust off.

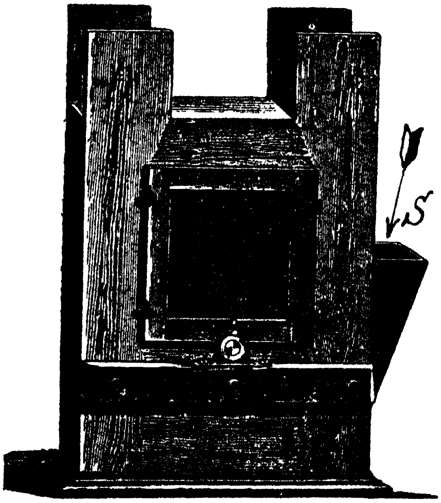


Fig. 449.

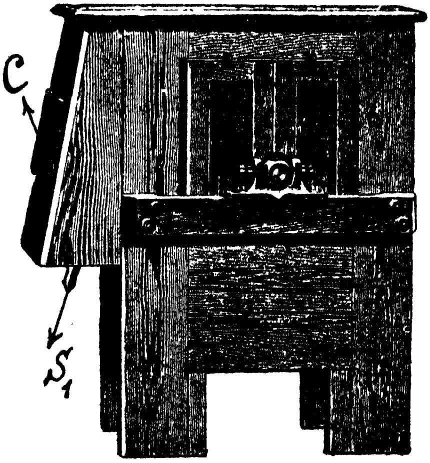


Fig. 450.

The essential parts of an elevator are its boot and head, in which the belt-pulleys are set. The simplest kind of a wooden boot and head is given in Figs. 449 and 450. The boot is a plain wood box with a feed spout *B*. The bearings for one, or if the elevator is double, for two pulleys, are set on cross bars, fastened to the box with bolts. For inspection of the chamber in the boot in case of a choke there is a door *A*. The head is also a box with a discharge tube S_1, a door for inspection of the belt-pulley, and a hatch *C* for controlling the discharge of the product by the cups.

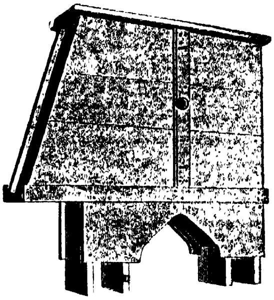


FIG. 451.

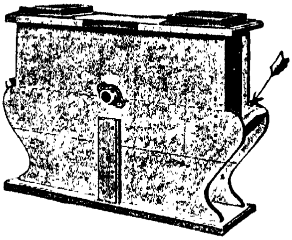


FIG. 452.

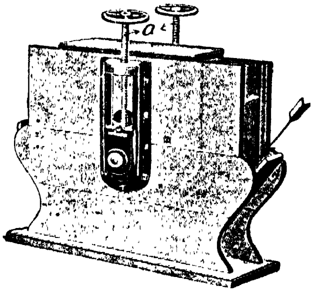


FIG. 453.

Among the defects of this construction must be mentioned the impossibility of regulating the tension of the belt without lacing it over.

In Figs. 451 and 452 may be seen the simplest construction of an American wooden head and boot without the possibility of adjusting the tension of the belt, and in Fig. 453 we have a wooden boot with adjustable bearings which may be lowered with the aid of screws *a* with hand-wheels.

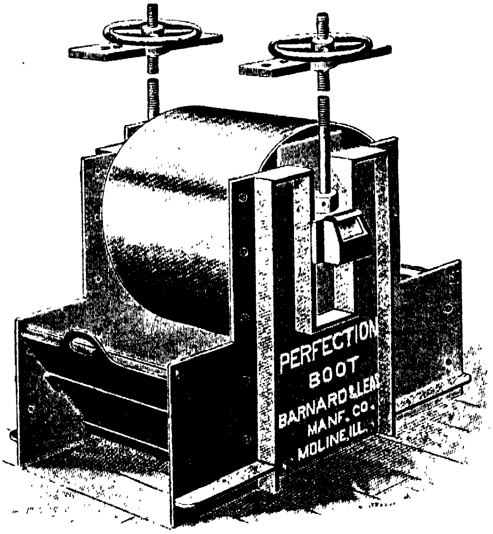


FIG. 454.

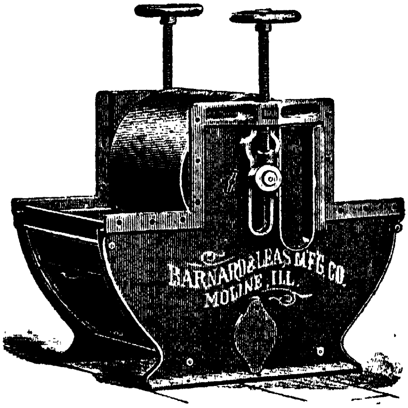


FIG. 455.

The metal constructions of boots of the American type are shown in Figs. 454 and 455. The first is iron and riveted, the second has a cast-iron or ingot steel frame. The bearings here are adjustable, and the regulation of tension of the belt is easy.

In Figs. 456 and 457 we have the perspective view of a wood and an iron elevator of the Amme, Giesecke and Konegen system very rationally constructed. The bearings of the boots are adjustable, the door *A* allows of inspecting the lower belt-pulley, and the hatch *B* is made for cleaning the boot in case it is blocked up with product. The lower part *C* of the left-hand side leg in the iron elevator is built up and has a door for inspection. The heads of the wood and the iron elevator can be easily taken off and dismantled.

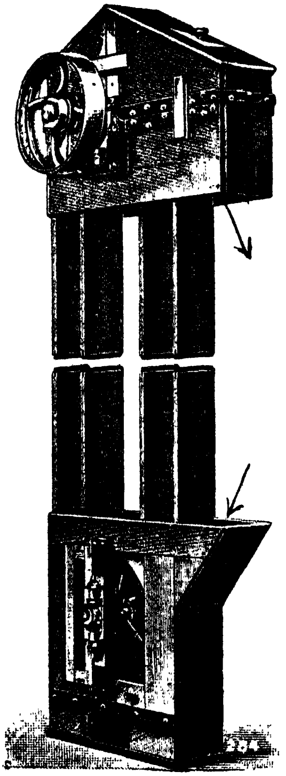


Fig. 456

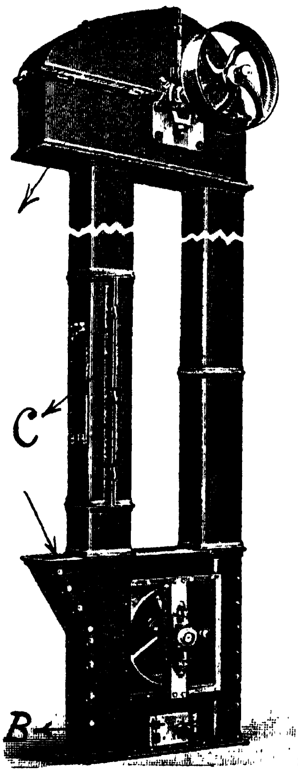


Fig. 457.

Useful Work of the Elevators.—The efficiency of an elevator depends on the following circumstances :

1. Shape of the cup, which determines its capacity.
2. Capability of the cup of retaining the product on the way from charging to emptying.
3. Capability of the cup of emptying at the spot given. The shapes of cups we examined determine their capacity. For the definition of the ability to retain the stock during the travel and to empty the cups the following line of reasoning is suggested.

Supposing on the belt-pulley *S* (Fig. 458) of the elevator boot we have a cup *U* fastened to the belt *R* running upwards.

The middle of the projection of the cup *K* lies at a distance r from the axis O of the belt-pulley, OK forming an angle ϕ with the vertical ; the angular velocity of rotation of the box is ω, the weight of the particle of product at K mg, and the centrifugal force of rotation of this particle $mr\omega^2$.

Then the resultant T of the forces mg and $mr\omega^2$ will be expressed by the diagonal of the parallelogram, and its direction will be determined by the angle a:

$$Tg\,a=\frac{BD}{DK}=\frac{AB+AD}{DK}.$$

But since

$$AD=mr\omega^2\cos\phi,\ DK=mr\omega^2\sin\phi,$$

we obtain:

$$Tg\,a=\frac{g+r\omega^2\cos\phi}{r\omega^2\sin\phi}\quad\dots\dots\dots\dots\quad(1).$$

Further, we shall define the point L intersection of the direction of the resultant and the vertical axis of the elevator:

$$h=LF-OF=r\sin\phi\,Tg\,a-r\cos\phi=\frac{g+r\omega^2\cos\phi}{\omega^2}-r\cos\phi,$$

whence we obtain: $h=\frac{g}{\omega^2}$, *i.e.* h is a constant quantity. In other terms, the position of the intersection point of the resultant T' with the vertical

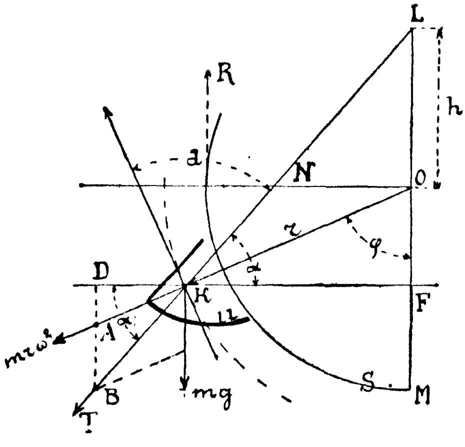


FIG. 458.

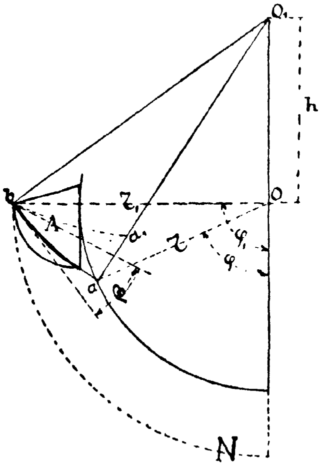


FIG. 459

axis of the elevator depends only on the angular velocity of rotation of the belt-pulley. The quantity h may be defined in accordance with the number of revolutions n, by substituting $w=\frac{2\pi rn}{60}$, and after some alteration we obtain:

$$h=\frac{894{\cdot}56}{n^2}\quad\dots\dots\dots\dots\quad(2).$$

If the cup A (Fig. 459) were to contain a fluid, when in motion the level of this fluid would be defined by a cylindric surface ba, where the point b is the highest position of the route over the circumference of the cup. But for dry substances the surface ba changes to ba_1 so that its angle of oscillation β (the angle of the tangents at b) forms approximately the angle of natural deflection of the product.

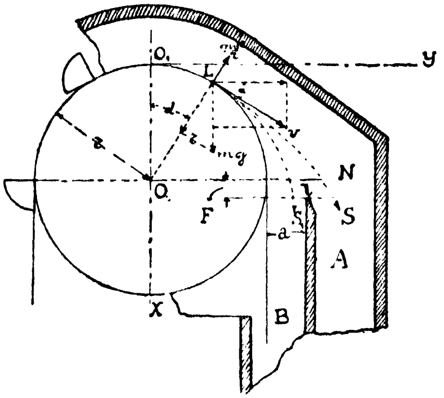


FIG. 460.

The data defining the favourable conditions of delivery of the stock, we can deduce starting with the supposition that the trajectory of motion of the product must be LS and not LS_1 for the product to drop into the outlet spout A, and not into the leg B of the elevator (Fig. 460).

At the moment of ejection from the cup the product has the velocity of motion of the belt v. Its horizontal resultant is

$$\frac{dy}{dt}=v\cos a \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3),$$

and the motive force in the vertical direction (gravity) $mg=m\frac{d^2x}{dt^2}$, whence

$$\frac{d^2x}{dt^2}=g \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

Having integrated these equations and excluded t from them, we obtain an equation of the curve, defining the law of motion of the product.

For the calculation of elevator capacities Professor Fischer gives the following empiric formulæ.

Supposing we have :

D—diameter of the belt pulley.
n—number of revolutions per minute.
A—projection of the cup.
B—breadth of the cup.
F—distance of the summit of the rib l to the horizontal plane O_1N.
w—distance between the walls of the casing.
L—capacity of the elevator in kilogrammetre-seconds.
M—capacity per second in litres.

All the lineal quantities here, D, A, B, F, and w are given in metres. For the quantities mentioned, supposing the highest limit for $r=\frac{D}{2}=h$ (Fig. 458), we have:

$$n=\frac{36\cdot 8}{D},$$

$$A\leqq 0\cdot 14D,$$

$$B=0\cdot 5D$$

$$F\geqq 0\cdot 17D,$$

$$w=1\cdot 4D;$$

$$L=50\sqrt{D^3},$$

$$M=0\cdot 05\sqrt{D^5}.$$

For the definition of the number N of horse-power required by the elevator, F. Baumgartner offers the following formula:[1]

$$N=\frac{1}{2000}L\gamma H,$$

where L is the capacity of the elevator per hour in hectolitres, H the height of elevation in metres, and γ the coefficient equal: for grain to 0·75, for break chop 0·5, for bran 0·35, and for middlings 0·30.

If we accept the denominations V for the bulk of product lifted in litres, η for its specific gravity, and H for the height of elevation, then the number N of horse-power for an elevator according to the data of the Nagel and Kämp works (Hamburg) will be:

$$N=(1\cdot 33-2)V\eta H.$$

Luther's works (Brunswick) give:

$$N=1\cdot 66\ V\eta H.$$

And, finally, Professor Fischer, taking for granted that the elevator is carefully looked after, suggests:

$$N=1\cdot 35\ V\eta(H+1).$$

For the definition of the working (¾ full) capacity I of the cup in litres Baumgartner suggests the following formula:

$$T=\frac{Q}{3600\ \gamma vz},$$

Where p is the same coefficient, v the velocity of motion of the belt per second in metres, z the number of cups to 1 metre of the belt.

---

[1] F. Baumgartner does not mention the origin of his formulæ.

The velocities of motion of the cups for different products are different.

Velocity for grain	2–3 mts. per second.
Velocity for middlings	1·5–2·0 mts. per second.
Velocity for flour	1·25–1·5 mts. per second.

The diameters of the belt-pulleys for elevators are 300–700 mm. The number of revolutions of the belt-pulleys fluctuates between 40 and 90, depending on their diameters and the given velocity of the belt.

Before closing the part treating of elevator transport we must give the bulk weights of grain and the intermediate products. Below is given a table of weights in kilograms.

WEIGHT OF 1 LITRE IN KILOGRAMS

Wheat	0·7 –0·86	Wheat middlings	0·55–0·65
Rye	0·6 –0·8	Large wheat bran	0·29–0·35
Barley	0·6 –0·78	Fine wheat bran	0·32–0·60
Oats	0·43–0·54	Large rye bran	0·37–0·44
Wheat semolina	0·35–0·43	Wheat flour	0·41–0·80
Rye semolina	0·50–0·55	Rye flour	0·57–0·60

2. *Horizontal Transport*

Archimedean Screw.—The Archimedean screw, worm, or conveyor is one of the oldest mechanisms of automatic transportation. This mechanism is a rotating helical surface, encased in a box, which is the route of transport. The transporting action of the screw is based on the fact that dry substances travel down the length of the box or the axis when the angle of the helical surface is less than the angle $90-\phi$, where ϕ is the angle of friction of the product against the surface of the screw. One turn of the screw brings the product forward (theoretically) by the size of the thread, which is expressed by the formula $\pi D tg a$, where D is the diameter of the screw, and a its angle.

The working organ, as we have said, is the helical surface, a perspective view of which is shown on Fig. 461, No. 1. This surface consists of the separate sections of "feathers" given below in A. The diameter is defined and these sections formed in the following manner.

Supposing, according to our calculation, we need a worm with a diameter D and a thread h. We have to define d the diameter of the opening of the feather. The length of circumference of the d sought for is a helical line with a pitch h. The angle of the screw is a; consequently, $h=\pi d tg a$, whence we define $d=\frac{h}{\pi \, . \, tg a}$.

Having defined the d, iron plate or zinc tin is taken of which the sections of the worm are prepared, and several rounds cut out with the diameter $D+d-d_1$, where d_1 is the diameter of the shaft, with concentric openings, d in diameter. Then they are cut and in the ends b there are holes perforated for rivet joints. The sections distributed along the screw are joined with rivets.

Besides the ordinary worm No. 1 (S right-hand thread, and S_1 left-hand) of the same sections, the paddle worm No. 2 is made by cutting the feather down its radius and the concentric circle in four or five places, and the parts k are bent at an angle to the axis of the worm. In this manner an enlargement of the screw thread is attained and a more energetic stirring of the product. These worms are mostly used in America.

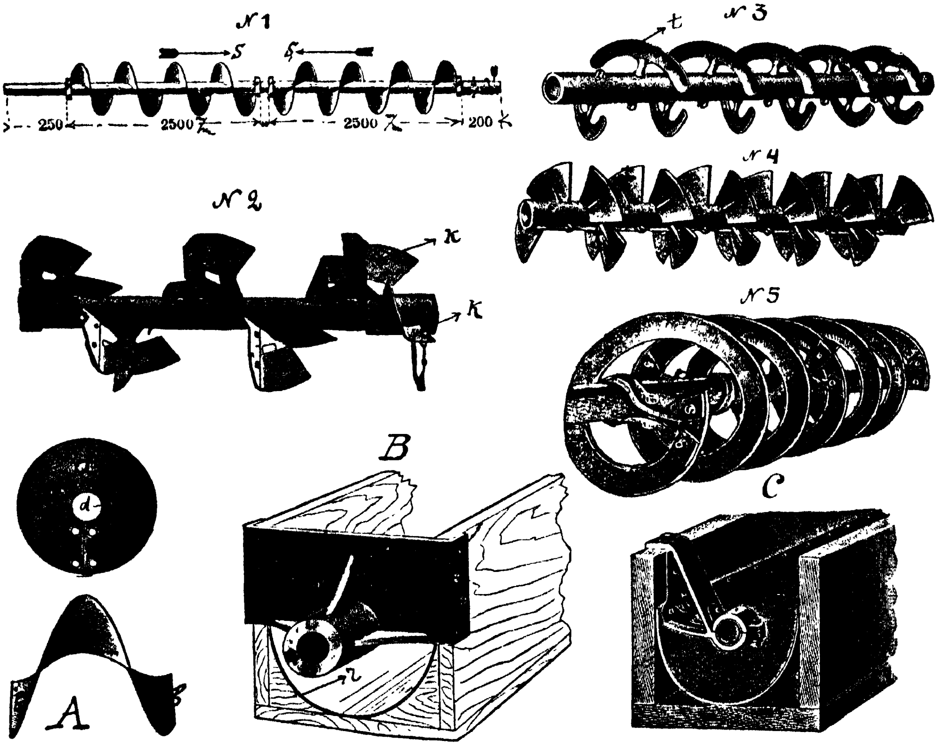


Fig. 461.

The worms Nos. 3 and 4 have separate, not joined to each other, sections t. These sections are cast of malleable cast iron and screwed to the shaft of the worm, which is an ordinary gas-pipe.

The worm No. 5 is called the band worm. Its arrangement is clear from the drawing without any description. It is used for the transportation of light product in purifiers, &c.

The worms Nos. 3 and 4 have this advantage over Nos. 1, 2, and 5, that the direction of motion of the product may be altered by turning the paddles *t* round their axis by 90°. Besides that, by turning *t* round their axes to a larger or smaller angle, the pitch of the worm, and consequently the velocity of motion of the product, can be altered.

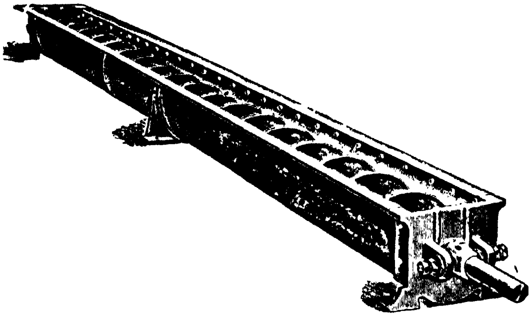


FIG. 462.

On *B* and *C* are illustrated the boxes or tubes of the worms generally met with in practice. Both the boxes are of timber, and the first has a timber bottom lined with tin *r*, to reduce friction of the product. The bottom of the working space in the second worm is of iron. The constructions of the bearings are sufficiently clear and need no description.

A whole iron box of a worm is shown on Fig. 462. The most characteristic combination of transport by worms is the transmission of product at right angles, shown on Figs. 463 and 464. In the first case it is done by an ordinary bevel gear system, and in the second we have a chain gear.

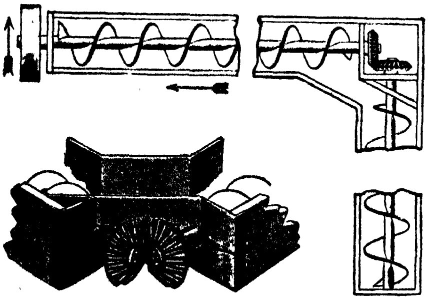


FIG. 463.

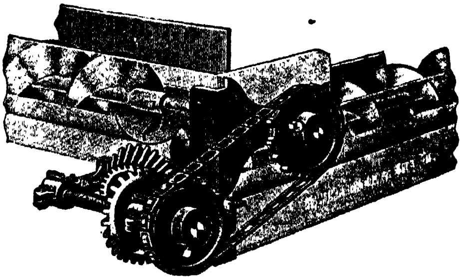


FIG. 464.

Turning now to the question concerning the calculation of the helical transportation, we must say that its theory is too weak and confines itself only to the above considerations respecting the angle of the worm surface. All the data of calculation are worked out by practice and grouped into empiric formulæ by Professor Fischer.

The diameter D of the worm accepted in European practice is 100–500 mm., while in America it is 100 to 400–450 mm.

The thread h of the worm in accordance with D:

$$h=(0 \cdot 5\text{–}1 \cdot 0)D.$$

The number of revolutions n per minute:

$$n=\frac{45}{\sqrt{D}}.$$

The capacity L per second in litres is:

$$L=171\sqrt{D^5},$$

D being taken in metres.

If the capacity L is sought for, the diameter of the worm D may be defined from the preceding formula:

$$D=1 \cdot 28\sqrt[5]{L^2}.$$

The distance a between the bearings supporting the shaft of the worm is defined according to the formula:

$$a=9\sqrt{D}.$$

The consumption of work in horse-power is:

$$N=f(lL\gamma),$$

where l is the length of the worm in metres, L the capacity in litres, γ the weight of a litre in kilograms, and f the practical coefficient, which has a numerical value of from 1·35 to 1·8.

F. Baumgartner gives another formula of capacity per hour in kilograms, namely:

$$Q=5D\pi nh,$$

where D is the diameter of the worm in decimetres, n the number of revolutions per minute, and h the thread of the worm in decimetres.

As in most cases, Baumgartner does not explain the origin of his formulæ. Fischer's formulæ are based on the experimental data of the works of Luther and of Nagel and Kämp, which date to 1890, and are consequently obsolete for modern types of constructions. Baumgartner's formulæ, on the other hand, in no respect correspond to the practical data and cannot therefore be used.

The following considerations must serve as the correct basis on which the capacity of the worm is calculated. We must take the area of cross section of the product filling the box of the worm, and the velocity of motion of the product, which depends on the thread of the worm and on the coefficient of friction of the product against the worm. This velocity may be defined only practically. By introducing a practical correcting coefficient into the formula of the quantity of product running in a unit of time through the given cross section, we obtain the capacity of the worm Q:

$$Q = n\frac{\pi D^2}{4}v.$$

Our researches have proved that D and v given in metres n is expressed by a numerical quantity 450.

In this manner for Q we have:

$$Q = \frac{450\pi D^2 v}{4}.$$

Experimental investigations show that v is expressed in accordance with the thread h of the worm and its number of revolutions per minute, thus:

$v_1 = (0{\cdot}32–0{\cdot}36)hn$ . . . . . for flour.
$v_2 = (0{\cdot}40–0{\cdot}43)hn$ . . . . . ,, dunst.
$v_3 = (0{\cdot}50–0{\cdot}54)hn$ . . . . . ,, middlings.
$v_4 = (0{\cdot}56–0{\cdot}60)hn$ . . . . . ,, break.
$v_5 = (0{\cdot}62–0{\cdot}72)hn$ . . . . . ,, grain.

For the existing factory dimensions of worms with their $h = 120–250$ mm. these velocities per minute will be expressed in round numbers: $v_1 = 4$, $v_2 = 5$, $v_3 = 6$, $v_4 = 7$, and $v_5 = 8$. Consequently, the capacity Q in its final shape per hour will be formulated thus:

$$Q \text{ per hour} = (84200 - 168400)D^2.$$

Here D is in metres. The coefficient 84200 corresponds to the capacity for flour, and 168400 for grain. For the other products Q may be obtained by substituting the corresponding velocities in the general formula.

The formula we are suggesting fairly accurately corresponds to the factory data of capacity, which differ from our calculations by 1 to 3 per cent.

Opposite is given the table of dimensions and capacity of the worms from Schmidt's works in Würzen, which may be acknowledged as normal.

TABLE XLVIII

DIMENSIONS AND CAPACITY OF WORMS

d.—Diameter in mm.	*h.*—Pitch in mm.	*n.*—Number of Revolutions per Minute.	*Q.*—Capacity in Hectolitres per 1 Hour of Grain.	Q_1.—Capacity in Kilograms per 1 Hour of Flour.
105	110	100	23	950
115	110	100	28	1150
130	110	100	36	1500
140	115	100	42	1830
150	125	80	50	2800
170	125	80	64	3000
190	140	80	88	4000
210	160	70	100	4500
250	180	70	150	6000
270	200	70	180	7500
300	200	60	220	9000
330	250	60	280	11,000
350	250	60	310	12,000
400	250	50	350	14,000

TABLE XLIX

DIMENSIONS OF AMERICAN WORMS

Diameter of the Worm in Inches.	Diameter of the Shaft in Inches.	Diameter of the Worm in Inches.	Diameter of the Shaft in Inches.
4	1·0	10	2
6	1·5	12	2
8	1·5	14	2
9	1·5	16	2
9	2·0	16	3
10	1·5	18	3

The diameter of the foundation of the box is made slightly larger than the diameter of the worm by 2·5 mm. (for flour and grain). The clearance between the worm and the box must be a little larger than the largest particle of the transported product, otherwise the worm would triturate these particles, and with a larger clearance the dead space would increase.

Horizontal Automatic Conveyors.—The ordinary type of a horizontal automatic conveyor is shown on Fig. 465. The product runs to the platform *P* (as, for instance, in filters), over which there pass scrapers *t* attached to two endless chains *g*.

Another construction of the same principle is given on Fig. 466. Here the product flows into tube-shaped boxes with round scrapers passing through them. In the present case the transmission of the product is effected in directions lying at right angles. The transmitting action is easily understood from the drawing. At the other ends of the boxes there are two belt-pulleys like *B*. If the conditions of space require it another conveying belt-pulley is set. The rope used for the traction is of wire. We must remark, however, that such transport is used by the Americans for small coal and seldom for grain.

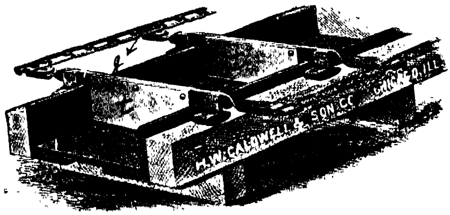


Fig. 465.

On Fig. 467 we see a band conveyor for sacks forming an endless cloth of separate timber planks attached to two endless parallel chains which run on four pinions. The tension is adjusted by transposing the bearing of the pinions lying on the left, which is done by turning the hand-wheels *m*. This cloth is brought into play from the belt-pulley *R*, which carries a second pair of pinions *n* on its shaft. To reduce friction, every other plank there is an idler set which runs in guiding rails.

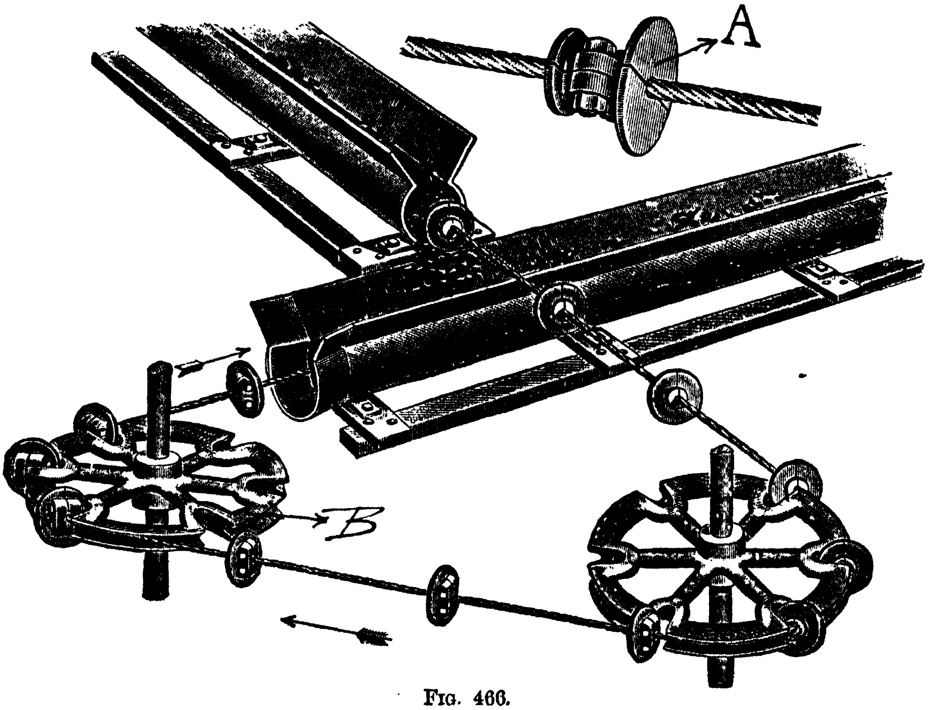


Fig. 466.

Band Conveyor.—The preceding construction of an endless cloth serves as an intermediate step to the band conveyor, which has become of late an indispensable appurtenance of grain elevators and large mills. The general idea of the band conveyor is shown in Fig. 468. The endless band *R* runs over two belt-pulleys *D* and D_1, the first of which is brought into action by the driving belt-pulley *N*; the other belt-pulley N_1 is loose. The band is supported by adjustable idlers from above and from below. The grain flows down *S* through the hopper *A* and is carried by the band to the "throw-off carriage" *T*, on which there are two guides, 1 and 2, with the band running over them. At the bend of the band over the pulley 1 to the 2nd the grain, which has acquired a force of inertia, is thrown off into the box *B*, whence it pours down the spout S_1. To tighten the band, a weight *G* with a pulley 3 is suspended to it. The method of throwing the stock into the box *B* is given in Fig. 469.

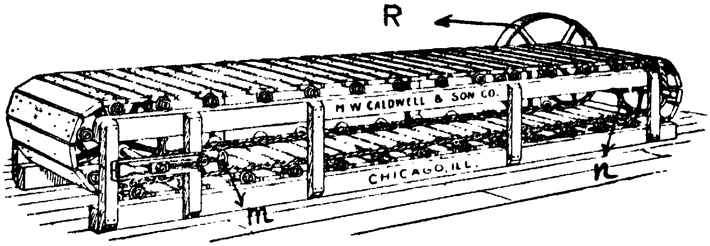


FIG. 467.

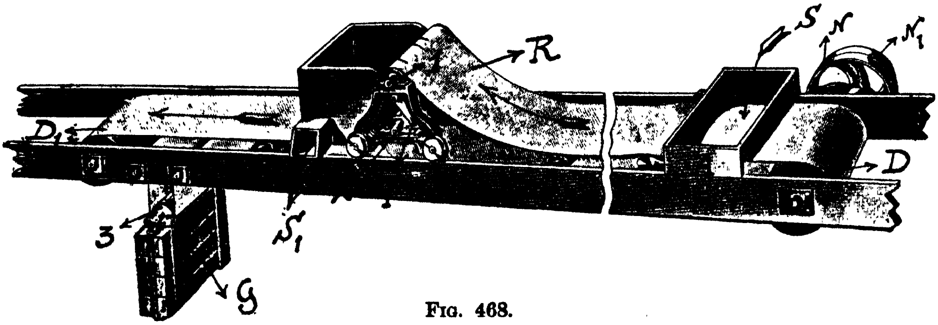


FIG. 468.

The position of the carriage *T* depends on the place where the product is to be emptied. By means of brake devices it is fixed to the spot.

Different construction of "live" guide-pulleys are illustrated on Figs. 470 and 471. On Fig. 470 we have a set of top and bottom pulleys supporting the band *R*; the axes of the top idlers are inclined. Guide-pulleys with inclined axes should be avoided, as the bearings do not retain the oil well.

On the upper drawing on Fig. 471 we see the top wooden guide with a conic turning out. The incline of the axes of the pulleys or the conic turning out or, as we have it in the bottom drawing, the globular rims, are needed to impart a trough-like shape to the band, which prevents the stock from falling off the band on its travel.

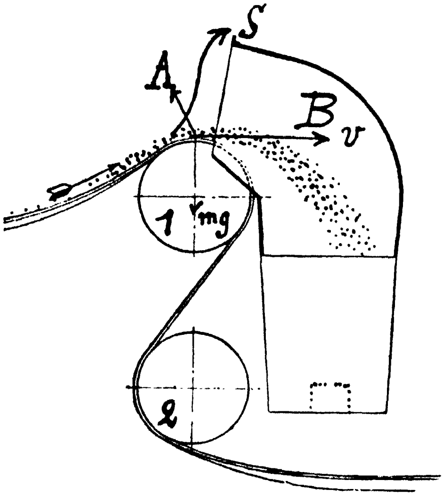


FIG. 469.

The arrangement of the top and the bottom guides (front and side view) is shown in Figs. 472 and 473. Here, instead of the globular guides bending the belt, we have a more simple construction—conic guide-pulleys. The top part of the band *A* feeding in the stock is bent by these belt-pulleys to a trough.

Proceeding now to consider the operation of the band conveyors, we must point out the relation existing between the velocities of motion of the product and the diameter of the guide-pulleys 1 and 2 (Fig. 469).

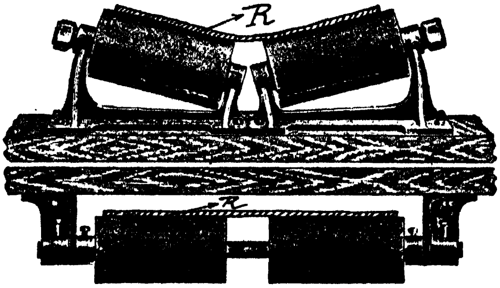


FIG. 470.

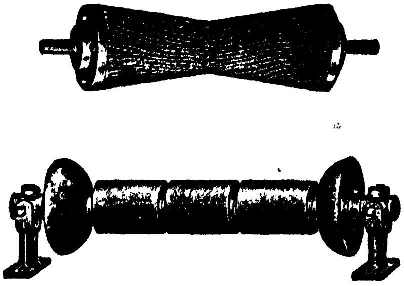


FIG. 471.

If v is the velocity of motion of the band (the same being the circumferential velocity of the pulley 1) and r the radius of the pulley, the value of v is defined according to the condition :

$$\frac{mv^2}{r} \geqq mg,$$

where $\frac{mv^2}{r}$ is the centrifugal force of the product at the turning-point of the belt to the pulley, and mg the gravity of the stock. To prevent the stock from running off the band before it reaches the top point *A* of the pulley 1, we must accept $\frac{mv^2}{r}=mg$.

Then v will be defined thus :

$$v=\sqrt{rg}.$$

The maximum value of v will be defined out of the inequality $v>\sqrt{rg}$, the limit for v being the condition that the product should not be flung outside the bounds of the box, as indicated by the arrow *S*. But this condition is indefinite, therefore it is better to accept $v=\sqrt{rg}$.

Given the velocity, the r of the guide-pulley may be defined. Generally one takes a radius not exceeding the values 0·40–0·64 of a metre. The limit largest values of velocity are pointed out by Professor Fischer from the experimental data of the works to be 2–2·5 metres per second.

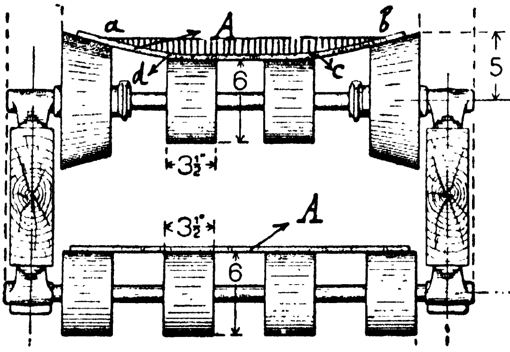


FIG. 472.

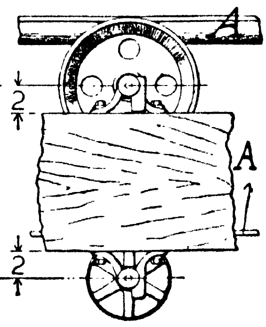


FIG. 473.

The diameter of the idlers 1–2 is the thickness of the band taken 25 to 30-fold. In empiric formulæ of calculation of band conveyors, the breadth of the band, which we shall name *B*, is taken as modulus. Marking the thickness of the band *e*, we deduce the following value for it from experimental data :

$$e=0{\cdot}01B.$$

The breadth *B* of the band varies between 300 and 1000 mm.

In defining the capacity of band conveyors Professor Fischer accepts a thickness of the layer of grain in the middle of the band not exceeding $\frac{1}{10}$ of the breadth of the band. As a matter of consequence the area of section of the layer of product is defined for a flat band as the area of a triangle with its angles at the base equal to the natural angles of the deflection of the stock. For bands of a trough-like shape of section (Fig. 472) that area is expressed by the area of a trapeze *abcd*.

Professor Zworykin suggests the following areas of section of a layer of grain :

For a flat band	$\Omega = 0{\cdot}07B^2$.
For a through-like band	$\Omega = 0{\cdot}1B^2$.

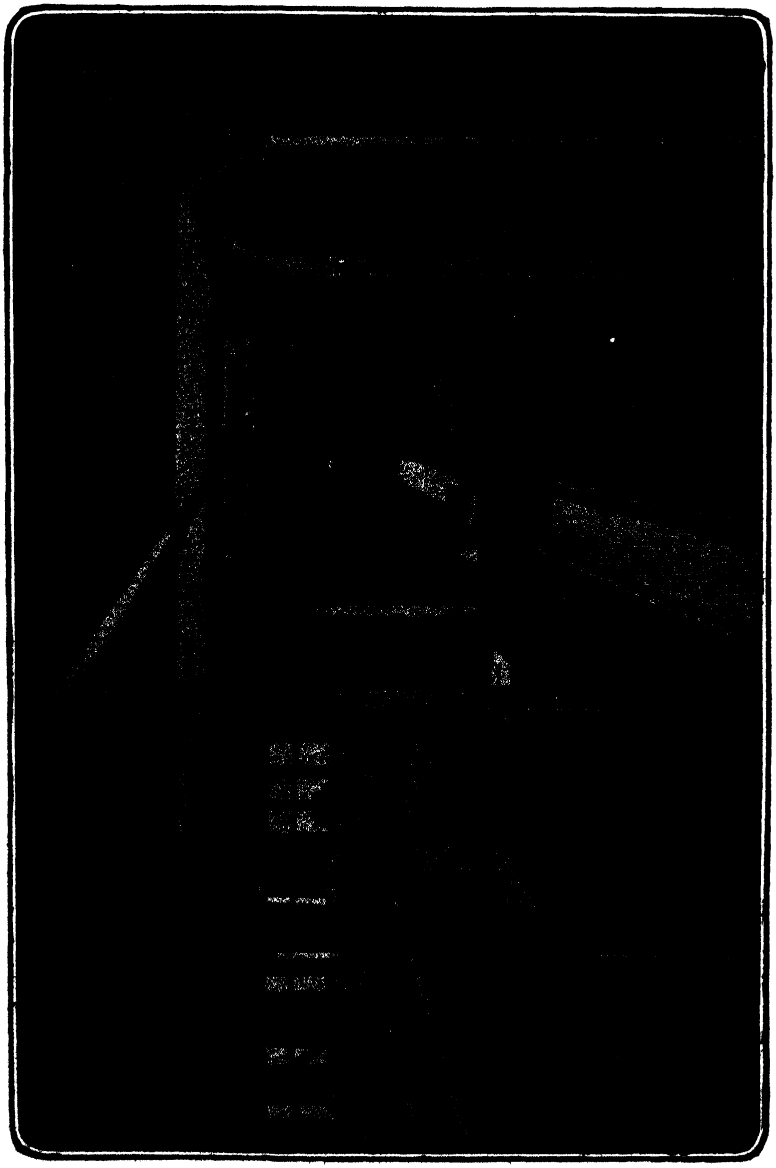


FIG. 474.—Arrangement of Band Conveyors with Electric Drive in an Elevator.

Once the area of section of a layer of stock on the band and its velocity of motion are known, it is easy to define the capacity Q of the band conveyor, which will be expressed thus : $Q = \Omega v$.

The consumption of power must be defined in dependence on the tension R of the band, which is taken to be equal to $1000B^2$ klgs.

The number N of horse-power for a band conveyor should be defined in accordance with the data evolved by Professor Petrov, who shows in his calculation that one horse-power carries 500 tons a distance of 1000 ft. We may consider that one horse-power transfers 400–420 klgs. per second. Consequently, N will be formulated thus:

$$N = \frac{Q}{400-420},$$

Q being the capacity of the conveyor per second.

V

APPARATUS FOR MIXING AND PACKING FLOUR

Flour-mixers.—Before sending the flour to the market, it is necessary to obtain a product of the accepted standard as regards the baking qualities as well as in its outward appearance. The quality of the grain depending on the conditions of the soil and the climate, the manner of treatment, &c., is very inconstant, and this naturally affects the standard of the product. Often during a day's run of a mill one does not succeed in obtaining flour of a certain kind uniform in quality. That being the case, one is obliged to blend the intermediate grades in corresponding proportion, to obtain the kind required.

If the mill works for eight grades, it yields from twelve to fourteen in its grist. These grades, except the first two or three, are mostly medium, and because of their insignificant difference in quality are blended and give the finished product. Sometimes flour of better grade is admixed to the inferior ones to improve their quality, if they are below the normal. That is the reason of the constant fluctuation in the percentages of yields of flour, especially of the medium grades. The apparatus used for mixing the flour are called flour-blenders.

The flour-blenders for mixing flour are divided into two groups. Blenders without circulation belong to one of them, those with circulation belong to the other.

The first blenders are used in cases where the intermediate grades of flour obtained at different times of the day's production are collected in bins or sacks according to uniformity, and are taken from there to be fed to the blender in a certain quantity decided upon by the miller, to obtain directly the grade required.

The second type of blenders has such a construction as allows of blending without interruption the flour obtained earlier and later, owing to their circulatory arrangement.

Fig. 475 shows a simple flour-blender without circulation. An essential part of this flour-blender is the disc *A* with pins, rotating together with the shaft *B* from the driving belt-pulley *C*. Over the disc *A* there is another stationary disc *D* likewise furnished with pins. These discs, as well as the cross bar for the bearing of the shaft, are set in a large chamber where the blended flour collects. Into the hopper *E* simultaneously different grades of flour are poured in a proportion to give the grade required. That flour passes to the rotating disc *A*, and is stirred between the pins. The disc *A* runs at 160 revolutions per minute.

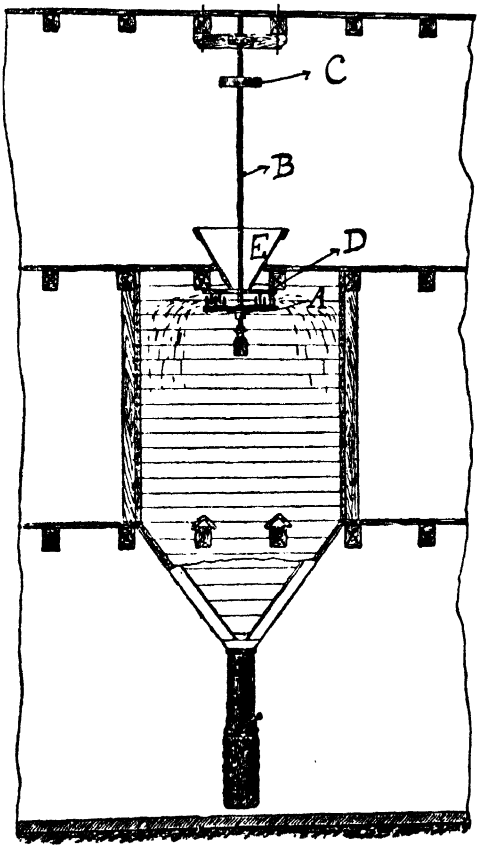


FIG. 475.

The defects of this flour-blender lie in the fact that its disc acts as a suction fan, owing to which the pressure in the chamber rises and the flour escapes through the chinks of the chamber.

Circulatory Flour-blenders.—On Figs. 476 and 477 is illustrated the ordinary type of a circulatory blender employed nowadays. The flour flows into the hopper *A* down *s*, whence it passes to the worm *P*. From this worm it goes to the elevator *R*, which carries it to the top part of the blender on the worm *N*, which conveys it then to the chamber on to the agitators *T*. From the agitators the flour again passes to the worm *P*, the elevator, and the worm *N*, this circulation being performed until a finished uniform product is obtained. Then the spout of the elevator to the worm *N* is covered over, and the flour directed down the spout *S* to the packer *G*.

The construction of this flour-blender, which is a modification of the old Weber Zeidler blender, belongs to the works of Amme, Giesecke and Konegen, but, with insignificant variations, is also built by other works.

On Fig. 478 is illustrated one of the latest types of the circulatory flour-blender, the construction of which is as follows :

The flour runs down the spout *a* and falls on the winged stirrer *b*, which has one common shaft with the worm *c*. In proportion as the flour collects at the bottom of the chamber, the worm enclosed in the pipe *d* lifts it up, and it again passes to the stirrer *b*. When the flour is sufficiently mixed, the valve *e* is opened and discharges the product.

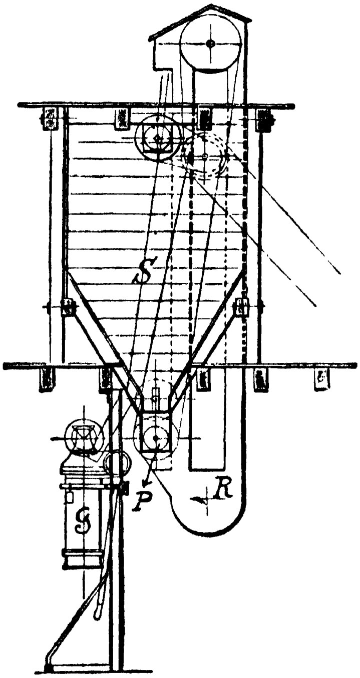


FIG. 476.

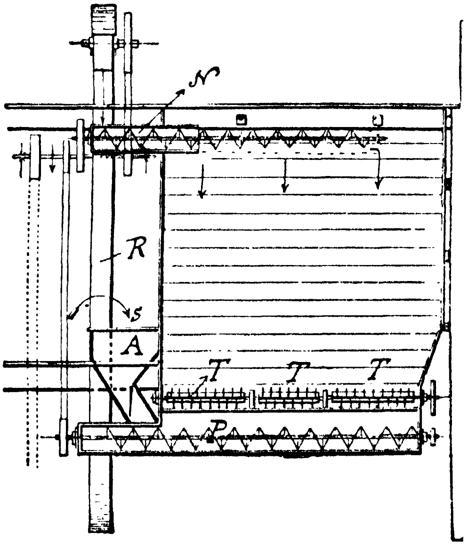


FIG. 477.

The defects of this blender (the forcing of air into the chamber by the winged fan) are the same as in the simple disc blender without circulation.

Quite recently there appeared on the market the flour-blenders of the Gebr. Meinecke Works in Germany. On Fig. 479 may be seen the more simple construction, the substance of which is almost the same as of the blender on Fig. 478. The difference is that in the hopper *A* there is a brush apparatus *E* which reduces the cakes and clots of flour before it passes into the chamber *B*. The worm, which is driven from a gear drive with the aid of a driving belt-pulley *D*, has two different diameters. At the lower pipe of the worm is suspended a conic shaker *F*. At the top, on the shaft of the worm, there is fitted a brush stirrer *G* which reduces the flour and throws it off the flange of the pipe of the top part of the worm. When the flour is sufficiently blended, it is delivered through the boss *C* by opening the valve.

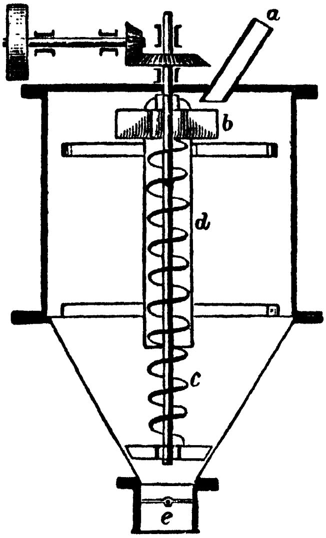


FIG. 478.

On Fig. 480 may be seen a blender with a more complete circulation. The flour is delivered into the hopper *A*, where there is a brush apparatus and a worm, as we shall see further on; from the hopper it flows into the elevator *B* which carries it to the chamber of the blender, where it can circulate just as in the blender (Fig. 479) or be conveyed by the worm *D* again to the elevator *B*, if, by means of the rod *E*, the gate valve of the boss of the outlet in the chamber is opened. When the flour is sufficiently blended, the spout is covered over by the valve *F* out of the elevator into the blender, and the product directed into the spout *G* for packing.

Figs. 481 and 482 illustrate a flour-blender from the same works with a vertical worm instead of an elevator. Fig. 482 exhibits the hopper *A* in section, showing that it contains a brush apparatus *B* and a horizontal worm *C*, which conveys the stock to the vertical worm *D*.

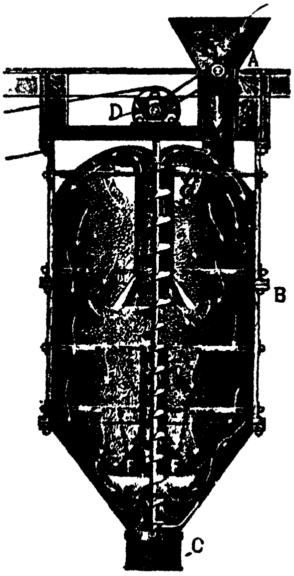


FIG. 479.

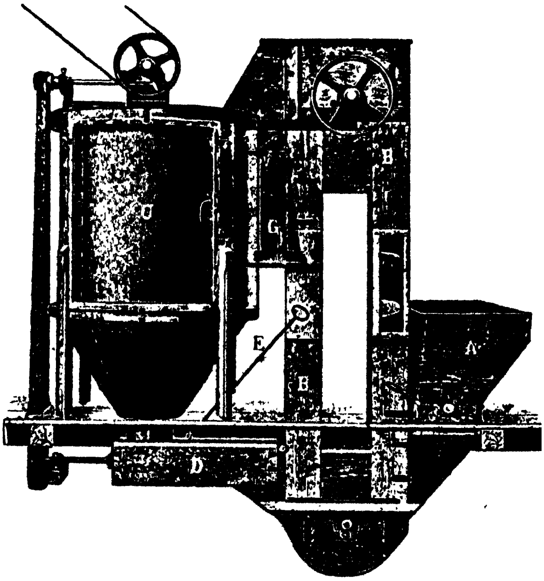


FIG 480.

Packing the Flour.—For flour which has to stand a lengthy transportation or lie a long time in warehouses, packing is of the greatest importance. In America flour is packed almost exclusively in barrels, and only small quantities from 30 to 60 lb. are packed in sacks of cotton.

Although barrel packing, where the flour is first put in a sack and then with the sack into the barrel, is considerably more expensive, its advantages are very great. The caking of flour packed in barrels is totally obviated, since, when stored in large masses, the pressure falls upon the barrels and does not affect the flour.

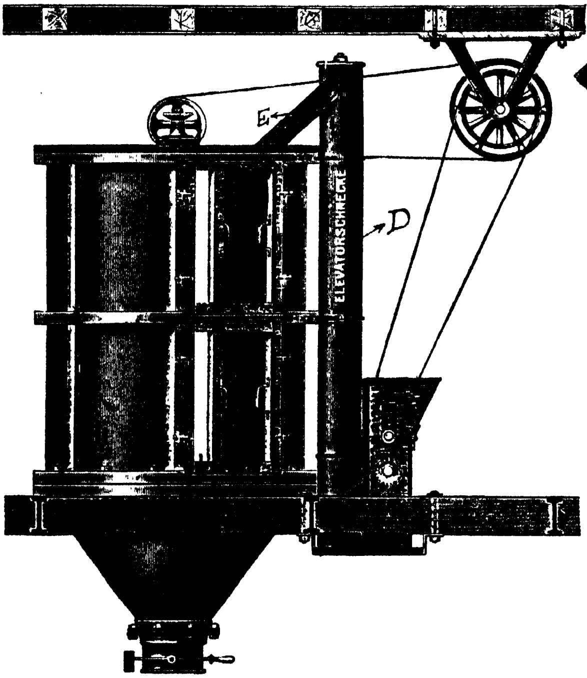


FIG. 481.

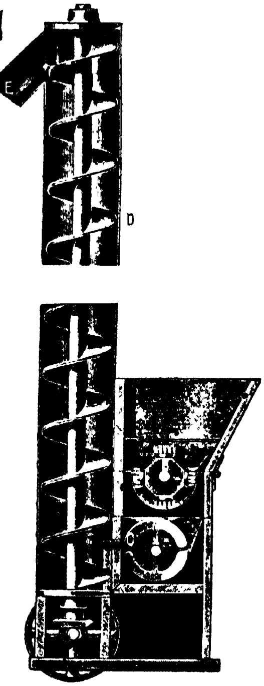


FIG. 482.

In Western Europe and Russia flour is packed exclusively in sacks, and consequently the heaping of sacks in large stacks is very dangerous, especially for a slightly damp flour, which cakes up and becomes heated.

The ordinary simple way of sacking the flour is performed by hand through the delivery spout. This method is satisfactory when the capacity is small, but cannot be adopted in large mills in which special flour packers are used.

In Fig. 483 is shown the Amme, Giesecke and Konegen packer, which differs but slightly from similar apparatus of other firms. Its nature is as follows:

The flour passes down the spout *S* to the auger *A*, in which there is a worm with a downward run of the flour. The worm is brought into action by a bevel gear system from the belt-pulley *B*, which is thrown in by the friction clutch *C*. On the auger *A* there runs freely the boss *D*, to which a sack is attached by means of a strap with a French clasp. The boss *D* is suspended on straps *E* (or on chains), which are wound on drums *F*. The boss is balanced by a weight *H*, because *F* and *G* are coupled by a rope or belt gear.

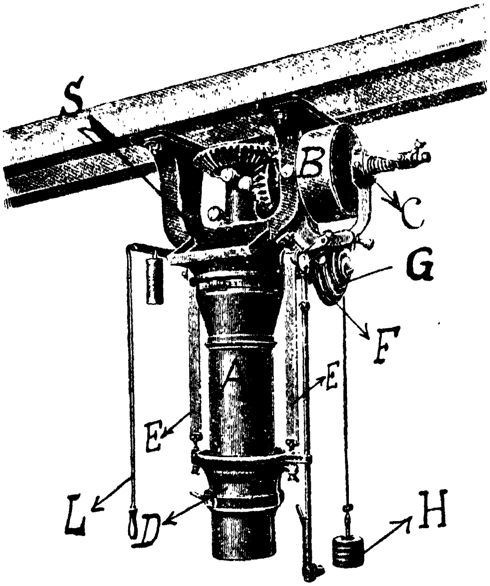


FIG. 483.

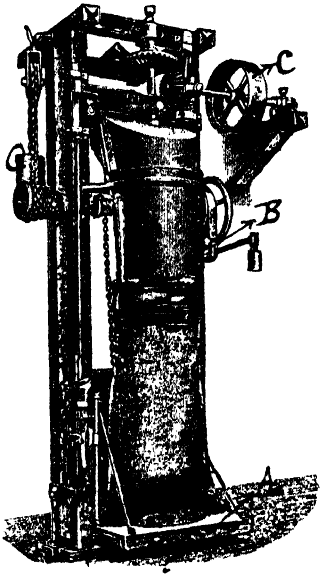


FIG. 484.

The sack is lifted at first, enveloping the auger *A*, and then, in proportion as it is packed, it drops down. During operation the worm discharges the product out of the auger into the sack, and when the sack is full, the same worm adds more flour and presses it down with its weight to the required compactness.

The rod *L* runs to the brake which regulates the lowering of the sack—in other terms, the degree of compactness of the packing.

In Fig. 484 we have Daverio's packer of a similar type, with an adjustable platform *A* for supporting the sacks. The lifting and lowering of the platform is done by means of chains (there are two chains for the sake of equability) winding on or off drums. The weight of the platform is counterbalanced by the weight *Q*. For skidding a band brake *B* is provided. The motion of the worm is received by the bevel gear from the driving pulley *C* which is rotated from the counter shaft with a loose belt-pulley.

American Packers.—Fig. 485 shows the Nordyke & Marmon Co. flour packer. The discharge worm is brought into action from a bevel gear, which may be thrown on and off by means of the friction clutch *a*. For packing sacks of various sizes there are augers of different diameters with conic, funnel-shaped ends, by which they are fixed to the discharge tube of the apparatus. At the end of the discharge worm is attached a ramming worm with one pitch. The diameter of this worm is altered in accordance with the size of the sack. The sack lift is suspended on chains, which are wound on and off a drum with a brake pulley.

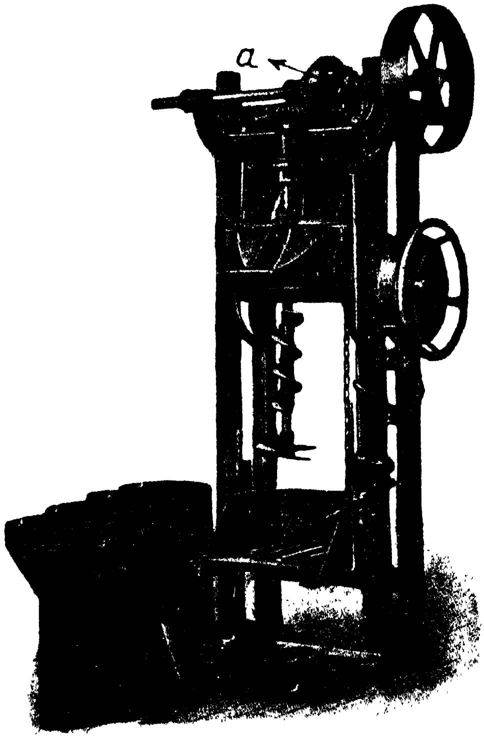


FIG. 485.

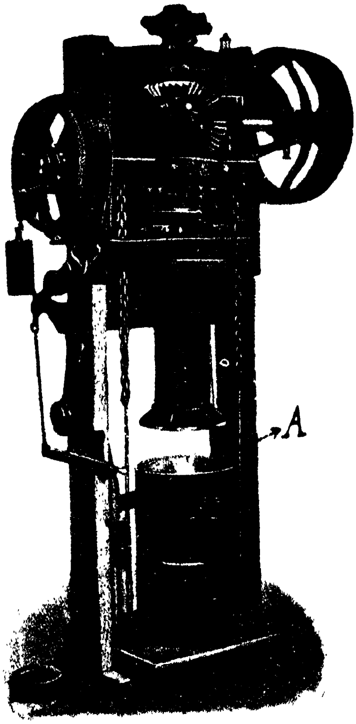


FIG. 486.

The number of revolutions of the worm per minute is 200. The weight of the sacks packed may be from 20 to 200 lb., the number of sacks from 70 to 100 per hour.

On Fig. 486 we see a packer for bran with the auger set the funnel-shaped end downwards. Since it is necessary to ram the bran down hard the sack is placed in an iron casing *A*, otherwise it might burst. After the packing operation is over the casing is opened and the sack removed from the lift.

The number of revolutions of the discharge worm is 200 per minute, the capacity 50 to 60 100-lb., or 35 to 40 200-lb. sacks per hour.

VI

APPARATUS FOR RECKONING AND REGULATING THE QUANTITY OF PRODUCT

Automatic Scales.—The apparatus which serve for reckoning the quantity of grain stock are constructed for dry substances generally,

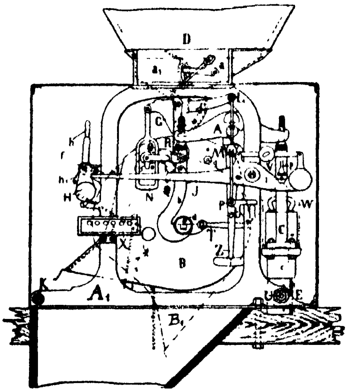


FIG. 487.

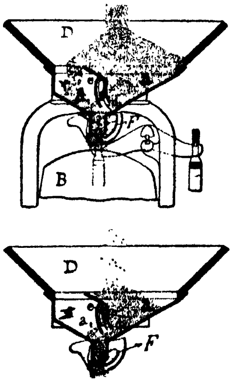


FIG. 488.

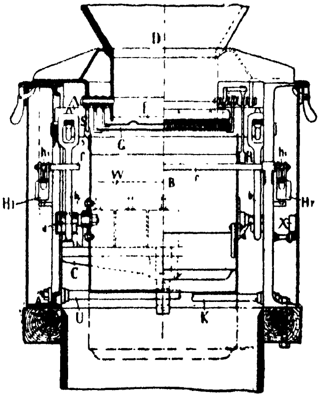


FIG. 489.

and their purpose is automatically to weigh the product flowing in without interruption to be treated or packed.

The most typical representatives of this kind of apparatus are the scales "Chronos," "Libra," &c.

Figs. 487, 488, and 489 illustrate the plan of the "Chronos" scales, and the essence of their construction consists in the following. There is a cast-iron frame A_1 on which the hopper *D* for the product is set. This hopper is divided by the partition a_2 with a slot, in which there runs the valve gate d_1 connected by a system of levers with the balance levers. On the right-hand side of the balance levers or scale beams *A* and *I* is set a scale *C* for weights, on the left on rods *b* is suspended the scale *B*, which rests with steel prisms *d*, set into the journals of the scale. The beams *A* and *I* rest with their steel prisms on steel linings in the brackets of the frame. To the beam *A* is attached an arm *Z* which indicates the correct setting of the scales when in vertical position.

Through the left-hand side part a_1 of the hopper D, the grain runs into the scale B, then the right-hand side a is covered with the gate d_1. When the scale is sufficiently filled with grain, it drops down and upsets, assuming the position B_1, and the grain quickly pours out. At the same time the lever x, connected with the scale (see perspective view) and with the meter x, drops down and turns one division of the pinion of the counting mechanism. Simultaneously with the dropping of the scale the valve F closes the outlet of the hopper. When the grain has run out, the weights return the scale to its former position, to take the next load of grain, &c.

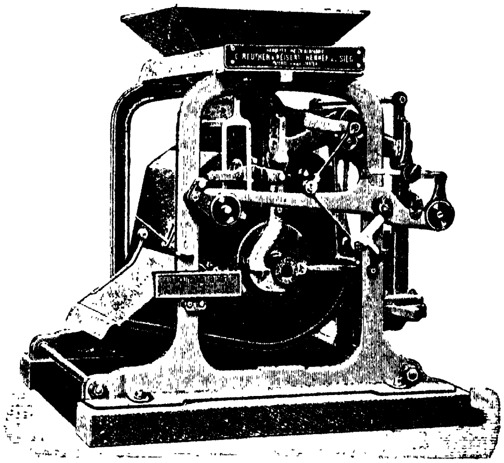


FIG. 490.

In the perspective view (Fig. 488) is shown the lever with the adjustable weight for accurately mounting the scales.

In Fig. 489 we see the scale "Libra," which differs from the "Chronos" in small details.

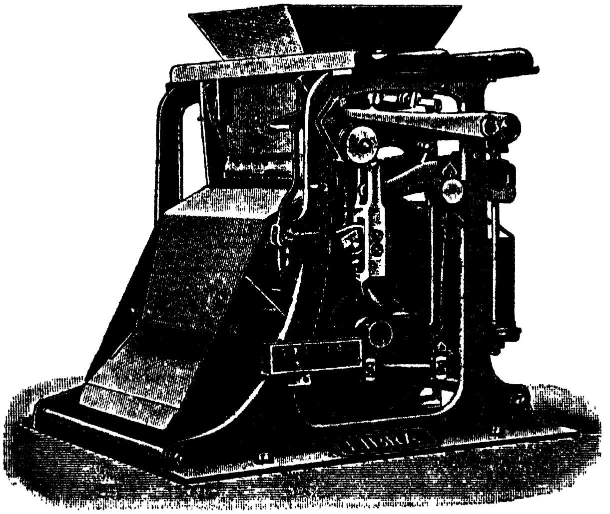


FIG. 491.

When mounting the scale it is enclosed in an iron case, which is locked or sealed, to prevent the workmen from altering the number indicated for the purpose of cheating. The chamber in which the scale is enclosed must always be exhausted, otherwise the delicate cranks of the scale beams and systems of levers, having become dusty, cease working accurately and the balance begins to show incorrect weights.

Fig. 490 illustrates a perspective view of the "Chronos" scale, and Fig. 491 a perspective view of the "Libra" scale, which is slightly different from the "Chronos" in its construction, but gives just as accurate a weighing.

Columbian Feed Governor.—For regulating the quantity of product fed to the roller mills, the American apparatus "Columbia" is employed.

It consists of a box *A* (Fig. 492), through the inclined wall of which there is made an opening *E*. In the opening *E*, attached to the lever *F*, there is a slide valve *G*, by raising or lowering which the quantity of grain passing through this opening is increased or reduced. When dropped to the bottom, the slide valve *G* closes the opening *E*, but only so far as to allow passage to the least flow of the apparatus of any given size.

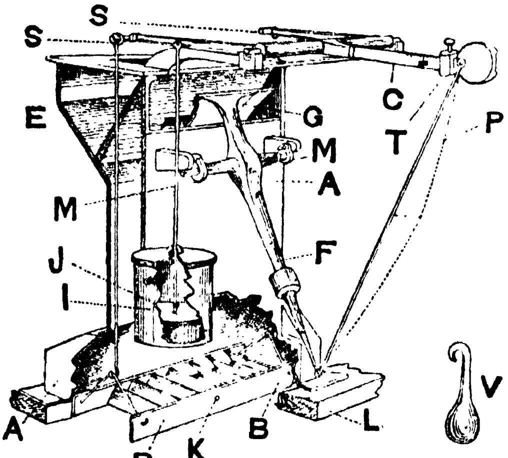


FIG. 492.

The automatism of action and adjustability of this apparatus consist in the following.

The lever *F* in its axis of rotation is fixed by hook-like rings *MM*, and by means of a solid rod is coupled with the lever *C*.

On one side of the lever *C* there are two counterweights, the larger of which is stationary, while the smaller one *T* freely travels over the rack part of *C*. By setting this adjustable counterweight *T* on a corresponding grade marked on the scale of the lever *C*, the quantity of product running per minute through the opening *E* is determined. The lever *C*, on the side opposite to the counterweights, has two handles *SS*, to the ends of which on wire rods a frame *B* with inclined planes *K* is suspended. The grains falling on the inclined planes *K* produce a pressure which imparts motion to the lever *C* and through it effects a corresponding alteration on the position of the slide valve *G* fixed to the lever *F*.

To attain a quiet, even action of the slide valve *G* there is a piston *J* running in a cylinder *I* with glycerine and connected with one of the handles *S* of the lever *C*. If the apparatus is designed to do service for a double roller mill, *i.e.* a roller mill with two pairs of rolls, it has to be stationed in the middle of the roller mill hopper, so that the frame *B* should be placed down the length of the rolls. But if the grain runs only to one pair of rolls, the apparatus is set over the hopper, so that the counterweights are opposite to the feeding spout of the mill.

In mounting the apparatus particular attention should be paid, that it is fixed on the hopper of the roller mill perfectly accurately in vertical and horizontal position, otherwise it will either operate badly or leave off working altogether.

The inlet aperture in the hopper of the roller mill is made 5 mm. larger in length and width than the outlet of the apparatus. The spout conveying the stock has to be set if possible not vertically but aslant. If the position of the spout is vertical several plates lying across each other should be set in it and receive the blows from the grain passing through. It is still better in such a case to fit directly under the apparatus in the outlet spout a slide valve, by means of which the inflow of grain may be stopped, if there is anything to be put into order, or a part of the mill has to be inspected.

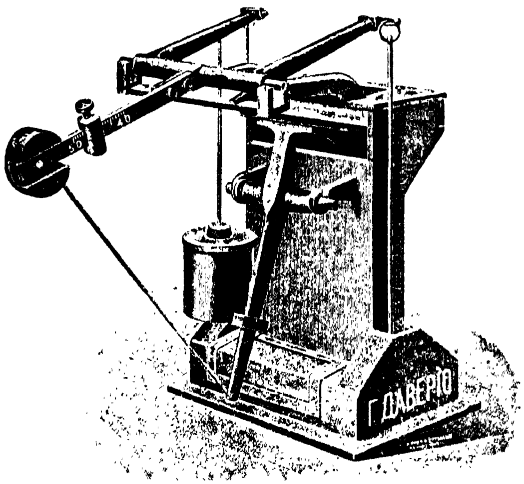


FIG. 493.

On Fig. 493 is given a perspective view of this apparatus.

Before starting the apparatus all movable parts must be examined to be sure that they work freely. The cylinder *I* must be filled with glycerine to a level 5 mm. from the top lid ; generally the glycerine is never added afterwards.

Before letting the grain into the apparatus, the adjustable counterweight *T* is set on the division of the lever *C* corresponding to the passage of the required quantity of stock.

When the apparatus is in operation, the feeding rolls and the feeding slide valve have to be so far open that the grain may pass through unhindered, and not collect under the frame *B*, otherwise the action of the apparatus will be incorrect.

If the handles *SS* of the lever *C* fall on the block *A* when the least quantity is being treated, then, to make the operation of the apparatus correct, the rod is slightly shortened by bending.

When cleaning the slide valve *G* or the passages between the inclined plates *K* (in the frame *B*) only wooden tools should be used, and in no case sharp metal ones. The pear-shaped weight *V*, given in addition to each apparatus, is set on one of the handles *S* of the lever *C* when it is necessary to close the opening *E* completely.

VII

FLOUR BLEACHING

Owing to the great development of milling technics during the last ten years, it has been shown that it is possible to obtain products of a perfection not conceived previously. The attempts to improve the outward qualities of flour referred to its colour as well. We must acknowledge that the consumer very soon became used to the grades of flour, which are of a better colour, for instance, and is extremely particular about it. The desire of the mills to comply with these demands forced them to have recourse to a chemical action upon the flour with the view to improving its white colour; the other grounds adduced in explanation of this manipulation, such as enhancing the baking qualities ot the flour, &c., being only of secondary importance.

The improvement in the white colour of the flour may be attained by treating it with bleaching substances. It is evident that a series of bleaching materials has to be excluded as injurious in this operation, and only those may be applied which are volatile and may be extracted after they have had their effect on the flour. Such, for instance, are all gases which have a bleaching effect on the organic substance: chlorine, sulphureous gas, ozone, oxides of nitrogen.

On the ground of previous experience as to the effect of these substances upon flour the following is known: though chlorine and sulphureous gas do bleach the flour they lower its quality so much as to make them commercially impossible. Ozone likewise bleaches the flour but imparts an unpleasant odour to it. Thus, the sole adaptable bleaching substances remaining are the nitrogen peroxides.

The Alsop Bleaching Process.—In 1903 Alsop patented his process of flour bleaching by means of electrified air in apparatus especially invented for the purpose.

Alsop's apparatus (Fig. 494) consists of four parts: a dynamo, an induction coil, an air pump for electrification, and a switchboard. The electrifying pump is the most important part of the whole system; in it the bleaching gases are produced. Between two couples of electrodes there is a constantly interrupted contact, owing to which electric sparks 7 to 15 cm. long are caused. Under the effect of these sparks chemical re-actions take place between the nitrogen and the oxygen of the air, which give NO_2, nitrogen dioxide. The electrode couples are placed in tubes *AA*, one of the electrodes in each being set fast on the bottom of the tubes, while the others move in the tubes with the aid of slide rods *EE*. The slide rods are connected with each other in such a way that they alternately approach the upper electrodes to the bottom ones and remove them, owing to which electric sparks are formed between the electrodes.

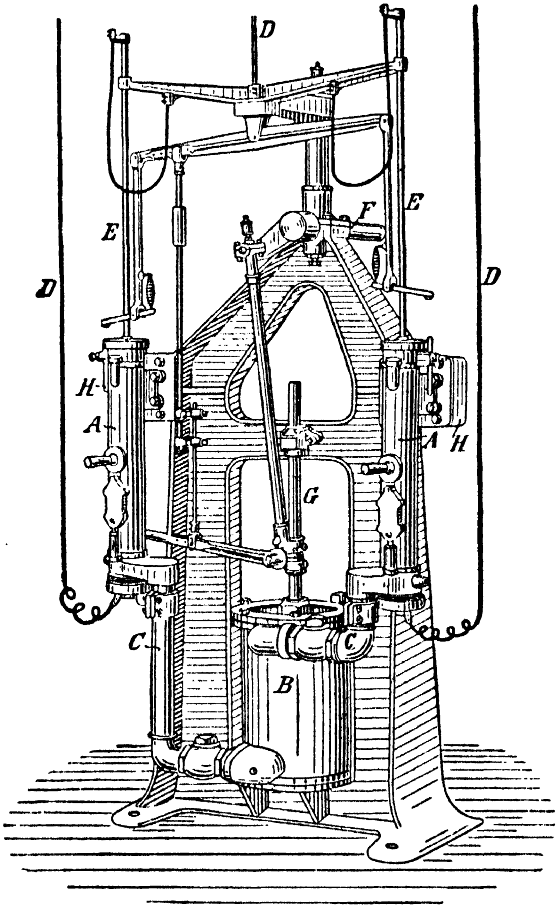


Fig. 494.

The apparatus operates in the following manner: with the aid of the double action pump *B* a current of pure air is by turns aspirated through the inlets *HH*. In the tubes *AA* the air is subjected to the action of the electric sparks. The aspiration of air takes place simultaneously with the production of a spark. The electrified air is conveyed through the tubes *CC* away, and flows through valves into the chamber *B*, whence through the connecting pipes and valves, set in the back wall of the chamber (not seen in Fig. 494), it passes into the pipe which conducts to the apparatus in which the flour is agitated. Further, the marks on the figure denote: *DD* wires for the current, *G* the sliding rod of the pump piston, and *F* the shaft on which a pulley of any particular diameter for driving the apparatus may be set. The agitating apparatus has the shape of an oblong drum in which the flour is kept in constant motion by a system of beaters ; owing to this the particles of flour come well in contact with the electrified air. The effect of the gases becomes manifest after about a minute's stirring of the flour.

The operation of the apparatus may be regulated. First of all, the quantity of air introduced may be altered through a special globe valve ; the tension of the current and its quantity can likewise be altered.

Experiments of bleaching after Alsop's method were performed with a strength of current of 5, 6, 7, 8, and 9 amperes. The stirring apparatus treated 36 to 40 sacks per hour ; the flour passed through the drum in the space of 1½ minutes and was consequently under the effect of these gases only during that time. Neither in the drum nor on leaving it did the flour smell of the gases. Three kinds of flour were tested. They were all obtained from Argentina wheat, which was just then being treated at the mill. The following were the grades :

Patent wheat flour	0 to 30 per cent.
Bakers' ,, ,, ...	30 to 64·5 ,,
Low grade ,, ,, ...	64·5 to 73 ,,

The experiments were commenced with a current 5 amperes strong. It appeared that with such a strength of current it was impossible to notice any visible change in the flour definable by pekarisation. Only beginning with 6 amperes did the effect of the gases upon the patent and bakers' flour become manifest, and then grew more intense with the increasing strength of the current. Before it was bleached the flour had that peculiar colour which is demanded in Germany in good wheat flour, or, at least, is very much appreciated. That colour remained after bleaching with 5 amperes unchanged ; with 6 amperes it was perceptible, but seemed already to be a little lighter ; with 7 amperes it was scarcely noticeable ; on the contrary, the flour began to assume a kind of dead grey colour, which with the further increase in the strength of the current grew more intense.

The effect of the gases appears to have been greater on patent flour than on bakers'. The patent flour when more strongly bleached assumes a colour reminding one of the colour of chalk, whereas the bakers' flour assumes a dead greyish-white colour. This difference is particularly visible by " Pekar's " test.

As to the low grades flour, the nitrogen peroxide seems to have no effect upon it. Even after a strong bleaching with a current 8 amperes strong one could not discover by dry test any alteration, while the wet test showed a slight difference in colouring. The low grade flour is practically unbleachable.

Other Bleaching Processes.—Besides Alsop's process there are other methods of flour bleaching. In all cases the bleaching agent is nitrogen dioxide (NO_2). The various processes of bleaching differ from each other only in the manner in which the bleaching gas is obtained. This is done in different manners—by electrifying the air, or as in one of the processes, chemically.

Two other processes belong one to the Ozonised Oxygen Co., Ltd., and the other to the Flour Oxidising Co., Ltd. Both the companies put the building of the apparatus into the hands of Henry Simon in Manchester. In the description of the Ozonised Oxygen Co. ozone is erroneously considered to be the bleaching gas; this idea found its way into the name of the company. In reality the bleaching gas here is also the nitrogen dioxide obtained through the discharge of a high tension current. As we see in Fig. 495, in the top part of the iron cupboard, where the whole system is placed, there is a glass tube *A* with six electrode couples, between which the electric discharges take place. Into this tube by means of a fan is drawn the fresh air, which is then forced into the air tank, whence it is directed to the drums *M*, where the feeding in and the stirring of the flour undergoing the bleaching process is performed.

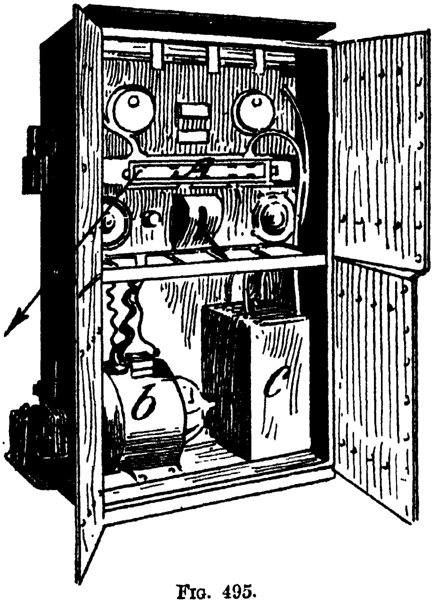


FIG. 495.

The experiments were made in London at one of the mills, where the system described operates with a steady strength of current of 15 to 17 amperes. The flour is bleached in six parallel drums, and remains under the influence of the NO_2 for only about one minute.

The bleached product the investigators treated was a flour from the following mixture: eight parts of Russian wheat, three parts of Australian, four of North Manitoba, four of La Plata, and eight parts of hard winter wheat (North America). The flour was of the first grades to the amount of 35 per cent. A similar unbleached flour served for comparison.

The experiments performed with these products gave no signs of the properties and the baking qualities of the bleached flour being modified. Contrary to former observations, however, it was established that not only the bleached flour, but the crumb of the bread made of it as well, appeared to be whiter. Nevertheless, the differences were insignificant, and could be noticed only when directly compared.

In the plant of the Flour Oxidising Co.'s bleaching apparatus the bleaching gas is procured chemically. Small quantities of ammonia gas are conveyed through a red-hot platinum tube, and thus the nitrogen dioxide obtained. As is shown on Fig. 496, a large quantity of air is forced with the aid of an air pump and reservoir into the tube generating the nitrogen dioxide, where those two gases blend and are directed to the bleaching drums.

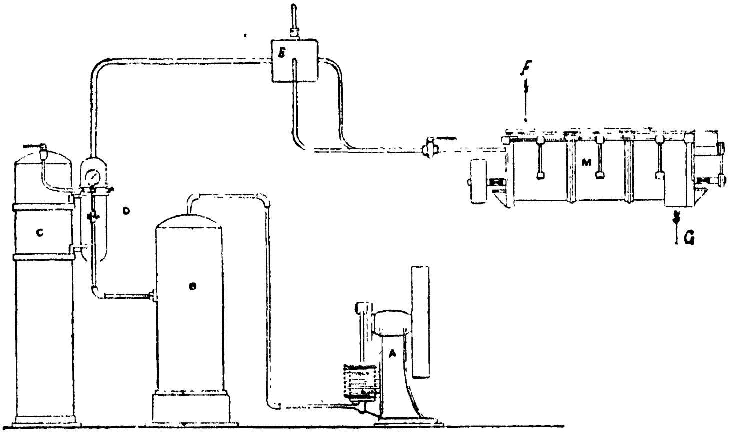


FIG. 496.—Bleaching Apparatus of the Flour Oxidising Co., Ltd.

A—air pump; *B*—reservoir for air; *C*—cylinder for ammonia; *D*—nitrogen dioxide (NO_2) generator; *E*—reservoir for NO_2; *M*—drum for flour; *F*—flour feed; *G*—bleached flour delivery.

The gases forming in the electric arc lamp can also serve for flour bleaching. Besides the various oxygen combinations of carbon (CO and CO_2) in the voltaic arc there are also formed oxides of nitrogen, and among them the nitrogen dioxide (NO_2) possessing bleaching properties. Owing to the high temperature of the voltaic arc, the gases appearing are immediately destroyed; but if the air out of the arc lamp is being steadily sucked away, a mixture is obtained consisting chiefly of air, though the above-named gases are present in sufficient quantity to have a bleaching effect. Especially convenient for that purpose are the arc lamps where the carbons are set not opposite to each other but form a sharp angle, as is the case, for instance, in the arc lamps for continuous current manufactured by the Arc Lamp Works, Ltd., in Nurnberg. Such lamps are easily joined into one system by means of a reservoir. If the electrified air were to be drawn out of this reservoir, it could be directed after cooling in the air tank to the bleaching drums.

General Results of Investigation.—The results of Buchwald and Neumann's experiments lead to the conclusion that the normal bleaching does not cause any great change of a chemical character. Attention must be especially drawn to the fact that even after a lapse of several months a test of the flour gave the same results ; consequently, the bleached flour, even in the course of time, shows no tendency to modification. At the same time it was established that the bleaching effect of the nitrogen dioxide is based on the modification of the fat in the wheat flour. Fleurent considers that the nitrogen oxide precipitates directly on the fat, since it disappears.

According to Avary and to Alway and Pinkney the oxides of nitrogen decolorise, in the same way as sunlight, the colouring substance dissolved in the fat of the wheat.

The fat obtained by Buchwald and Neumann out of bleached flour, the raw fat of ether extraction, displayed no changes in colouring. The benzol extract proved to be lighter only in a strongly (9 amperes) bleached flour. In optical respect the fats showed no deflections. The quantitative differences in the contents of fat are caused by bleaching apparently only in the patent flour, the quantity of flour soluble in ether at the same time increasing, but also here the differences are insignificant. In the bakers' grades, where, owing to the larger percentage of fat, greater modifications would be expected, there were likewise no differences noticed.

In its fresh condition and after it had been lying the flour contained the same amount of water. Neither was there any difference noticeable in the quantity of acid.

The diastatic power of flour, manifest in its property of converting to sugar, apparently increases in case of a weak, *i.e.* normal bleaching, and drops when that process is exaggerated.

An important point in the inventor's methods is the assertion that the quantity of protein in the flour increases owing to his method of bleaching, while the amount of carbo-hydrates diminishes. The truth of such an assertion seems incredible, but it is interesting to watch the effect the bleaching gases have on the amount of nitrogen and gluten in the flour.

From the results of Buchwald and Neumann's experiments the following may be inferred : the quantity of nitrogen remains the same if the bleaching is weak, but it diminishes, especially in the bakers' grades, if the bleaching is strong. An analogous phenomenon was observed in the gluten. The differences in the amount of gluten proved to be insignificant owing to the inaccuracy of the method of investigation, but must be regarded as correct, since the numbers obtained in the manifold repetitions of the investigation were the same.

Out of these experiments the following numbers were obtained :

TABLE L

	Patent.			Bakers' Grades.		
	Unbleached.	Bleached.		Unbleached.	Bleached.	
		6 Amp.	9 Amp.		6 Amp.	9 Amp.
Water	10·59	10·30	10·28	10·57	10·38	10·4
Fat	0·89	1·25	1·12	1·29	1·30	1.16
Total quantity of proteins	11·50	11·80	11·42	12·18	12·18	11·18
Proteins dissolved in water	2·35	1·80	2·75	1·89	1·81	2·55
Gluten	10·60	11·00	10·20	12·00	12·00	10·80
Sugar (maltose) . . .	0·97	0·71	0·81	0·74	0·75	1·01
Diastatic power . . .	19·2	23·8	18·2	21·7	29·0	19·6

The results obtained from experiments in baking have the most weight for practice.

The flour the investigators had at their disposal was tested in accurate laboratory experiments as well as practically in baking establishments ; both the results coincide well. There were no advantages or defects discovered in the bleached flour.

In no case was the bleached flour found to be worse as regards the baking qualities.

The experiments were so arranged as to have the process of fermentation, on the one hand, take place in particularly favourable circumstances in the laboratory experiment—and on the other hand, in the conditions obtaining in practice. It appeared that the water-absorbing capacity of bleached flour is slightly smaller ; the quantity of water being the same, a larger amount of flour was necessary to prepare the same dough.

	Unbleached.	Bleached.	
		6 amp.	9 amp.
Quantity of water required by patent flour .	1·380	1·460	1·440
„ „ „ bakers' grades .	1·640	1·726	1·692

In other words, bleached flour absorbs less water, viz. :

Patents	by 4·0 per cent. to 3·1 per cent.
Bakers'	„ 4·6 „ „ „ 3·2 „

The fermentation took place in all kinds of flour equally and normally.

The baked products were of an equal structure. The brownish colouring of the crust was a little deeper for the bleached flour. The bulks of the loaves were in all cases good, the differences fluctuating within the limits of inaccuracy in the experiment. On the average, out of ten experiments, there was obtained to 100 gr. of flour a loaf in cubic centimetres :

	Unbleached.	Bleached.	
		6 amp.	9 amp.
Patent flour	458	453	456
Bakers' flour	449	450	458

The numbers received in practical experiments do not materially differ from them, viz. :

Patent flour	451	450	435
Bakers' flour	439	469	462

Thus it appears that the bleaching of flour has no substantial influence on the baking process. The quantity of bread obtained proved to be a little less for bleached flour as regards weight, there being no difference in its bulk. It is remarkable that the bread crumb was no lighter in colour for bleached flour than for unbleached. In respect to bread baking the advantages of bleaching were, consequently, an illusion.

In reviewing the results of all the experiments, the investigators arrived at the conclusion that flour bleaching is of no consequence on principle.

With regard to baking, the bleaching after Alsop's, Simon's methods, and others similar to them deserve no attention. This general inference may be made seeing that the flour used for the experiments was of extreme types. The flour undergoes no modification, neither in its consistency nor in its baking qualities. Therefore the improvement in the quality of the flour which was observed (or, at least was asserted to have been observed) by the inventors of the apparatus must be denied. However, the investigators point out that they never once observed any deterioration in the flour as a nutritive substance.

At the second International Pure Food Congress, which took place in Paris in October 18–24, 1909, as regards the bleaching of flour and middlings, by the majority of votes it was decided to allow the bleaching of flour by means of nitrogen oxides on condition that the sacks are stamped with a special mark. No injurious consequences to the health from such bleaching were discovered by the Paris Congress.

The bleaching of semolina, on the contrary, was acknowledged to be inadmissible, since it would allow the adulteration of hard wheat middlings bleached by nature itself with the aid of white rice middlings.

That Congress gave utterance to what the investigators were already demanding in the interests of custom taxation, namely the establishing of standards of bleached flour.

But on the other hand, in the United States, where the chemists, E. F. Ladd and R. E. Stallings (North Dakota), are stubborn antagonists of bleaching, in several of the States bleaching is considered to be an adulteration of flour injurious to health, and is forbidden by law.

CHAPTER VIII

MILLING DIAGRAMS

I

CLASSIFICATION OF MILLING SYSTEMS

IN the preceding chapters, where we had to speak of the reduction of grain in connection with the character of operation of the machines, we mentioned in brief outlines the different milling systems. Now we have to give a definite and accurate classification of the various milling systems met with in practice, otherwise it will be difficult to make out the innumerable varieties of milling schemes proceeding from the quality of grain, local conditions of production, and the demands made by the local, district, and world markets.

From the remotest time up to the end of the sixteenth century the technics of flour milling knew only one method of reducing the grain, the essence of which consisted in that the grain was passed but once through the milling machine and was reduced together with the integuments. In the end of the sixteeenth century there was invented in France another method of milling, ascribed to the miller Pigeaud. That method was kept in secret by the French a long time, until in 1760 Bouquet, a well-known miller in Lyons, published it under the name of "Mouture à la lyonnaise," having perfected the old French method of milling of the end of the sixteenth century. In the more recent French literature that milling system is called "Mouture économique." The essence of that system lay in the fact that the grain was reduced not by one passage but by several. When letting the stock pass three or four times in between the millstones, the upper stone, the runner, was set high over the lower one, and gradually the distance between them was reduced to the normal necessary for fine grinding. The product obtained after a passage through the first millstone with the runner set high was bolted on a reel-separator and gave flour as throughs, while the overtails containing the large particles of grain was fed to the second stone, the grinding and the bolting being repeated until the tails from the last reel-separator consisted of bran. Owing to such a method of milling, a considerable part of the bran was not admixed to the flour, and the flour obtained was whiter.

That method of milling began to spread rapidly in Europe and America under the name of repeated, high or reduction system. But in Austria-Hungary, where the dry and hard wheat has brittle coverings, that method gave no good results, as the integuments were reduced together with the starchy part of the grain, and imparted a darker colouring to the flour. With the invention of the purifier by the Hungarian Paur the repeated milling was enriched by one very important stage in the milling process—the freeing of middlings of the offals, which brought a new improving alteration into the milling process.

Thus the historical course of development of grain milling and its present state defines two methods of grinding :

1. Plain grinding.
2. Repeated grinding.

The substance of these methods is perfectly clear from the preceding. But milling practice demands a complication of the plain milling towards the repeated milling, not realising, however, fully the principle of modern high milling on the one hand, and on the other, often simplifies the high milling, without bringing it up to the complicated system.

German flour milling technics have established three types of milling :

I. Flachmühlerei—low or plain grinding.
II. Halbhochmühlerei—semi-high grinding.
III. Hochmühlerei—high grinding.

It must be remarked, however, that the most learned Austrian scientist, Professor Kick, follows the first classification, *i.e.* he divides the milling in two groups, plain and high, regarding the semi-high milling as high with a reduced number of breaks.

In our further studies of milling we shall keep to the classification established by practice and defined by the substance of the process itself. For this reason we offer the following two types of milling systems :

I. Plain (low) grinding.
II. High grinding.

The essence of the plain milling system for wheat is defined not by the number of passages of the product through the grinding machines, but by the purpose of these passages. The object of each passage through the grinding machine in plain milling, is to obtain flour immediately as the chief product. The total number of passages may fluctuate between one and five. The absence of purifiers must be regarded as a characteristic

feature of plain wheat grinding, for the middlings and dunst obtained are not graded according to quality, but subjected to a further immediate reduction to obtain a greater or smaller amount of flour.

High grinding gives us three separate stages in the process of reduction. The problem of the first stage is to obtain semolina, middlings, and dunst with the least possible quantity of flour, which is undesirable here, because it becomes dirtied with triturated bran. That part of the process is called, as we already know, break (rebreak must also be included in it). In the second stage the cleaned semolina undergoes further reduction, which may be named rebreak (in Russia that process is called the polishing of middlings). The object of this part of high grinding is not so much the production of flour as the reduction of semolina to middlings for further grading according to quality. Finally, the third stage of high grinding is the reduction of middlings and dunst and the cleaning up of the offals.

We must regard as a characteristic peculiarity of high grinding the grading of middlings and dunst according to quality, and consequently the cycle of machinery must necessarily include a purifier.

The characteristic of high grinding we have just given was evolved by Hungarian flour millers, who have mostly to do with hard wheats. That system has been accepted partly in Germany and Russia. In France, England, and America the Hungarian system is simplified in so far that the number of breaks in it is seldom more than five, the rebreak of middlings is absent, but the purifiers are always included. The simplified Hungarian high system is called by the Germans semi-high (Halbhochmühlerei).

High rye milling differs according to the universally accepted plans from wheat milling, in that the grading of middlings according to quality is always absent, *i.e.* the cycle of machinery contains no purifiers. We shall become acquainted with this system of milling more in detail below, and turn now to the milling diagrams.

II

PLAIN GRINDING

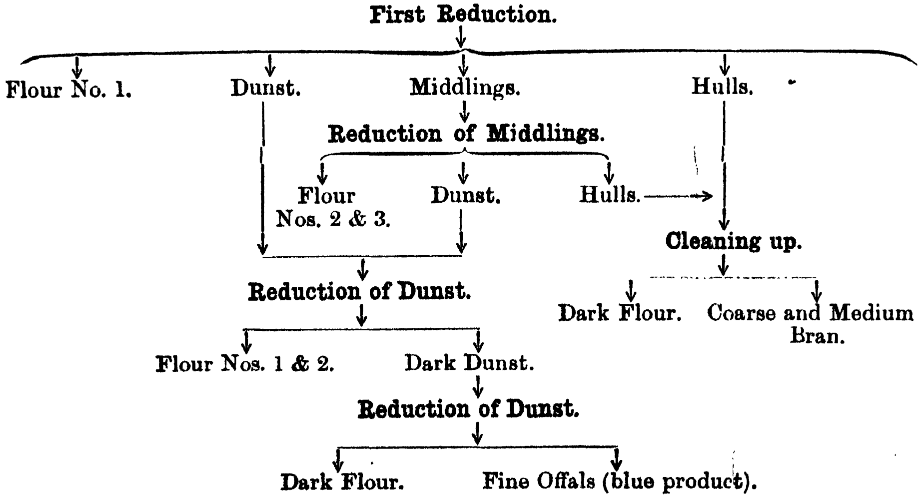
Single Passage Milling.—This system is known under the appellation of peasant grinding in Russia, and the French have a characteristic name for it: *mouture pour le pauvre* (milling for the poor). The grain is passed through the stone of the roller mill once and is ground to flour together with the offals. In this manner, the system yields 100 per cent. of flour. The bolting away of the unreduced offals is done by hand sieves before baking if the bran is too large, which happens when the grain is not perfectly dry,

The Single Passage Sifted Milling differs from the preceding in that the bran is sifted away in the mill by means of a reel or sifter. In the latter case the mill is generally constructed for improved plain milling, which can yield two or three kinds of flour, but in dependence on the demand for the peasant-sifted flour can produce this flour after one single passage. The single passage bolted milling yields 85 to 95 per cent. of flour.

Single Passage Intense Milling.—The aim of this system is the reduction to flour not only of the grain kernel, but of its integuments too. After reduction the product runs to the bolting machine, which yields flour as throughs and tails over bran. The bran goes to the same sole milling machine which receives the grain. Thus we have a locked cycle for the flow of the bran, which results in the bran being reduced to particles of flour, and the whole 100 per cent. of flour is obtained from the grain.

Improved Plain Milling.—The purpose of this system is to extract all the flour particles as far as possible from the grain, and to separate away the offals containing no flour. The number of reductions in this system is from two to five, the product after each reduction machine passing to the bolter.

The general diagram of the improved plain milling system is this :



We can see in this plan that each reduction system yields a gradually deteriorating flour, dunst, middlings and offals. The flour deteriorates the more quickly, the less the number is of reduction systems.

It has already been mentioned that an improved plain system consists of two to five and seldom six reductions. With two reductions, generally up to 70 per cent. of flour is obtained from the first, and up to 15 per cent. from the second. 85 per cent. should be regarded as the limit of flour yield for the improved plain system; a certain percentage of yields for each reduction may be at the same time taken, to calculate the milling machines. In the case given, with two reductions, the first one yields 70 per cent. of flour directly. The second reduction system receives the remnant of the product, *i.e.* $\frac{30}{100}$. If we take 50 per cent. of flour from it, we obtain $\frac{30 \times 50}{100} = 15$ per cent. Thus 15 per cent. will be discharged as bran. 20 per cent. of flour might be taken from the second reduction, but then the flour would be too dark.

As to the quantity of intermediate products on the improved plain system with three or more reductions, modern practice offers little definite material. In that case much depends on the way the miller performs the reduction. Still we must append the data of a German specialist, Wingert, for three and six reduction systems (Tables LI and LII).

TABLE LI

Nos. of Reductions.	Product Reduced.	Fed in 100 Per Cent.	Yielded in 100 Per Cent.			
			Flour.	Middlings and Dunst.	Bran.	Blue Flour.
1	Cleaned grain . .	100	50	30	12	6
2	Middlings and dunst	30	20	10	..	..
3	Middlings and dunst	10	10–7	..	..	..
Total quantity in 100 per cent.		140	77–80	40	12	6

TABLE LII

1	Cleaned grain . .	100	35	50	15	..
2	Middlings and dunst	50	25	25	..	..
3 and 4	Dunst	25	10	15	..	..
5	Dunst	15	6	..	..	24
6	Bran	15				
Total quantity in 100 per cent.		205	76	90	15	24

Let us now proceed to examine several typical diagrams of the improved plain milling system.

III

DIAGRAMS OF IMPROVED PLAIN MILLING SYSTEMS

The improved plain milling system has lately begun to gain a wide local market. That system showed particularly rapid development after the roller mills were adopted. The number of flour grades obtained with this system is generally from one to three, and sometimes up to five.

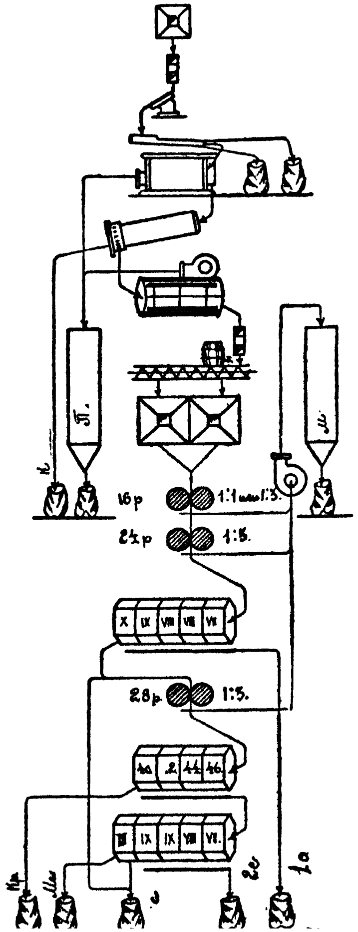


Fig. 497.

2c—Flour, 2nd grade.
M—Flour dust.
1c—Flour, 1st grade.
p—Corrugations.
K—Cockle.
Kp—Bran.
r—Dust.
Me—Sharps.
c—Offals.

Let us examine several typical diagrams of the plain roller milling system.

Fig. 497 gives a diagram of the plant for a mill of 100 to 130 sacks capacity per 24 hours.

The grain is deposited in the storing bin, whence the elevator carries it to the magnet, which detains the iron extraneous matter. From the magnet apparatus, the grain flows in a broad sheet to the aspirator (separator) with a sieve and manifold fanning. On the sieve the grain is freed of the large impurities: straw, barley, wild oats, maize, &c. On the separator likewise are partly sorted away the small impurities: cockle, small and broken grain, and the dirt adhering to the stock.

The diameter of the meshes on the aspirator sieves is 4 to 5½ mm. the large, and 2 mm. the small.

After the aspirator the grain goes to the cockle cylinder (trieur), where the grain is freed of cockle, pease, broken and small grains, and other analogous impurities.

From the cockle cylinder the grain is directed to the horizontal emery scourer with triple aspiration, where the germ, beard, part of the bran coatings, and dust lying in the crease are removed.

From the emery machine the grain is carried by the elevator to be dampened, and then to the bin to be tempered for about one to four hours according to the dampness of the grain. Sometimes dry grain (without any dampening) goes directly to be milled.

The dust from the grain-cleaning machines passes to the dust chamber and thence into sacks.

The reduction is performed by two pairs of rolls. But since it is difficult to reduce the grain in two passages (much power is uselessly spent; a whiter and a finer flour cannot be obtained, the bran discharged is very rich), an accessory breaking down passage is introduced into the scheme.

The length of the break rolls is taken approximately one-third less than the reduction rolls.

Length of the break rolls is	500 mm.
Diameter	250 mm.
Number of corrugations to an inch	16
Differential velocity of the rolls	1 : 1 or 1 : 3.

If the differential velocity of the break rolls is 1 : 1, the grain will be broken in halves; the differential velocity being 1 : 3, the grain is divided into several parts.

From the break mill the grain passes directly to the first reduction pair.

Length of rolls in the first reduction mill	800 mm.
Diameter	300 mm.
Number of corrugations to an inch	24
Differential velocity of rolls	1 : 3.

From the first reduction mill the whole of the mixed product is carried by an automatic elevator to the reel-separator, which is clothed with silks Nos. VII, VIII, IX, and X.

The tails of the reel-separator goes to the second reduction mill, and the throughs yield high grade flour.

Number of revolutions of the reel	25
Diameter of the reel-cylinder	900 mm.
Bolting cloths	3
Breadth of cloths	33·25 inches.

From the second reduction mill the whole mixture passes to the 4-cloth reel-separator, which is clothed in metal sieves and has the following numbers: 46, 44, 42, and 40.

The tails from this reel-separator is large bran, while the throughs go to the next reel-separator with five cloths, and the numbers of silk are VII, VIII, IX, X, and III.

The tails of that reel-separator are fine bran, and the throughs yield flour of the second grade and dunst, which goes to the mill.

If it is desired to give a better finish to the goods of the second grade the dunst is sacked off.

Length of rolls of the second reduction mill	800 mm.
Diameter	300 mm.
Differential velocity of the rolls	1 : 3
Number of corrugations to an inch	28
Number of revolutions of the 4- and 5-cloth reel-separators	28
Diameter of the reel-cylinder	900 mm.

Both the reduction and the break mill are exhausted.

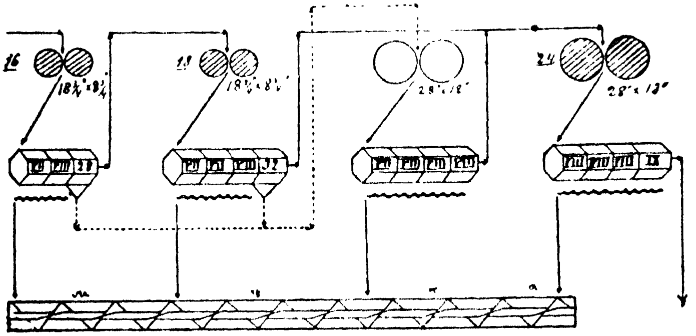


FIG. 498.

The ordinary type of the popular improved plain milling system, especially in the south of Russia, has the following form :

Grain Cleaning.—An aspirator or separator with a sieve, a trieur (cylinder), and a horizontal scourer.

Grain Reduction.—Two passages through corrugated rolls and one passage through a millstone. After the roller passages the product is bolted on sifters or on reels. After the stone, which cleans out the bran, the bolting yields flour of the last grade and the refuse gives bran. If two grades of flour are prepared, the product is yielded as follows : first grade 45 per cent., second grade 36·25 per cent., bran 17·5 per cent., different losses 1·25 per cent. If desired the first and second grades may be mixed to one straight grade.

Fig. 498 illustrates a milling diagram with four passages. The grain-cleaning department of such a mill consists of the following machines: the grain goes first to the dust reel-separator, where it is freed of heavy dust and small extraneous matter. The wire cloth used for small impurities and dust is No. 16, to separate the large impurities from the grain No. 5

(to an inch). From the reel-separator the grain goes to the trieur, whence it passes to the magnet apparatus. From the magnet apparatus it goes to the horizontal emery scourer. From the scourer into two bins, where the grain is tempered for five or six hours. Then it goes to the reduction machines.

Grain Reduction.—The reduction is performed in two four-roller mills. The first one is 450 × 200 mm. in size, the second 700 × 300 mm. The whole reduction process is ended in four passages. The first break gives dark flour (blue flour) and coarse middlings, which are bolted on a 3-metre reel-separator. The refuse goes to the second break, which is bolted on a 4-metre reel-separator. The flour obtained is fairly white, and the middlings are medium sized and mix with the middlings from the first break, and together with them run to the smooth rolls, where both are reduced, and give white flour first grade, and overtails, the so-called flat product, which mixes with the tails from the second break and goes to the fourth passage. Here the flat product and the tails from the second passage undergo a final reduction, and are then bolted on a 4-metre reel-separator, where the flour obtained is better than the one from the first passage and darker than that from the second. Since the flour goes to a common conveyor, the grades may be combined at pleasure; the first may be obtained separately, I, II, III, and IV, &c. Naturally, instead of reel-separators sifters may be employed. That mill can grind up to 500 bushels of wheat per day (24 hours) on this plan.

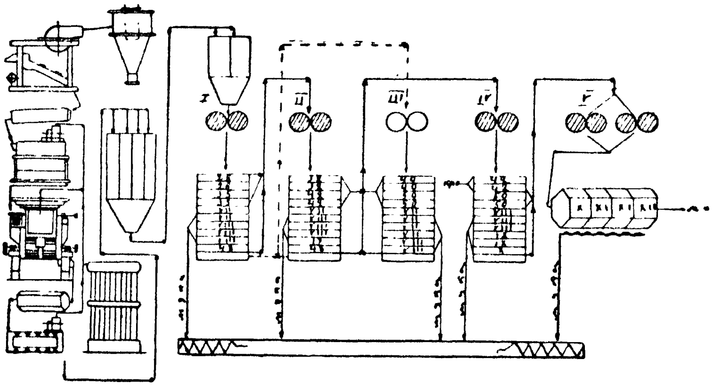


FIG. 499.

Fig. 499 shows a diagram of cleaning and reduction with five reduction passages.

Grain Cleaning.—The inexpensive cleaning department of the mill consists of an aspirator, a trieur, a Seck scouring machine with a scouring sieve, Luther's emery scourer, a brush machine, and a clean reel-separator. From the storing bin the grain is fed to the aspirator with one or two sieves, where it is freed of large and fine impurities, such as straws, cobs, clods of dirt, &c. The fan in the meanwhile carries away the dust, which is of very little value, to the cyclone or the filters. After that the grain passes to the trieur, where the cockle, pease, &c., are separated away.

In this manner the grain, freed of all foreign matter, undergoes further treatment. The beard and the germ coats are broken off, the grain is polished, and then passes to the reel-separator ; from the reel-separator to the brush, where the grain is subjected to a final polishing, and at the same time the dust brushed out of the creases. The pure grain is damped and then, by means of the conveyor, more or less satisfactorily stirred and carried into bins for tempering. The grain thus prepared is then milled.

The Milling Department (Fig. 499) consists of three four-roller mills, a two-box sifter with four divisions, and a reel-separator. The first mill is 32 × 12 in., the second 32 × 14 in., the third 20 × 10 in. The second mill has one pair of smooth rolls which reduce fine middlings. The bolting machines may also be set in the following order : one sifter for three products and the second sifter for two products.

The number of grooves on the first pair of rolls in the first mill is 16 to an inch, on the second pair of the first mill 18, on the fourth pair of the second mill 22, and in the third mill both pairs of rolls have 26 grooves.

The order of milling is the following. Before the first passage the grain runs over the magnet apparatus. In the first passage the grain is broken down, and the product of grinding goes to the first division of the sifter. The larger break chop and large semolina, and the tails of the bottom tray undergo a second passage. The product obtained passes to the second division of the sifter. The throughs from the bottom trays of the first two systems, fine semolina, are fed to the smooth rolls *III*. The product ground is bolted in the third division of the sifter. The larger chop and rebreak, and the bottom tails of the second division, the tails of the top sieves, and the bottom tails of the third division, go to the fourth pair of corrugated rolls. The product received from the fourth pair runs to the fourth division of the sifter, where from the first two trays cleaned large bran is obtained. The product of the next two trays and the bottom tails, dark dunst, pass to the fifth pair of rolls. The product from the fifth rolls is fed to the reel-separator, whence fine bran and dark dunst are discharged as tails. If desired the dark dunst can be delivered separately. Then the last cloth in the reel-separator should be for dunst, *i.e.* No. 5. Both the order of milling, as well as the products obtained, are clearly seen in the diagram. The whole of the flour is received by the conveyor, where it blends into one grade named sifted flour. In case of need it may be separated into grades. It is evident that the flour from the smooth rolls of the third system is the best. The next in quality is the flour from the second system. The darker grades are obtained from the first, fourth, and fifth systems. When milling soft kinds of wheat in the place of Nos. 48 in the first and second divisions of the sifter, Nos. 42 should be set, keeping the grinding in the first and second systems as high as possible. Then in all the divisions of the sifter flour silks coarser by one number must be placed.

This milling system is in vogue in the region of the Northern Caucasus, and mills of that type work for peasants, who bring the grain from quite remote parts. Owing to the latter circumstance, the possibility of correctly tempering the grain is not everywhere possible. This is explained by the fact that in some places the peasants, on bringing the grain, pour it into the pit for immediate milling.

Under such conditions the dampening of the grain is greatly hindered. To avoid undesirable consequences in that respect, there have to be arranged five or six bins of 25 to 35 bushels capacity each, and the milling operation performed in such a manner, that when one bin is emptied, the grist should be directed from the next one, and the empty bin filled with the grain cleaned in the scourer. Then, while the grist is flowing out of the first bin, the grain in the fifth or sixth bin, *i.e.* belonging to the customer standing in the fifth or sixth place, has a certain possibility of being tempered. In other parts, where the peasantry leave the grain and come to fetch the flour in two or three days' time, it is quite possible to temper the grain correctly. Still better is this operation arranged in localities where the peasants get the quantity of flour according to the weight of their grain.

Now, the question arises, How are the interests of the mill customers who have grain of different qualities, in respect to its impurity as well as specific weight, to be reconciled ?

To answer this case practice has evolved the following rules.

For grain containing a fairly large amount of impurities the loss in the product escaped with the air and in grain cleaning allowed is from 3 to 5 lb. *per* 36 lb., and not over 1 to 1½ lb. for grain of higher purity.

The regulation concerning flour is similar to it. Owing to such regulations it is possible to mill the grain of different customers together. Of course, a lot ought not to have such wheat admixed to it containing any proportion of rye, even if the quantity of admixture should be small, because the flour assumes a darker colouring in consequence.

Under such circumstances it is possible to treat all the grain together and temper it some ten or twelve hours if it is of a hard kind, and four or five if softer.

It is very desirable that the grain cleaning should be performed in two scouring passages, it being necessary to dampen the grain before it goes to the second scouring passage. In such a grain-cleaning process the first scouring passage frees the grain of the dust and dirt. After damping the grain is tempered, and then undergoes the second scouring passage.

But since grain cleaning of that kind at the farm mills is comparatively expensive, it is difficult to expect it to spread, though we must remark that good flour repays the extra expenses.

The mills described grind Kubanka with a 10 or 20 per cent. admixture of winter wheat.

In ending the review of the improved plain milling system, the fact should be noted that with this system it is not difficult to obtain good flour from soft wheat covered with elastic bran coats, which do not break up so much, and leave the flour undirtied. The best grades of flour prepared from hard wheats, on the other hand, become dirty owing to the offal being ground. For this reason the milling has to be performed cautiously, the dry grain being damped and the number of passages increased.

IV

HIGH GRINDING

The high, repeated, or gradual reduction process has already been characterised in brief outline. We shall now study it more minutely.

To extract the whole of the mealy part out of the grain and separate away the integuments, having removed as far as possible all mealy parts, is the purpose of high grinding. This is attained in a certain degree by the break and rebreak process, the aim of which is to break the grain down to middlings and dunst, to separate from them the particles containing no offals, and lastly, extract out of the particles of integument the remaining particles of meal.

As regards the character of reduction, high grinding may be divided into four separate categories. In the first must be placed the breaking of the berry down the crease, which allows of the removal of dust settled in the crease from the halves, and otherwise inextractable in the cleaning process. The French call this passage "preliminary break" (*l'avant broyage*), the Germans Hochschrot. In the second category are a series of passages in which the halves of grain are consecutively ground to middlings and dunst ("break proper," *broyage proprement dit*) of a better quality.

In the passages of the third category, which should be named the "completion of break" (*complément de broyage*), middlings and dunst of a lower quality (soft) are produced. Finally, the passages of the fourth category are designed to clean off the mealy particles from the bran (*curage des sons*).

A developed rebreaking process in which there are at least three passages represents the three last categories of the breaking process, or with one or two the reduction of the rebreak middlings.

The breaking and rebreaking process has to be so performed as to produce as little flour as possible, because it cannot be freed from the mealy particles of integument, and can be sent only to the worst grades.

The number of breaks varies between five and ten, the breaking of the grain down the crease included; the number of rebreaks, between one and five. The harder the wheat is and the more middlings and less break flour is it desirable to obtain, the greater is the number of passages used.

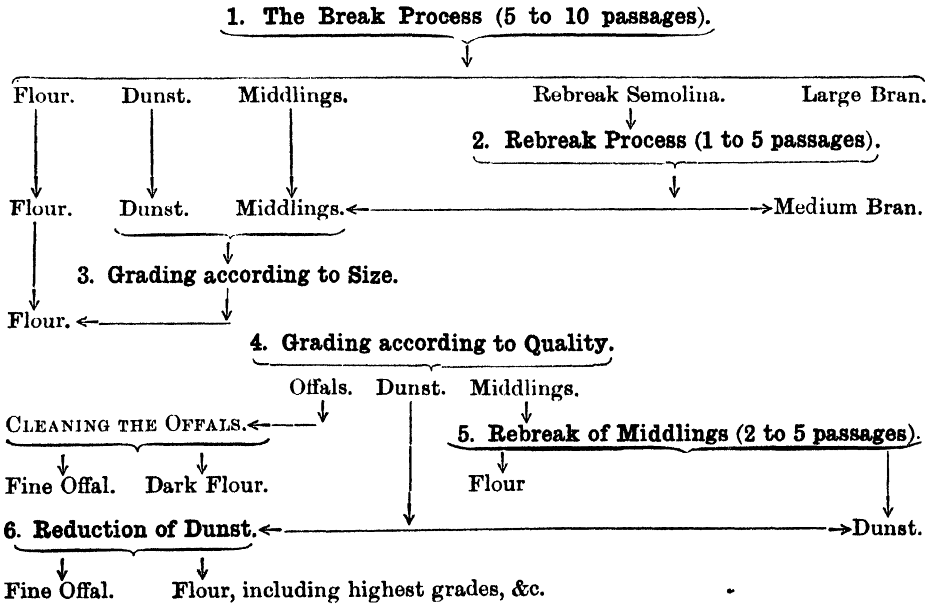
The product obtained from each separate passage is sorted on bolting machines, and gives a series of middlings and dunst of various size and quality. Then they are blended according to size and quality (sharp or hard and soft), and subjected to grading according to their quality on purifiers.

When the middlings and dunst are freed of bran and graded according to size and quality, the process of reduction commences. That process is divided into two parts. First the middlings are broken down finer. That part of reduction is analogous to the rebreaking process, and ought to be named the rebreak of middlings (polishing of semolina). The sense of that part of the process has to be explained. However well the purifier may work, we shall always have a certain percentage of middlings covered with offals. It is impossible to extract these grains of middlings, but by breaking them down on porcelain or smooth rolls, we obtain particles of these middlings covered with bran coats of a larger size than those of pure starch. Owing to that we have the possibility of separating the branny middlings on bolting machines in a second grading according to quality.

Consequently, in developed high grinding, when rebreaking the middlings, the production of a large quantity of flour should likewise be avoided.

Finally, when the middlings and dunst are completely graded, they are reduced to flour on smooth rolls.

With the details of high grinding we shall become acquainted through the various milling diagrams ; at present we give a general plan of high grinding.



We shall now proceed to acquaint ourselves with the milling diagrams designed for this system.

Hungarian High Grinding.—On Fig. 500 we see the diagram of Hungarian high grinding for a mill with a capacity of 5000 bushels of wheat per 24 hours.

The grain-cleaning diagram includes the diagram of silo cleaning with a passage of the grain through a zigzag separator and its distribution in the fourteen silos of the elevator. From the silo the grain goes through the grain-blending apparatus to the zigzag separator of the grain-cleaning department, then through the magnet apparatus and a two-box sifter with metal sieves, which grades the grain according to size. The grain graded according to size passes to two groups of trieurs, consisting of cockle cylinders, barley cylinders, and re-cylinders. The product received from the trieurs may further be subjected to double

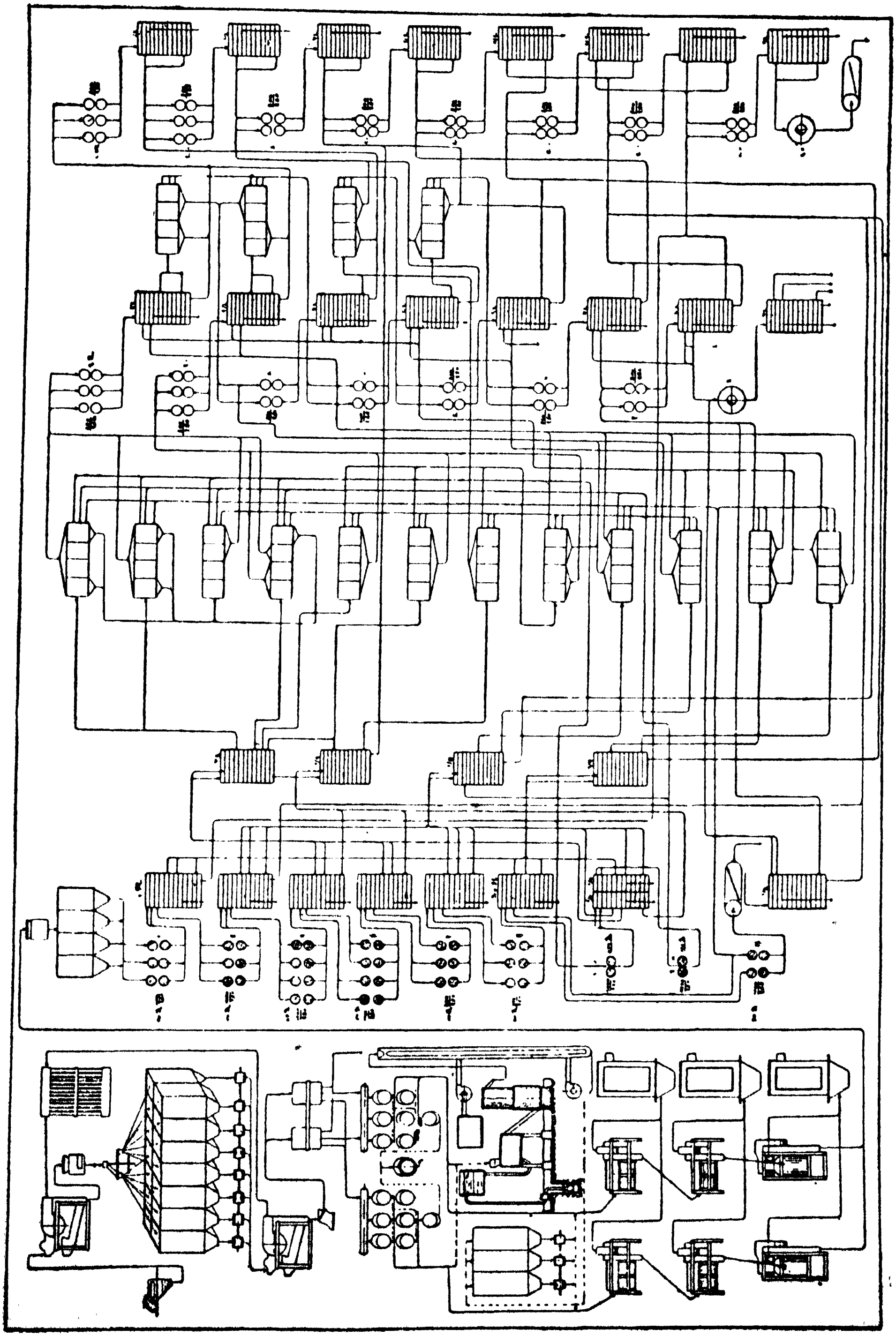


FIG. 500.

cleaning: dry and wet. In cases when the grain is not too dry the washing plant is missed. The grain passes consecutively two emery horizontal scourers, then it goes to the floor brush machine and through the scale into the bins for further treatment in roller mills. The small and large grain undergoes scouring on parallel separate scourers and brushes. If the wheat is very dry and hard it is subjected to wet scouring. Then from the trieurs the grain goes directly to the washing machine, whence, after drying and tempering in bins, it is taken to be scoured.

The cleaning scheme examined here is far from perfect, since the sifting away of heavy offals between the first and the second scouring passage has not been provided for, and a magnet and a dampening apparatus after the brush machine are absent.

The milling process forms three groups of roller passages, and the rebreak (polishing) of middlings and reduction of middlings and dunst are ended by the millstones for scraping out blue flour.

The first break system consists of seven breaking passages and two rebreaking passages. We must note that the Hochschrot is absent here, and the whole breaking process is not developed to its utmost limit. The rebreak (scratch) rolls treat the middlings which are tailed over by the purifier. The reduced product is subjected to a preliminary grading on the first group of sifters, on which the break flour is separated and the preliminary grading of middlings and dunst according to size is performed. The last breaking passage cleans the bran and heavy offals of the purifiers which sort the large and medium semolina. The product from this passage goes first to the reel-separator which gives bran as tails, while the throughs pass to the sifter, which gives dark flour, blue flours of medium size, and dark dunst of two kinds. The blue flours go to be reduced on the stones, for middlings rebreak, and the second grade of dunst to the seventh reduction.

After the preliminary grading the middlings and dunst pass to the sifters, which sort them into three to eight grades according to size. Here the breaking and rebreaking processes end. The product, graded according to size, runs next to the first group of purifiers, which sort it according to quality. After that operation the product, grouped according to size, undergoes a process we name middlings rebreak. The middlings rebreak performed on smooth rolls is in fact a process analogous to the break process. For this reason for the larger middlings we have here a system of sifters and purifiers. That process is, of course, much shorter than the breaking process. The sifters of this system supply us with flour, dunst,

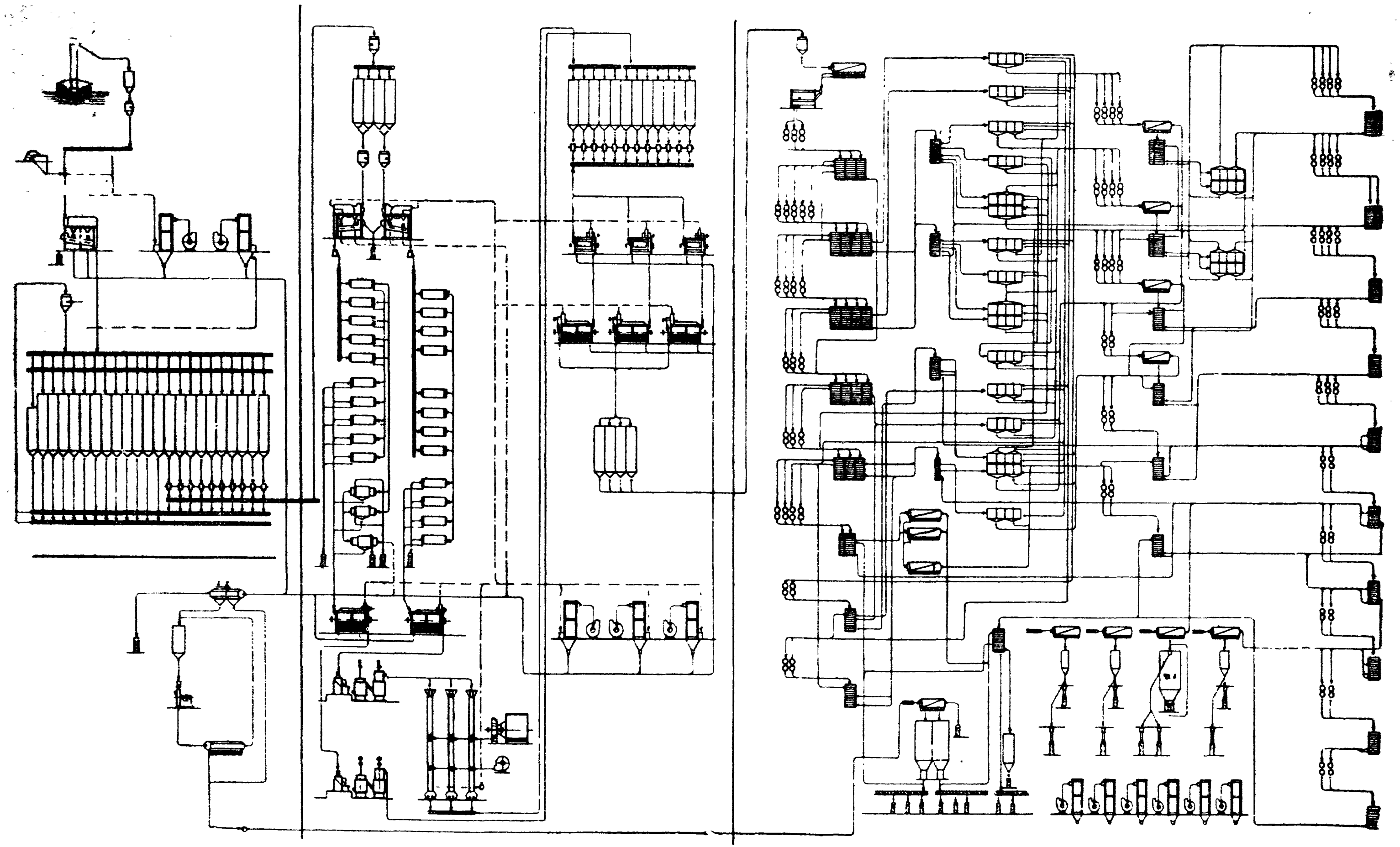


FIG. 501.

and middlings, which are subjected to a final reduction on the third reduction system of smooth rolls. The number of reduction passages is nine, the stone for cleaning up the dark dunst included.

German High Grinding.—To illustrate a typical German high grinding system at the Dresden Exhibition in 1911, the firm of Seck Bros. exhibited the milling diagram shown in Fig. 501. The mill grinds about 6000 bushels of wheat per day (24 hours). We shall pass by the diagram of the silo and the wheat-cleaning system, and only point out that grain cleaning in the mill is developed considerably better than in the preceding plan. Here the wet scouring of grain with a dryer and without it is provided for.

The mill proper is arranged after the same scheme that is used in the Hungarian mill, with the sole difference that the number of breaks in this case is limited to six, the number of rebreaking passages for middlings is reduced, but the number of reductions is increased. The bolting machines for semolina rebreak are centrifugals and sifters in conjunction. Besides that, to obtain the final product, flour, there are centrifugal redressers.

The two diagrams of high grinding systems examined give a sufficient idea of the standard separate stages of the milling process.

Since we are acquainted with a general outline of the grading of the product of the breaks, a more detailed plan of that grading should be given.

Let us take, for example, the third break (Fig. 502), as characteristic of break stock, and examine the process of grading the product obtained.

The product of the third break passes on to the sifter No. 1, the upper sieve of which is covered with a metal cloth No. 18. The overtails are break stock for the fourth break. The next sieve is likewise covered with a metal cloth No. 22, and yields the rebreak semolina. Then follow two silk flour sieves Nos. 10 and 11 ; next one silk sieve No. 3, for separating middlings from the dunst ; and finally, one silk sieve No. 9, for separating dunst as throughs and fine middlings as tails. Before the flour sieve very often is set a sieve for separating the large semolina (Nos. 32–38). The mixed middlings of the tails of No. 3 go to the sifter No. 2, which grades them into eight different sizes, and hence each of the eight grades passes to the purifier *A* for treating the semolina.

All the first runs of purified stock are generally mixed together, but each size may be collected into sacks or spouts (if automatic) separately, if desired. The same may be said of the second runs.

The third sizes of middlings are mixed together, &c. The offals of all the eight sections of the purifier are likewise run together.

The throughs of the last sieve (No. 52) consist of dunst, which is directed to the sifter No. 3 for dunst.

The dunst from the break sifter (No. 1) goes to the dunst sifter No. 3 which grades the dunsts. The top sieve yields flour. Then follow six dunst sieves (Nos. 8, 7, 6, 5, 4, and 3) of which the last, No. 3, tails over middlings which are directed to the sifter No. 2. The throughs from these six sieves go to the purifier *B* yielding the first, second, and third cleaned dunst, which are reduced together independently of the size, but divided according to quality. The light offals constitute a finished product.

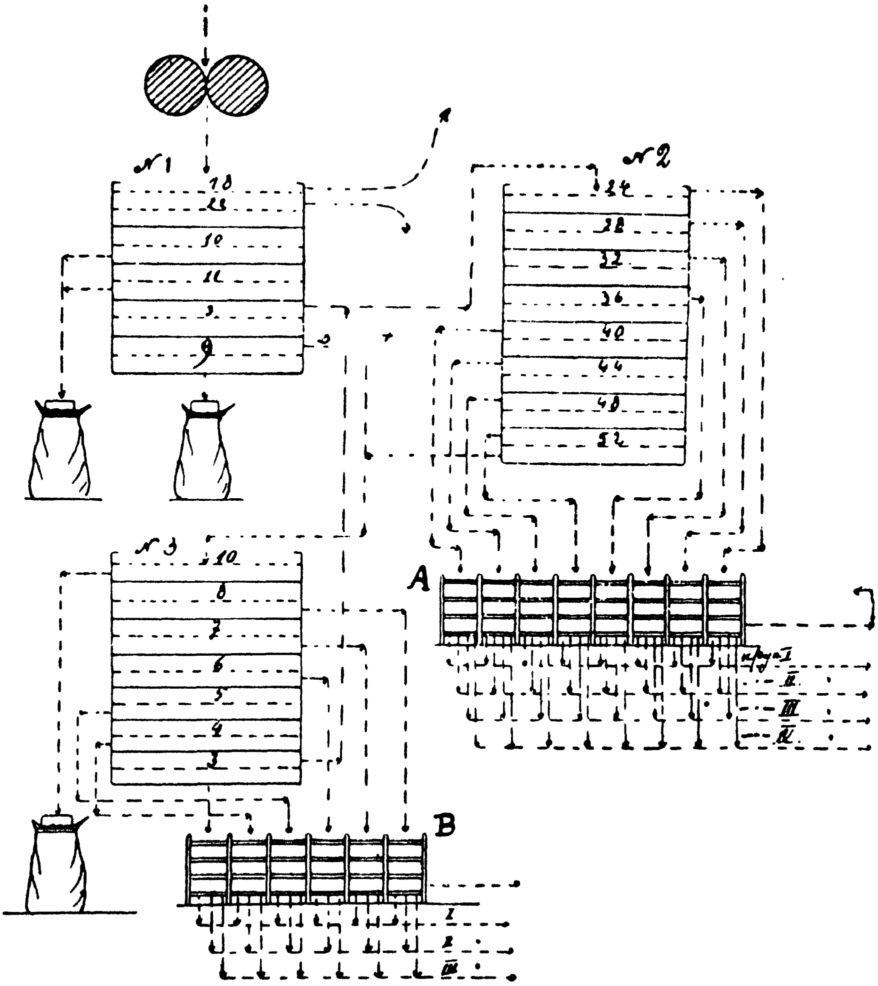


FIG. 502.

The quantities of middlings yielded with a well-arranged high grinding system are given in the appended table. The raw material here is Hungarian wheat, weighing 8·1 klg. a litre.

There were obtained :

Middlings from sieve	No. 24	15 per cent.
,, ,, ,,	No. 28	12 ,,
,, ,, ,,	No. 32	11 ,,
,, ,, ,,	No. 36	12 ,,
,, ,, ,,	No. 40	9 ,,
,, ,, ,,	No. 44	5 ,,
,, ,, ,,	No. 48	3 ,,
,, ,, ,,	No. 52	2 ,,
		69 per cent.
Dunst		9·5 per cent.
Break flour		6·0 ,,
Bran		14·0 ,,
Losses		1·5 ,,
		31 per cent.

In a similar manner are obtained the middlings and dunst of the remaining breaks, ending with the fifth or sixth break.

Now there remains the further process of grading the middlings to be examined—their sorting for reduction to flour.

We know that the production of semolina is not a fundamental purpose of milling. For its production, in America for instance, there are special mills, which prepare such semolina for certain kinds of biscuits. In Russia and in Europe semolina is a by-product of milling, and is obtained directly from the controlling purifier.

The number of grades of cleaned middlings must be reckoned as not exceeding four, and dunst three. In the rest of the breaks from the sixth to the eighth (the ninth cleans the bran) there is still much dunst produced, as well as a small quantity of poor middlings which are not worth cleaning. Therefore they are reduced to the lowest grades of flour untreated or treated very slightly. We shall not speak of them here, since we have only the best middlings and dunst in view.

The middlings are reduced on smooth rolls, avoiding as far as possible the formation of flour, to dunst and then to flour.

Further, we must note that all middlings and dunst of equal quality, even though of different size, are blended together, from the second to the fifth break. Now supposing the middlings and dunst to be separated and then graded and purified as in the diagram (Fig. 502), the following diagram (Fig. 503) shows the further treatment all the purified middlings and dunst receive.

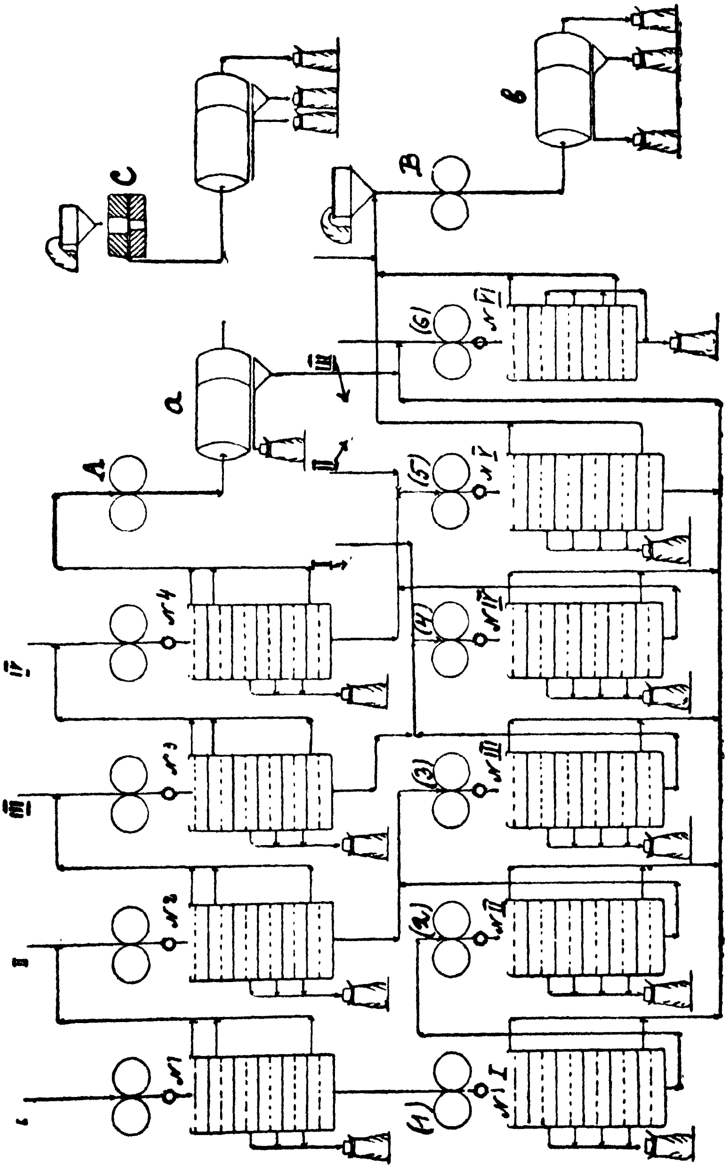


Fig. 503.

We begin with the coarser purified semolina (in the diagram, Fig. 503, middlings I). It runs to the rolls, is reduced there, and then sent to the sifter No. 1. The flour goes to the sack or to a redresser.

The overtails of the sifter go to the second rolls, to which the second middlings are likewise directed. The first middlings have become equal to the second in size and quality after the reduction. The best dunst from sifter No. 1 goes to the first reduction mill (1), where it is finally ground to flour. The latter is produced in large quantities, and after bolting is sacked off or also conveyed to the redressing sifter and then into a bin (this is not given in the diagram, our aim being to illustrate the treatment received by the middlings).

The tails of the first and the last sieve of sifter No. 1 consist of rich, uncleaned offal, which, on being blended with like particles from other sifters, is cleaned up separately, as will be shown presently. The remaining dunst passes to the second reduction mill (2), where the same process as in the first takes place.

That which remains unreduced of the dunst (the throughs from the last sieve of sifter No. II) goes to the mill (3) of the second middlings.

The second middlings, together with the tails of the first, are ground on the second mill. The tails of sifter No. 2 pass to the third mill, where, on being mixed with the third middlings, it undergoes the same operation. The sifting is performed as before, and the remains go to the fourth mill, &c.

The tails of sifter No. 4 pass to the rolls *A*, whence the product runs to the centrifugal, which produces dark flour and dark dunst as throughs and tails over the branny particles, which are sent to the last break to be cleaned up. The dark dunst goes to the last (6) reduction roll.

The dunst of the second middlings goes to the third reduction mill (3) and, together with the remains of the first dunst, is reduced.

The flour after sifting is collected in bags or in a bin. The remaining dunst passes to the fourth reduction (4), and is ground together with the dunst of the third middlings.

The tails (dark dunst) of the first and the last sieves of the sifters Nos. I to V are sent to the reduction roll (6). The break dunst III is also admixed to it.

The break dunsts (I, II, and III), blended with the middlings dunst, are in comparison to it less valuable, since they are formed of particles lying closer to the integument, whereas the middlings dunst lies nearer the central parts of the grain. Therefore the break dunsts, even should they be perfectly white in appearance after purification, can be blended with middlings dunst only when the latter, arrived at the mill (4), has already lost somewhat in its quality owing to the reduction of the mealy particles on the three preceding rolls.

To the fifth reduction mill there go the dunst from the mill (4), the middlings dunst (from sifter No. IV) and the second quality break dunst. From the sifter of that mill (sifter No. V) the flour is sacked off, and the throughs of all sieves, together with what remains of the tails from the four preceding sifters, with the third cleaned break dunst and the dunst from the centrifugal, are sent to the sixth reduction mill. The flour is sacked, while all the tails is directed to the seventh mill *B*. The latter likewise receives the inferior dunst from the rest of the breaks. For bolting there is the centrifugal *b*. Here everything is collected in sacks or bins and the reduction of the middlings and dunst is ended.

One more mill or stone *C* should be put in to treat the products which suit nowhere, as well as for cleaning the bran. For bolting the product of this mill there is again a centrifugal or sifter, all the products of which are sacked off separately.

Under the reduction mills should be stationed detachers, shown in the diagram, otherwise the produce, sometimes crushed into flat flour flakes, cannot be properly bolted.

For rolls followed by centrifugals there is no special need to have detachers, as the distributing beaters of the centrifugals break up the thin film-like flakes of mealy product, formed through the strong pressure of the roller surfaces upon it.

V

Shorter Gradual Reduction Systems

The abbreviated or semi-high (Halbhochmüllerei) grinding is characterised mainly by a reduced number of breaks and rebreaks (the latter may be totally absent), by a curtailed grading according to size (the absence of middlings grading sifters) and quality, a reduction in the number of rebreaks for middlings, and finally a lessened number of reductions.

The resultant influence of abridgment in the high grinding scheme becomes noticeable first of all in the fact that the yield of the best grades of flour diminishes, and the quality of all the grades, except the first and partly the second, becomes inferior; this is especially brought about by the reduction in the number of purifiers, *i.e.* the abbreviation of the process of grading the product according to quality.

Let us examine a few shorter gradual reduction diagrams.

German Abridged High Grinding.—The mill grinds 2000 bushels of wheat per day (24 hours). In the diagram (Fig. 504) there are seven breaks, the first one (Hochschrot) being designed to split the grain in

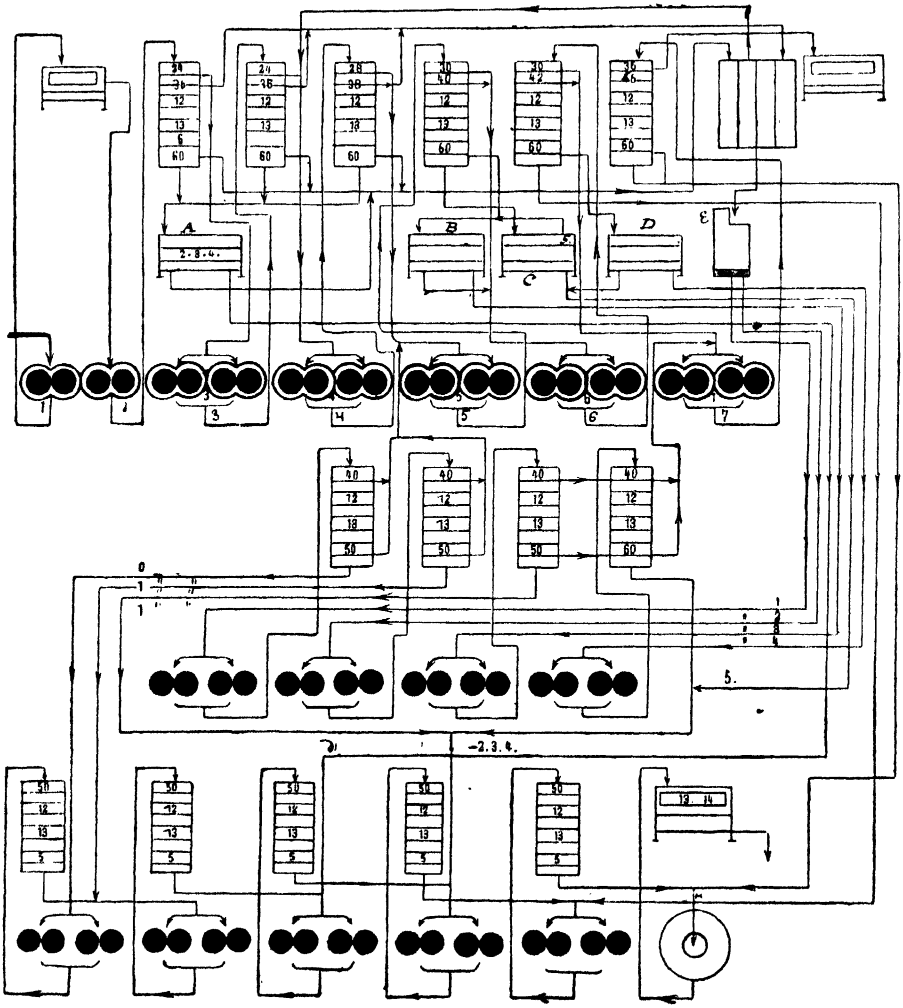


Fig. 504.

two down the crease. After the passage through the high break the product goes to a brush duster, which gives break middlings as tails, and blue flour (a dirty greyish-blue flour with dust) as throughs. The further process of breaking is performed in the usual order with grading of the break chop on sifters. The characteristic feature here is the high numbers of wire sieves starting with No. 24, and the correspondingly higher numbers of all the sieves in the sifters. That suggests the grinding surfaces of the corrugated rolls have been brought close up together; through these, in fact, the finer and more flaky flour is prepared.

In watching the breaking process in the diagram, we see the following picture.

The unfinished break stock passes as usual to the next break, and finally the tails of No. 36 sifter of the seventh break are large bran, which goes to be cleaned on the bran duster (brush). From the thirty-sixth to the thirty-eighth number of the second, third, and fourth breaks large semolina is obtained, which in our milling systems would constitute rebreak semolina.

This semolina, as well as the fine middlings from the same sifters, goes to the grading for middlings (one may say the controlling) sifter, which sorts separately the large and the fine semolina. The tails, large semolina, which ought to be directed to a separate rebreaking roll, is sent to the fourth break, which acts the part of a rebreak.

That is, properly speaking, the first item of abridgment of the milling process.

The fine and the large middlings graded—each into two kinds—are subjected to further sorting on a purifier of the "Nemelka" type. The tails of the chop from breaks 5 and 6 mix with the tails from the middlings sieves of the same systems in the later breaks, while their fine middlings are cleaned on purifiers of the "Reform" type. The dunsts of the second, third, and fourth breaks are mixed together and cleaned on a purifier of the same type. The dunst from the fifth break is purified separately, while the fine dunst of the sixth and seventh breaks go to be reduced: the first on the last reduction roll, and the second, together with the fine semolina, on the stone mill. The fine middlings from the fifth and sixth breaks are graded apart, on purifiers *C* and *D*, having besides that a controlling purifier *B*.

The process further consists in that the graded middlings go to be rebroken in the second row of roller mills with smooth rolls. A characteristic point in that part of the process is the deflection of the middlings refuse to the fifth, sixth, and seventh break systems, which we must acknowledge to be expedient.

The dunsts from these systems go to be finally reduced. So the grading of dunst according to quality is absent here, and this causes the tails from the sifters of the middlings rebreak to be directed to the fifth and seventh reductions. The absence of these purifiers is the second material abridgment in the process.

We shall not speak of the further details in the diagram, the rest being sufficiently clear. The grading of flour is not given in the diagram, as it depends to a considerable degree on the brands sold by any particular mill.

The general data characterising the dimensions of the roller mills are as follows: the break systems have rolls 1000 × 250 mm.; the reduction systems 1000 × 300 mm., and finally, the stone mill 1300 mm. in diameter. All the stock is bolted on sifters, except that the stone mill is followed by a centrifugal.

American or English Grinding.—The diagram introduced to our attention (Fig. 505) is a characteristic scheme of American or English high grinding, which must be classed with the abridged high grinding of the European type as it is accepted with us. In this scheme the system of rebreaks is absent and the number of breaks is reduced to five, and the reduction process is very much curtailed, containing at the same time no purifiers for the rebreak of middlings. By reason of the latter circumstance one is obliged to use the purifiers which sort the break product. The diagram (Fig. 505) is for a mill in the State of Kansas working on hard wheat and having a capacity of 280 sacks per twenty-four hours.

It may be seen in the diagram that there are five breaks and nine reductions here. The five breaks are characterised by the dimensions of the rolls successively—9 in. × 30 in., 9 in. × 30 in., 9 in. × 30 in., 9 in. × 24 in., and 9 in. × 24 in., and by the differentials of the rolls of the fast to the slow, in the same succession from the first break to the fifth—3 : 1, 3 : 1, 3 : 1, 2¾ : 1, and 2½ : 1.

The aim of this mill was to yield as much flour of the first grade (patents) as possible, and therefore on turning to the diagram we see that the flour from all the break sifters, except the fifth, and from all the reduction sifters, except the last three, is sent to patents. Still, however, there is a combination for sending the flour from the break sifters to the second grade (clear).

It is interesting to note the grading of middlings. The purifier No. 1 receives the coarse semolina from No. 34 sieves of the first three break sifters. This purifier, as well as all the others (see the arrangement of the sieves, the order of their Nos.), is arranged to give light offals which run to the filter *DC*, heavy offals which go from No. 1 to the fine bran (feed), and, finally, the throughs. The throughs from the purifier No. 1 mixed with the throughs from sieve No. 26 of the second purifier (No. 2) go to the smooth rolls 9 in. × 24 in. The Americans call that the first rebreak or "sizing" of middlings.

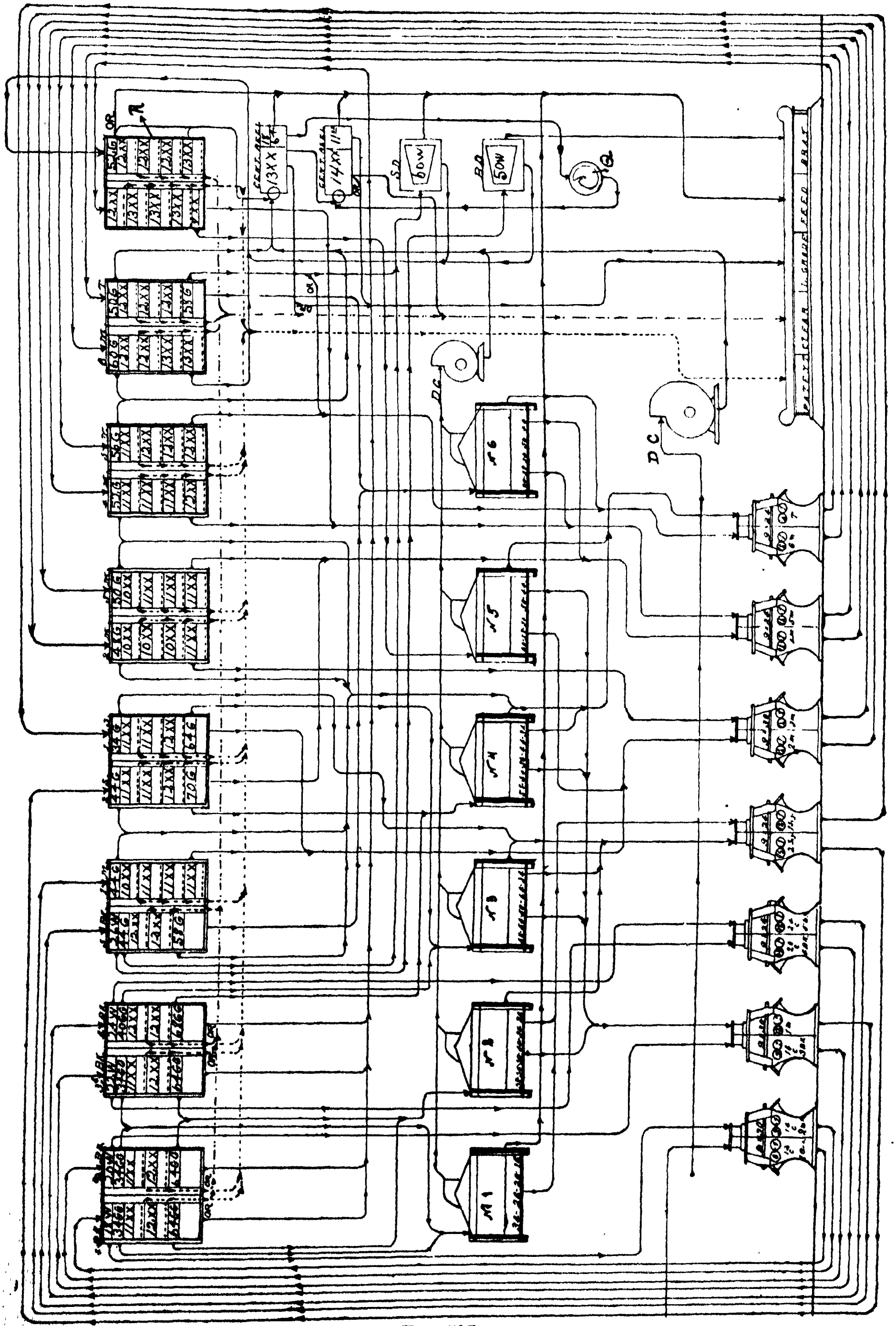


Fig. 505.

It must be noted that the Americans have no rebreak grooved rolls in their break system at all, and in that respect their milling process is greatly curtailed in comparison with the German and Hungarian.

Proceeding further, we see that the same three break sifters pass fine semolina tails off the sieves No. 64 to the purifier No. 2. The throughs from the sieve No. 26 go to the first sizing roll, as we have seen, while the Nos. from 58 to 34 send the cleaned middlings to the first reduction.

The heavy offals from this purifier, like those from No. 3, go to the smooth rolls for a second middlings sizing (rolls 9 in. × 24 in., and differential 1¼ : 1), mixing with the tails of the first middlings roll. From the point of view of the Russian millers, such blending is a downright crime. But we must not forget that the Americans produce only three or four grades of flour, and in the given case there is the wish to obtain the greatest quantity of patent flour.

The purifiers Nos. 5 and 6 purify the finer middlings: No. 5 from the B.M.R. sifter, which grades the throughs of sieves Nos. 64–68 of the first four break sifters, and No. 6 of the fifth break sifter and of the last reduction sifter.

Besides the sifter we have yet two centrifugals (13xx–64, 14xx–11xx) and two brush dusters *SD* and *BD*. The throughs of the centrifugals run to the second and third grade of flour, while the tails (as well as the tails from the brush *SD*) goes to the fine bran. The throughs of the brushes pass to the redressing sifter *R* and the tails from the brush *BD* yields large bran. *DC* designates the fans.

We need not dwell on the operation of the reduction rolls, as the milling process is easily traced in the diagram.

Hungarian Milling Process.—Fig. 506 illustrates the diagram of an automatically working mill, after the system of which many mills have been erected in Hungary in recent years. The wheat brought by customers is milled not in separate lots, but mixed together according to quality. Having first ascertained the weight of wheat, it is despatched to the cleaning department. After milling the customer receives the quantity of flour corresponding to the weight of the wheat brought by him.

Since the wheat is not milled separately, it is natural that the customer does not receive the actual gotten out of his own wheat; but in order to serve everybody equally well, even if the goods supplied are different in quality, the good wheat of equal quality belonging to several customers is mixed and milled, and then a worse wheat, but also equal

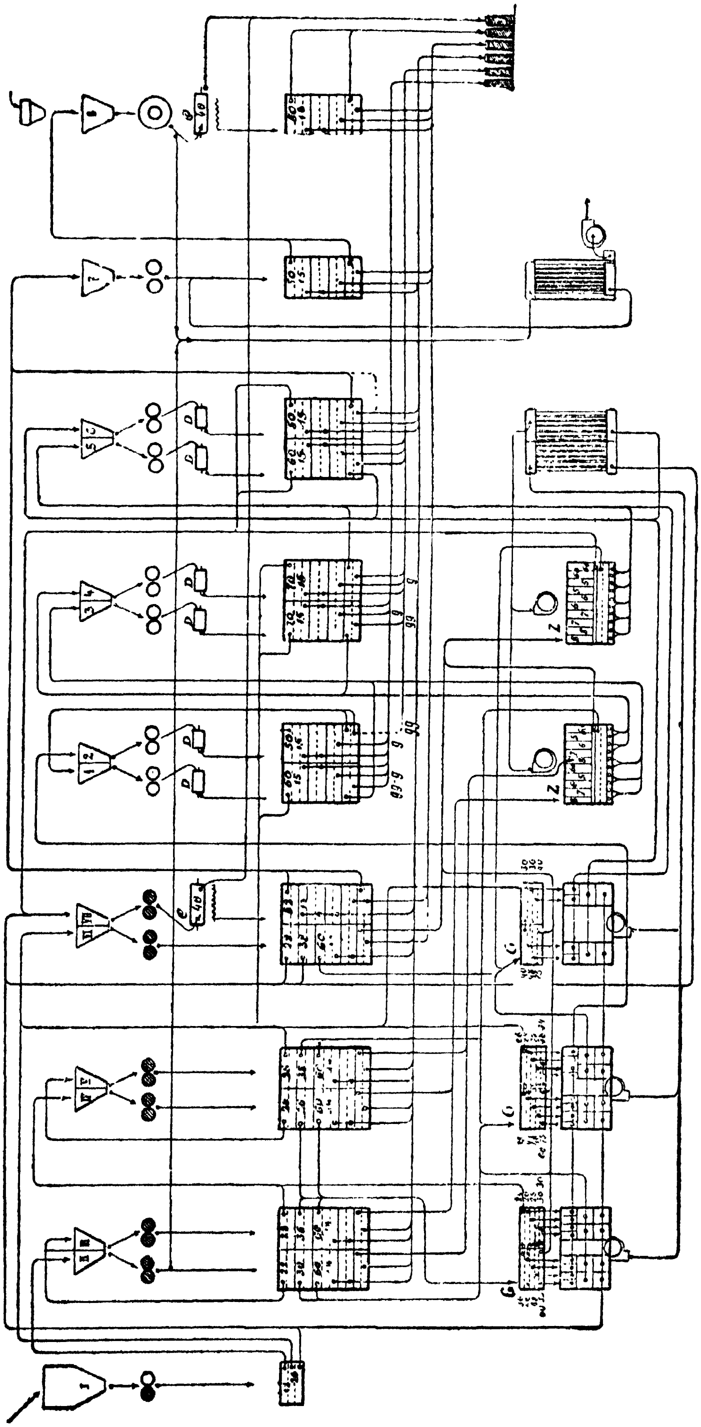


FIG. 506.

in quality, is ground. Such a method affords the possibility of satisfying everybody.

That arrangement contains no rebreak rolls, as the coarse rebreak middlings go to the break rolls. The reduction of middlings and dunst is performed with the aid of six pairs of smooth rolls of hardened cast iron, which are marked in the diagram by figures 1-6.

The cleaning up of the low grade stock and fine bran is done on a pair of finely fluted rolls of hardened cast-iron and on a millstone.

After the reduction the middlings and dunst before bolting pass through the detacher *D*. The seventh break and bran to be cleaned previously to going to the sifter run through the centrifugal *C*, to free the coarse tails of dunst and flour and shake up once more the remains to be sifted.

The bolting system consists of Haggenmacher's sifter with six sections, containing 6×11 trays. The first high break is treated on the smaller part of this bolting apparatus.

For bolting the reduced middlings and dunst there is also a sifter with six sections and 6×9 trays and a small sifter of the same construction with 2×9 trays. The purification is divided into three systems, and consists of two purifiers of the Haggenmacher type with eight sections and one with four sections *G*. In the machine with eight sections are purified the middlings from the second and fifth breaks; the smaller machine receives the fine middlings from the sixth break.

There are two purifiers with ten sections. To the first half there goes the dunst from the third and fourth breaks to the second—that of the second and third breaks. The second machine purifies the tails of the first machine, the dunst from the purifiers, and the break dunst from the sixth break. The first break is kept very high, and bolted on a steel sifting cloth Nos. 18 and 26. The tails of No. 26 are coarse middlings which pass to the sixth break, while the throughs go to the last break. In the following breaks the grain is gradually reduced so that the seventh break yields clean broad bran. The upper three trays of the break sifter are furnished with a coarse bolting cloth which separates away the tails, the coarse and the fine middlings. The throughs pass on to the next flour sieves, which yield as tails dunst to be cleaned.

The middlings directed to the purifiers *G*, by means of a small sifter stationed at the top of the machine, are sorted in eight grades according to size, and each grade passes into one of the eight divisions of the machine, where every one of them is purified separately. The coarse tailings of the feeding sieve of the grading sifter return to the break rolls, while the fine throughs from the last sieve go to the dunst.

The pure middlings from the first and second purifiers are directed to the rolls 2. The heavier liftings of the first machine are cleaned, together with the middlings of the second and fifth breaks. The heavier liftings of the second purifier go with the middlings of the fourth break, to the small fourth purifier. The pure middlings from that machine pass to the fifth reduction rolls, the liftings to the sixth system. All the branny stock from the three purifiers goes to the seventh break.

The purifiers *Z* are divided into two equal groups. The first group receives dunst from the third and fourth breaks, the other that of the second and fifth breaks. Both the tails of that machine are added to the middlings of the second and fifth breaks. The pure dunst of the first half of the machine and the first fine pure dunst of the second half are the product of the third reduction roll. The tails of the first machine are cleaned by the second. The pure dunst from that machine yields a product for the fifth reduction roll. The tails go to the last break rolls.

The product running from the reduction rolls to the sifter is divided into a coarse and a fine tails and several grades of flour. For that purpose in every sixth part of the sifter there is a scalping sieve and several flour sieves. The tails of the scalping sieve in the first four reduction roller systems go to the sixth break. The tails of the fifth and sixth systems are directed to the seventh break. The dunst, according to its quality, is despatched to the reduction system.

With this semi-high milling process there are obtained only four grades of flour, which from the sifters go to collecting worms and, totally blended in them, are delivered into sacks.

French Milling System.—In Fig. 507 is given a typical scheme of high French grinding, which, from our standpoint, should likewise be referred to the abridged high grinding.

A. Coarse semolina from the first four break mills go to the first purifier to be treated and thence to the first reduction to be reduced.

B. Fine semolina from the first four break mills go to the second purifier, and thence to the second pair of rolls of the first reduction mill.

C. Middlings from the second, third, and fourth break mills go to the fourth reduction mill.

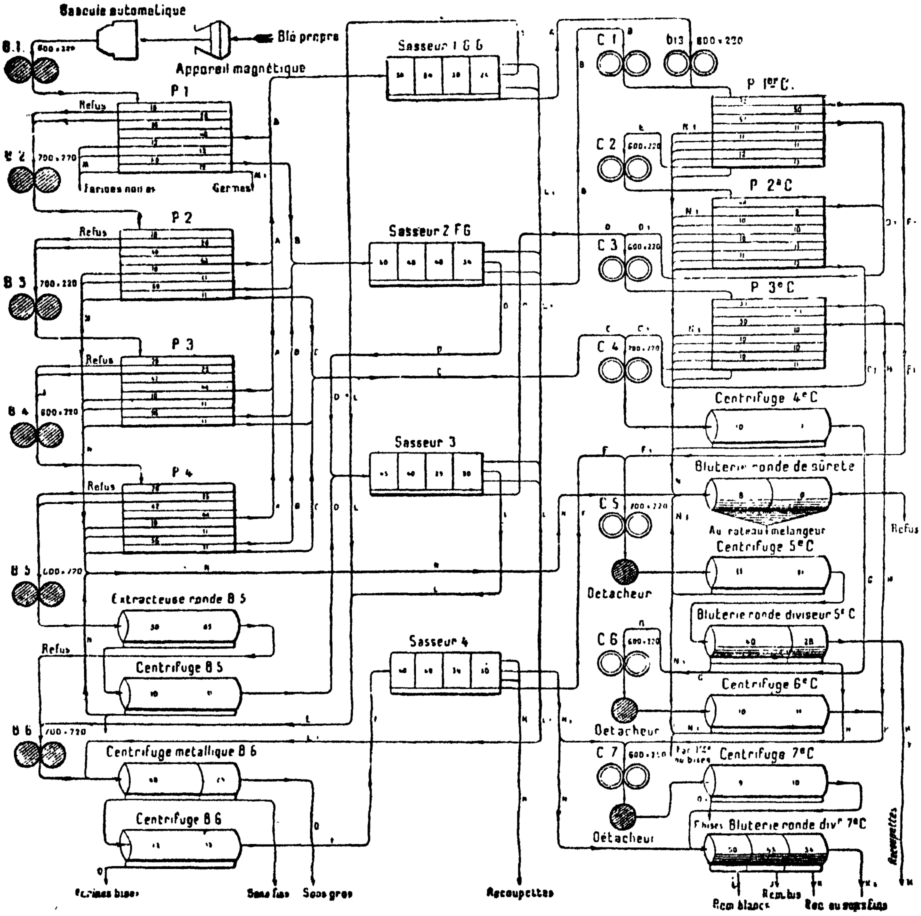
C_1. Middlings from the second reduction mill go to the fourth reduction mill.

D. Tails (dunst) from the fifth break mill and from the second purifier pass to the third purifier and thence to the third rebreak mill.

E. Middlings from the first reduction mill go to the second reduction mill.

F. Middlings from the sixth break mill pass to the fourth purifier and thence to the fifth reduction mill.

F_1. Tails from the first and third reduction mills go to the fifth.



Centrifuge metallique—Centrifugal with metal cloth.
Sasseur—Purifier.
Bluterie ronde de sûreté—Round redresser.
Bluterie ronde diviseur—Grading reel.
Détacheur—Detacher.
Refus—Tails or to offals.
Bascule automatique—Automatic scale.
Blé propre—Pure grain.
Appareil magnétique—Magnetic apparatus.
Extracteuse ronde—Round reel.
Centrifuge—Centrifugal.

FIG. 507.

G. Tails from the fourth reduction mill (after the centrifugal) and the product No. 40 from the fifth go to the sixth.

H. Tails from the third and sixth reduction mills and the product No. 28 from the fifth, go for final treatment to the seventh reduction mill.

H_1. Tails from the fourth purifier go to the seventh reduction mill or the offal sorter, depending on the quality of the product.

I. Fine sharps (thirds, etc.).

J. Coarse sharps (Pollard, etc.).

K. Coarse Pollard.

K_1. Fine bran.

L. Tails from the first and third purifiers go to the sixth break mill.

L_1. Liftings from the first, second, and third purifiers go to the centrifugal with wire cover for the extraction of flour out of them.

M. Dark flour.

M_1. Dunst from the first break mill. If the products seem to be good they may be reduced on the sixth break mill.

N. Flour from the second, third, fourth, and fifth break mills.

N_1. Flour from the first, second, third, fourth, fifth, and sixth reduction mills.

O. Dark flour from the sixth break mill.

O_1. Dark flour from the seventh reduction mill.

P. Fine bran from the wire-covered centrifugal.

Q. Broad bran.

The flour from the fifth break mill and sixth reduction mill is sent further in the manner answering the wish to obtain a greater or smaller quantity of flour of the highest grade.

If the tails of the fourth purifier is not of much value for baking, it may be directed to the seventh reduction mill with a centrifugal, having previously subjected it to strong aspiration.

Very Short Milling Systems.—The desire to make the equipment of a mill cheaper, and at the same time to obtain as good a flour as possible, compels one to have recourse to the extremely abridged milling process, an example of which may be taken in the form of a diagram of an American process for mills of from 100 to 200 sacks capacity.

According to the diagram (Fig. 508) we have but four break systems with corresponding differentials : for the first system 2 : 1, second 2 : 1, third 2½ : 1, and for the fourth 3 : 1. The number of corrugations for the first system is 12 to 1 in., for the second 16, for the third 20, and for the fourth 24. It must be noted at the same time that often these limits are changed from 18 (instead of 12) to 28 (instead of 24) corrugations to an inch. The length of rolls is 30 in. and their diameter 9 in.

The whole process of milling takes course as follows : from the first break system the product runs to the sifter on to the distributor (or, what the Germans call Sammelboden), whence it passes to the wire sieve No. 18 (18-w). The tails of the scalping sieve No. 18 go to the second break, the middlings from No. 44 to the purifier K_1. It is supposed that all the large middlings are separated away, and from the Nos. 10, 11 and 12 of flour sieves the throughs yield flour, which goes to the second grade (bakers'), while the refuse off No. 12 passes to the purifier K_2 for medium middlings.

Further, if we watch the second, third and fourth breaks, we shall see that the preceding process of grading the middlings and flour is perfectly and accurately repeated: all the tails off the middlings sieves go to the purifier K_1, the throughs from the flour sieves to the second grade of flour, and the tails of the last sieves (11xx, 11xx, and 12xx) to the purifier K_2. As to the tails from the scalping sieve No. 34 of the last break sifter, it runs to the bran duster *BD*.

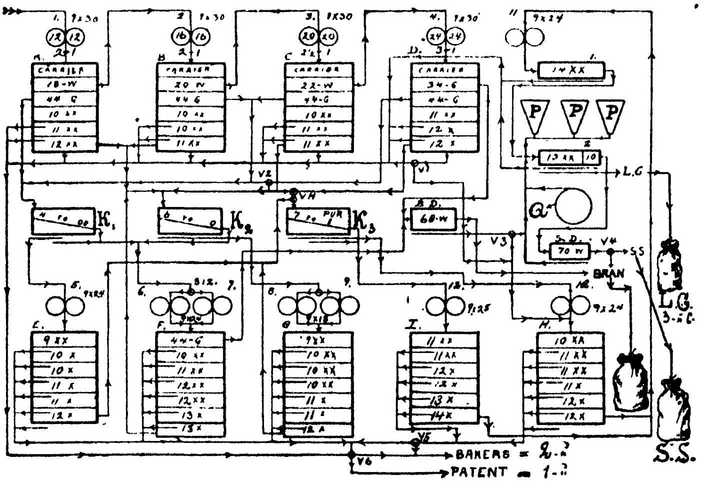


Fig. 508.

Laying aside for the present the possible variations which are shown in the diagram, let us direct our attention to the work of the reduction rolls. Roll 5 (9 in. × 24 in.) receives the throughs (pure middlings) of the purifier K_1, rolls 6–7 (9 in. × 24 in.) the cut-off and tails from the purifiers K_1 and K_2, rolls 8–9 (9 in. × 18 in.) the throughs from K_2, roll No. 10 (9 in. × 24 in.) the throughs from the purifier K_3, and, finally, roll 12 (9 in. × 25 in.) receives the cut-off and tails from the purifier K_3.

First of all, we must note that the flour from all the sifters corresponding to the six reductions goes to one first grade, generally named Patent.

The tails from the sifters *E* and *G* (first and third) go to the purifier K_3, the tails of sifter *F* to the purifier K_2, while the tails of the sifters *I* and *H* pass to the eleventh (9 in. × 24 in.) finishing roll, after which the throughs of the centrifugal (No. 14xx) go to the second grade, and the tails go to the second centrifugal, which gives the last worst grade (low grade) as throughs, sending the tails to the brush duster *SD*. From the machine last mentioned fine bran is obtained as tails, and the throughs are deflected to the second centrifugal.

In the diagram *Q* denotes the fan, and *P* the dust-collectors, which despatch the products also to the second centrifugal.

In this manner we have followed the main details of the preparation of flour of the first, second, and third grade. It must be pointed out that the tails No. 44 of the sifter *F* likewise goes to the bran duster *BD*, which tails over large bran.

In recapitulating the general run of the diagram we may say that the first grade (Patent) is obtained by the Americans by reducing the purified middlings, *i.e.* from all the reduction systems in the throughs of the flour sieves of the sifter; the second grade (Bakers') from the flour sieves of the break systems, the third grade (low grade) from the cleaning up rolls.

The first variation V_1 affords the possibility of sending the throughs of the last break sifter *D* (sieve 12) to the last reduction sifter *H*, to be controlled as it were; by the variation V_2 the middlings from the last break sifter *D* are directed to the purifier K_2 or K_3, which is more reasonable than to K_1 which purifies the heavy and large middlings. By the variation V_3 the throughs of the bran duster are directed to be redressed in the sifter *H*; by the variation V_4 the large and the fine bran *SS* may be mixed; by variation V_5 the first grade is improved by excluding the flour from the fourth and fifth reductions; finally, in variation V_6 the first and second grades are blended together and produce the medium sort (Straight), in other terms, the whole grist is divided into two grades of flour (straight and low grade).

In Fig. 509 we have a diagram of an extremely short system suggested by Baumgartner. The grain runs to the Hochschrot with one corrugated and one smooth roll. After it has been broken down the crease here the grain passes to the brush scalper, which yields as throughs blue flour or offals, which depends on how drastically and rigorously the grain is treated on the Hochschrot. Further, the product is subjected to a triple break, and is cleaned up on the fifth corrugated passage, which produces branny flour *e*, feed *f*, and large bran *g*.

After the first break mill the product is bolted on a plansifter. The flour is then sacked off as second grade.

The tails go to the second break. The semolina passes into a purifier with an inside sieve of four sections, the fine middlings to a purifier for dunsts of a similar construction.

From the second break there is obtained bolted flour of the second grade, coarse and fine middlings, which go to the corresponding purifiers. The tails run to the third break mill. The flour produced here is turned to the third grade, a small quantity of middlings and dunst are directed to the purifier, the integuments and coarse tailings go to the last break mill. The reduction stock from this roll is graded on a hexagon reel, and yields the products *e*, *f*, and *g* spoken of above.

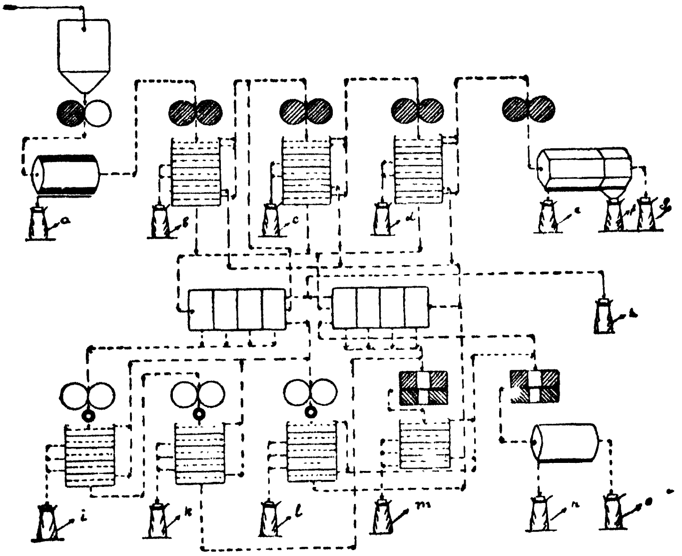


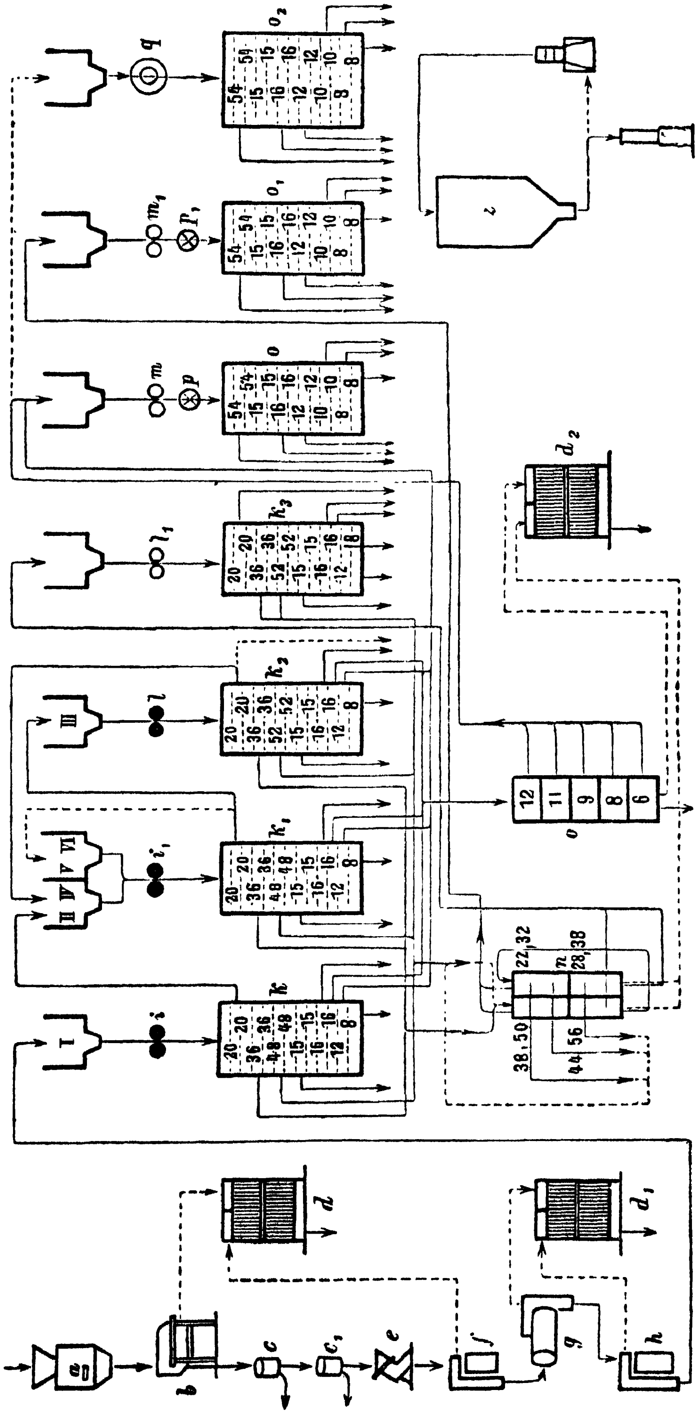
FIG. 509.

The liftings of the purifier are sacked off, as ready product-bran. The tails from the middlings sieves are directed to the second break, the tails of the fine stock go with the middlings from the purifier.

The pure middlings pass to the first smooth rolls, thence to the detacher and plansifter. Here second grade flour *i* is obtained.

The coarse stock is turned to the third smooth roll, while the fine middlings go to the second. The latter, after it has been ground and loosened, is bolted on a plansifter, and produces flour of the first grade *k*. Only the less coarse parts pass to the third smooth mill, to which likewise the worst middlings from the purifier are turned.

After reduction and sifting a flour of the second grade *l* is produced here. The larger tails go to the second dunst millstone, the finer parts go to be recleaned in the middlings purifier. Now they are made equivalent


a
b
c
c₁
e
f
g
h
d
d₁
d₂
I
II
III
IV
V
VI
i
i₁
l
l₁
m
m₁
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k
k₁
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o₁
o₂
n
z
20
36
48
52
54
15
16
12
10
8
11
9
6
22,32
28,38
38,50
44
56

FIG. 510.

to the break middlings. The purified break midds pass to the first midds millstone and yield after bolting flour of the second grade *m*. The tails go to the second millstone, and after reduction to the centrifugal, which yields flour of the third grade *n*, and fine bran as overtails.

The corrugated rolls should be 300 mm. in diameter and have 1 : 2½ differential, the smooth rolls 350 mm. in diameter and the 2 : 3 differential.

We must add that this abridged diagram cannot produce the fine grades of flour obtainable in high and semi-high grinding.

Still the grades of flour received are pure and fetch fair prices; at the same time it must be borne in mind that to obtain them less machinery is needed, and therefore the expenditure of original capital is less.

Semi-automatic Grinding.—Up to the present we have been examining plans of automatic mills, in which from the feeding in of the grain to the delivery of the flour the whole process is performed without the assistance of mill hands. Since semi-automatic mills are still used in Russia we append the general type of a scheme (Fig. 510) of such a mill, which is characterised by the limited number of reduction machines.

The wheat is poured into the hopper and carried by the elevator to the automatic scale *a*, and thence to the separator *b*, which is furnished with a large meshed sieve. That sieve removes the larger impurities—stones, wood, &c. The sand and dust are separated away with the aid of a second sieve and travel to the outlet. The cleaned grain passes through the sieve to the dust cleaner or separator, whence the lighter particles are driven by the fan into the dust-collecting tubular pressure filter. The wheat cleaned in this manner passes to two cockle cylinders *c*. The re-cockle cylinder c_1 separates the half grains from the cockle. Through the magnet apparatus the product runs to the elevator, which lifts it to the horizontal scourer. In that machine iron beaters throw the grain against a sieve of steel wire, to separate away the yet remaining dust and beard. The separate particles are carried to the pressure tubular filter *d* by a strong air current. The filter is divided, and one part serves for the separator, the other for the scourer.

The total number of tubes of the filter is 2 × 60 = 120. After the vertical scourer the wheat flows into a horizontal emery one, on which the grain coverings are partly torn off. The light particles separated away are blown into the first half of the pressure tubular filter *d*, and the grain by means of the elevator passes into the vertical brush machine *h*, where it is freed of the dust lying in the crease of the grain and falling in during the cleaning. The separate particles go to the second half of the pressure tubular filter *d*, likewise with 120 tubes. The perfectly cleaned wheat flows now into the bin, and thence to three pairs of corrugated rolls (650 × 220, i, i_1, l), on which it is subjected to break six times. The cleaned wheat runs from the bin mentioned to the first half of the roller mill *i*. The first break chop by means of the elevator is lifted to the first quarter of the sifter *k*. The tails, separated on sieve No. 20, goes to the second half of the hopper; the sieve No. 36 separates coarse semolina, sieve No. 15 first grade of flour, the tails of No. 12 yields midds to be purified, sieve No. 8 dunst to be reduced. In this manner the further breaking is performed, and the wheat is subjected to break six times. The mill l_1 serves for reducing the coarse semolina and midds, and has two pairs of smooth rolls, 650 × 220 in size. The semolina and middlings are subjected to cleaning on purifier *o*. That machine is connected with one pressure tubular filter d_2, with 120 tubes. The purified middlings go to the second pair of rolls *m* and to the second quarter of the sifter o_1. Since the middlings in passing through the rolls are crushed into thin flour flakes, before the sifter there are placed detachers pp_1, which loosen these flakes and thus quicken the grading. The purified midds go to the first pair of rolls *m* and to the first quarter of the sifter *o*. For reducing the low grade stock and bran there is a French stone mill *q* of 42 in. The reduction stock passes into the second half of the sifter o_2. The duties of the trays sifter o, o_1, and o_2 are appointed as follows: sieve No. 54 separates the tailings, sieve No. 15 and No. 16 first flour, sieve No. 12 second flour, sieve No. 10 third flour, sieve No. 8 dunst.

VI

RYE GRINDING

As in wheat grinding, rye grinding may be divided into plain and high systems.

Plain Rye Grinding is characterised by the number of passages, which varies between one and four. If the milling is performed on rolls, they are all corrugated, while for a more rigorous clean up of the bran there is placed a stone mill for the last passage. The schemes for plain wheat grinding examined may be adapted for rye grinding as well, with the sole difference that for rye grinding there have to be used rolls 300 to 350 mm. in diameter, as owing to a stronger pressure the corrugations wear more rapidly and require more frequent renewal.

In Russia the plain rye grinding is characterised, in addition, by the total quantity of flour obtained. In the market the plain ground flour is known under the name of "scoured" and "break" flour.

The "scoured" flour is obtained to the amount of 95 per cent. of the quantity of grain fed into the mill. In other words the grain is ground to flour together with the bran, and 5 per cent. goes to the offals in cleaning. Two or three passages suffice for complete reduction. In computing the length of rolls one should take the starting-point of its capacity as 130 to 145 lb. to 1 cm. per day (24 hours).

The "break" flour when ground in three to four passages, the large bran being sifted away, is obtained in the quantity of 80 to 85 per cent. One ought to reckon 115 to 130 lb. per day to 1 cm. of rolls.

The high rye grinding can be characterised by a more accurate bolting of the flour, and the number of passages from five to ten; the crushing passage, in which the grain is broken down the crease, included. The high rye grinding is designed to produce several (two to four) grades of flour, or one higher than the scoured and break grades of flour.

On the Russian market rye flour from high grinding is known under the appellation of dressed, sifted, and bolted flour. Dressed flour is obtained to the amount of 70 to 72 per cent., only one grade: sifted and bolted flour (two to four grades) yields up to 70 per cent. Bolted flour of the best grades does not exceed 20 to 30 per cent.

In very rare cases in Russia purifiers for grading the middlings according to quality are adopted in bolted rye grinding. In other countries the use of purifiers in high rye grinding is not to be met with.

Let us examine some of the characteristic schemes of high rye grinding.

High Rye Grinding.—The common plan of high rye grinding practised in Russia is illustrated in Fig. 511. The mill of 400 sacks capacity per day operates in the south-western region, producing the best flour.

The rye brought in sacks is poured out in front of the silo granary, whence it passes through the elevator to the automatic scale, hence to the preliminary cleaning apparatus, and then through the elevator and distributing worm into the bins.

The zigzag separator for preliminary cleaning easily cleans the rye, separating away mainly the coarse impurities, so as to prevent these admixtures from passing together with the rye into the silo and stopping it up. The dust and light particles of impurities sucked in by the fan in the cleaning apparatus go to the pressure filter, and are thence automatically sacked off.

From the silo the rye passes into the collecting worm, is blended in the proportion desired, and, mixed in this manner, goes to be cleaned. Then it runs through the automatic scale, aspirator, magnet apparatus, and three cockle cylinders connected with a re-cockle cylinder.

Further, it passes through the first scouring machine, dust reel-separator, second scourer, brush machine and apparatus and worms for damping, hence it goes to the drying chamber, where it remains several hours to allow the moisture to spread well in the bran. The damping apparatus may also be passed over or not, according to the quality of the rye.

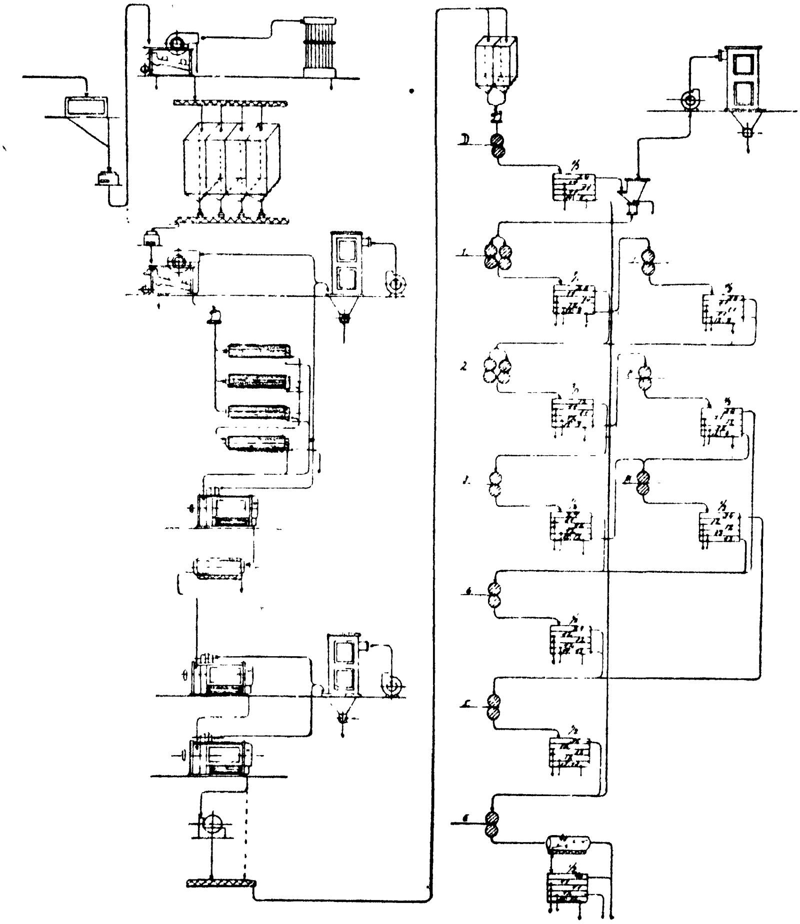

FIG. 511.

All the machinery, beginning with the automatic scale, aspirator, and cockle cylinders, &c., is freed of dust by aspiration; in a like manner the heavy dust is separated from the light.

The clean rye in the drying chamber passes through the magnetic apparatus, the crushing roll 800 × 350, with smooth rolls without fluting, and is then bolted through one-third of the sifter.

The broken-down rye passes through an apparatus with a filter for cleaning the break chop for the first break. The break is repeated six times.

The dimensions of the mills and sifters are as follows :

For the 1st break .	2	pair of rolls	1000 × 350	mm. and	1	sifter with	5	sieves.
„ 2nd „ .	2	„	800 × 350	„	⅔	„	5	„
„ 3rd „ .	1	„	1000 × 350	„	½	„	5	„
„ 4th „ .	1	„	1000 × 350	„	½	„	5	„
„ 5th „ .	1	„	1000 × 350	„	½	„	5	„
„ 6th „ .	1	„	1000 × 350	„	½	„	5	„
For reduction of semol.	1	„	800 × 350	„	⅓	„	5	„

The middlings from the first, second, and third breaks go each separately to a pair of rolls with fine corrugations ; from the fourth break onwards they are all ground together. The flour mixes together with the aid of collecting worms suspended under the sifter, and all the grades can be prepared for sale. The yield of flour, depending on the quality of the rye, is 68 to 72 per cent.

The roller mills, as well as the elevators, are ventilated by a powerful fan communicating with a suction filter, owing to which the heating of the running parts of the mills or the sweating of the machinery in general becomes impossible.

The scheme examined is defective in so far that it contains no grading of middlings according to quality, which is a characteristic peculiar to high wheat grinding.

To obtain a good white rye meal it is certainly necessary to introduce purifiers. In Fig. 512 we have a diagram including a purifier for cleaning coarse midds from the first, second, and third breaks. The mill, of 400 sacks capacity per day, operates in the government of Ekaterinoslav.

The coarse midds obtained are cleaned on the purifier and subjected to rebreak on passage I with smooth rolls, the corresponding sifter yielding the dunst, which is then reduced on rolls II. The flour obtained from this dunst to the quantity of 6 to 8 per cent. is the best, and is never mixed with the best kinds of break flour. The flour from the other smooth rolls is blended with the uniform-quality flour from the corrugated rolls, and the whole is divided into four grades. Flour No. 0 from the smooth rolls between 6 and 8 per cent. ; No. 1 smooth rolls together with break flour, from 23 to 25 per cent. ; No. 2, from 22 to 24 per cent. ; millstone flour together with the last break, from 10 to 12 per cent. The total amount obtainable with an accurate scraping is between 65 and 69 per cent.

The employment of centrifugals for the fifth and sixth breaks

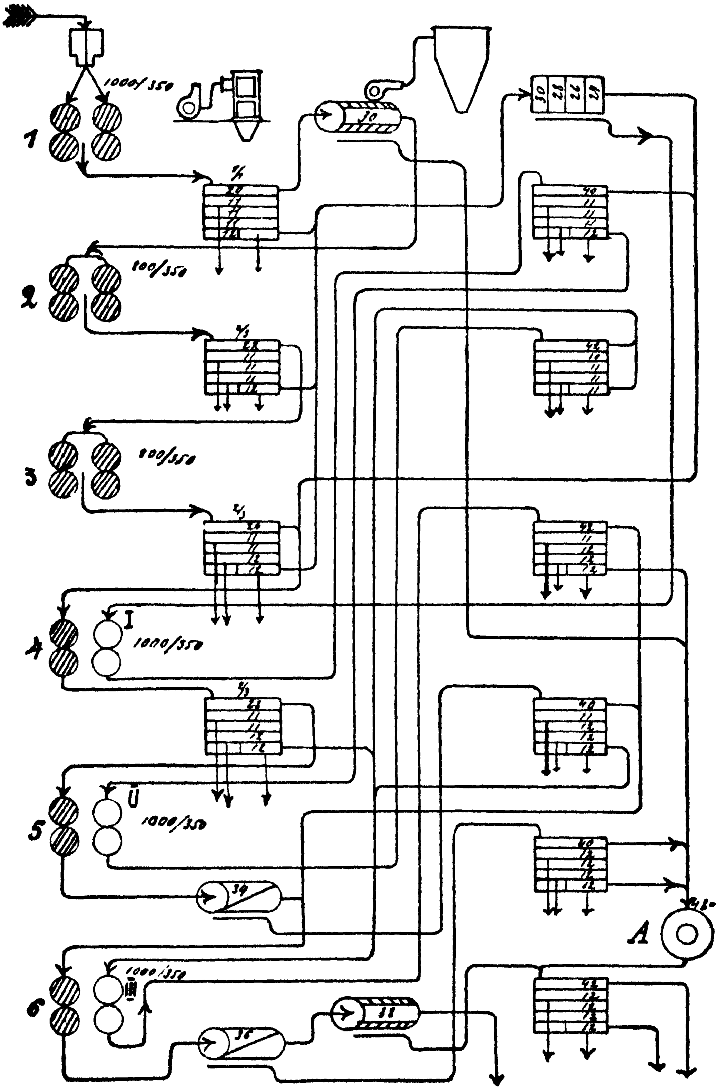

FIG. 512.

appears to be useful, as the rigorous threshing of the product to be sifted allows of a better separation of the flour from the offal.

The defect of this scheme lies in the absence of Hochschrot, which is very necessary for rye, as it is generally very dirty owing to the dust lying in the crease.

On the other hand, it must be acknowledged that the adaptation of a millstone for cleaning up is very useful, because the cleaning up of the offals is performed much more successfully on stones than on corrugated rolls, as the corrugations become rapidly blunted owing to strong pressure.

German Rye Grinding.—The rye-grinding schemes here appended are widely practised in the Chemnitz district. Let us successively examine each diagram.

In the first diagram there are three breaking passages through corrugated rolls, the first pair of rolls (800 mm. × 300 mm.) having 15 corrugations to 1 in., and the two other pairs 18 corrugations to 1 in. The differentials of the corrugated pairs is 1 : 3. Further, there are two passages through porcelain rolls, 600 mm. × 350 mm. in size, and, finally, two stone mills 1200 mm. and 1000 mm. in diameter (Fig. 513).

The whole grading process is performed on hexagon reels. The wire sieves of the first reels begin with No. 28 and end (cleaning up of integuments) with No. 36, while the numbers of flour sieves of the flour-dressing reels have as their utmost limit fourteen (cleaning up the offals and third break). The dimensions of the reels are given in millimetres in the diagram (length and diameter), therefore we shall not repeat them here.

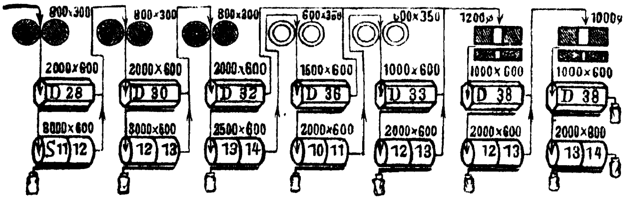

FIG. 513.

Let us watch the milling process.

After cleaning, the grain in the present case goes to the first break, though often enough the Germans employ in the first passage a pair of crushing rolls, the purpose of which is to divide the grain down the crease. Up to the third break the tails from the wire and flour sieves run successively to the second and third break, while the throughs from the flour sieves yield the final product, flour, which may be directed to flour-blenders. But the tails of the wire sieve in the reel scalping the third break go to be finished on the first stone, and the tails of the flour reel (silks Nos. 13 and 14), which is a more or less pure dunst and fine middlings, pass to porcelain rolls. The tails of the wire sieves in the reels after both roller mills with porcelain rolls, and from the flour sieve of the second passage through porcelain rolls, go to the first stone. And, lastly, we have two passages on millstones, the aim of which is to give a final clean up of the offal.

The capacity of such a mill varies between 120 and 160 sacks with a motor of 60 H.P., the grain cleaning included. As to the grades of flour, they may be combined according to the quality to three or four brands. In the region where this combined grinding on corrugated and porcelain rolls is practised, there is generally obtained 45 to 50 per cent. of the so-called "white" flour, No. 0.

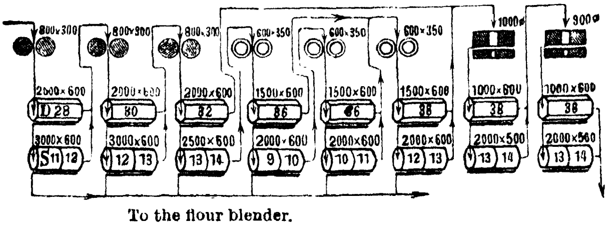

FIG. 514.

The second diagram (Fig. 514) differs from the first only in that it has an extra pair of porcelain rolls. Therefore, owing to the more accurate reduction of dunst and middlings, there is obtained up to 62 per cent. of flour No. 0 and No. 1, which is also classified as white flour.

There is a mill in Chemnitz on the same plan, which having the same capacity, requires 63 H.P. for the milling department only, *i.e.* not reckoning the cleaning of grain. Such great consumption of power can be explained solely by the considerable demand made by its shafting, which could have been designed more accurately.

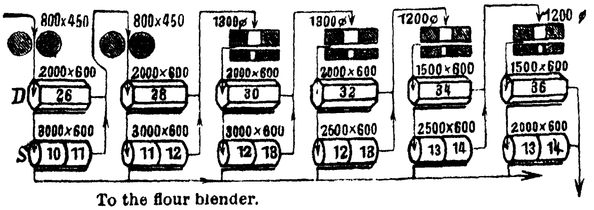

FIG. 515.

Finally, in Fig. 515 we have a third milling diagram for the same capacity per day. A mill with grain cleaning needs 60 H.P. This type of diagrams approaches the old French milling systems, in which two-thirds of the whole process in high grinding was performed on stone mills.

Improved Scheme of German Rye Grinding.—In the newest German rye grinding mills the hexagon reels are totally discarded, and the cleaning up of the offals is done not on stones but on rolls.

In Fig. 516 we have the outline of an inexpensive semi-automatic mill, which shows that the grain goes first to the crushing mill with smooth cast-iron rolls, where it is broken down the crease. On the first half of the small sifter *A* the blue flour is pressed through No. *X* and sacked off, while the tails pass to the first break to rolls 2. The product of the first break runs to the first quarter of the sifter *B*, whence the flour goes to the second half of the sifter *A*, which does controlling duty in that part. The tails of the first quarter of the sifter *B*—the break stock, middlings, and dunst—runs into the bin *II* and awaits its turn to pass through the rolls 2. After the second passage through the rolls 2, the product is bolted on the same first quarter of the sifter, the tails going into bin *III* for a third passage—through rolls 3. The sifting of the third passage is performed on the second quarter of the sifter, dropping the tails into the bin *IV*, whence the product goes to the same rolls 3 after the passage of the third break.

The rolls 4 serve also for two passages, the product of which is bolted on the third and fourth quarters of the sifter *B*. All the flour out of sifter *B* is directed to the controlling half of the sifter *A*. In this way one may obtain several grades of flour by distributing them among the bins, or, if they are run together in the blender, one grade.

The rolls 5 serve for cleaning up the bran. On these rolls large as well as fine bran may be obtained, for which purpose there are three bins, *VII*, *VIII*, and *IX*, over them.

From the controlling sifter the dunst is sent to the first quarter of the sifter *B*, where the flour fallen into the tails is separated from it, after which, together with the dunst and middlings, from the first break it goes to the second break.

With the same machinery milling can be practised according to a more abridged scheme with four passages after the crushing mill.

Then there are three breaking passages and a fourth for cleaning up the bran.

All the roller mills, except the Hochschrot, are ventilated by means of fan *C* and a suction filter *D*.

Thus, the whole milling plant consists of a crushing mill, two four-roller mills with corrugated rolls, two sifters for two and four sections, a filter, and a fan. A flour-blender, not given in the diagram, is likewise indispensable.

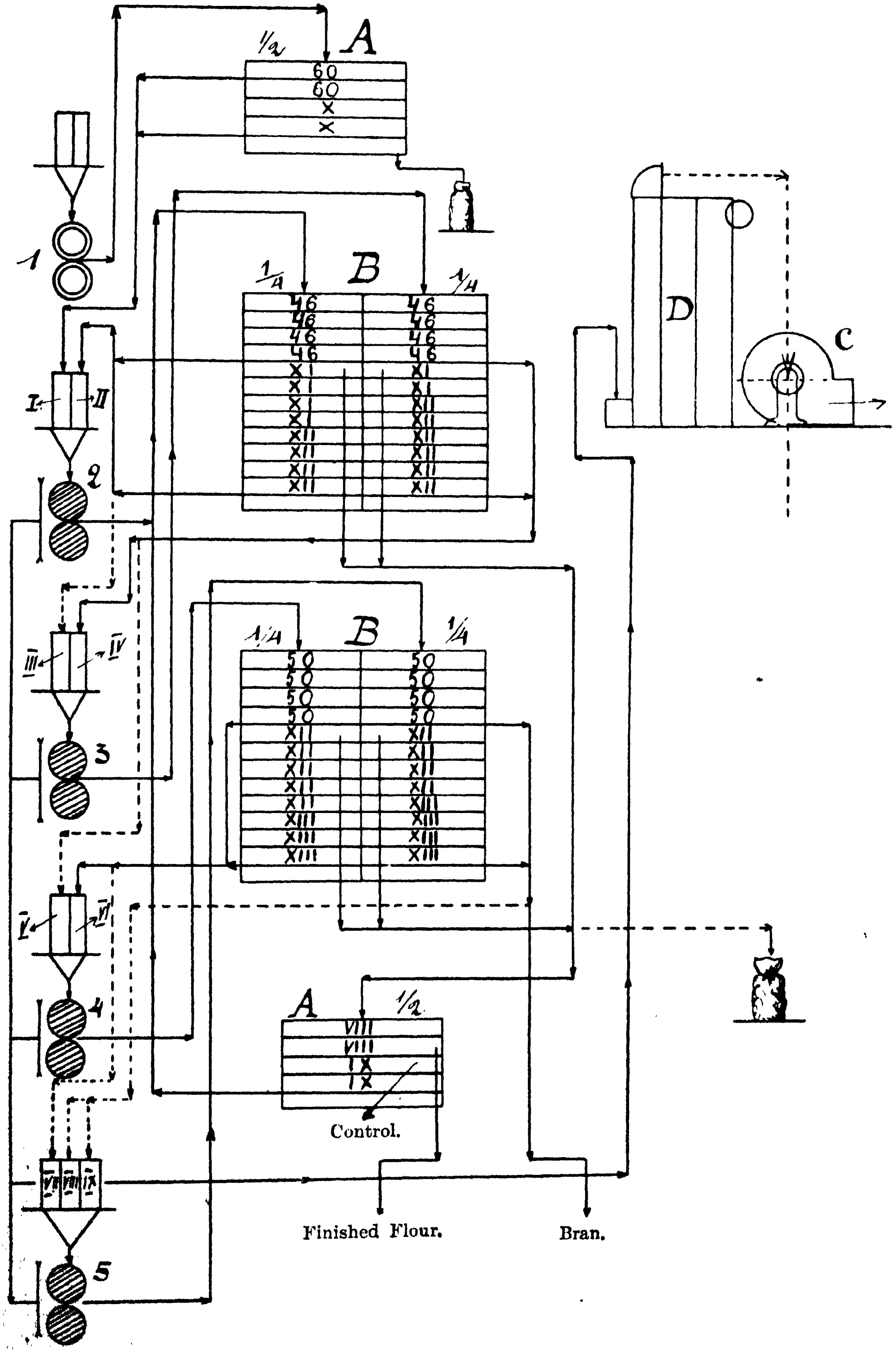
A
1/2
60
60
X
X
1
B
1/4
1/4
46
46
46
46
XI
XI
XI
XI
XII
XII
XII
XII
46
46
46
46
XI
XI
XII
XII
XII
XII
XII
XII
D
C
I
II
2
III
IV
3
B
1/4
1/4
50
50
50
50
XII
XII
XII
XII
XII
XIII
XIII
XIII
50
50
50
50
XII
XII
XII
XII
XIII
XIII
XIII
XIII
V
VI
4
A
1/2
VIII
VIII
IX
IX
Control.
VII
VIII
IX
Finished Flour.
Bran.
5

FIG 516.

VII

MAIZE GRINDING

In Russia there is only known a primitive system of maize grinding with a single passage through a millstone set without sifting away the offals. In the south of Russia, however, especially in Bessarabia, the question of rational grinding is awaiting a solution. For this reason we append a diagram of maize grinding, accepted in America and partly in Hungary.

The maize (Fig. 517) is poured into the storing bin *a*, whence the elevator carries it to the separator *b* with a sieve. The sieve separates the large impurities, such as stones, clods of earth, &c.

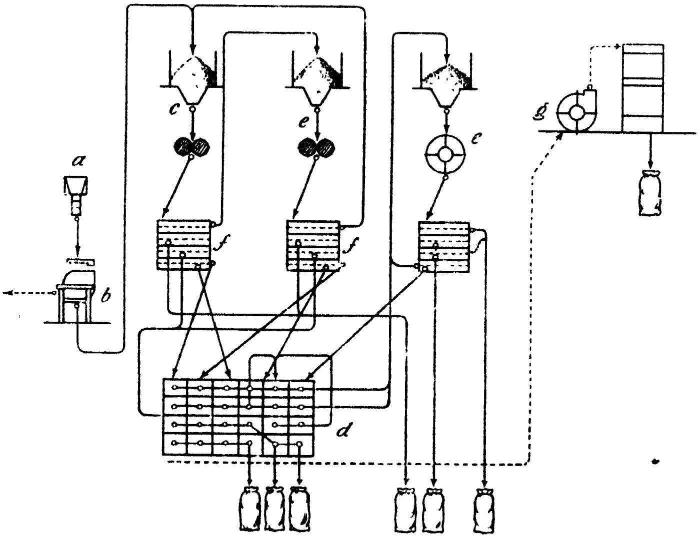

FIG. 517.

By aspiration in the separator the maize is freed of straw, dust, &c., and this light refuse collects in the dust chamber.

The cleaned maize is conveyed by the elevator to the bin *c* over the roller mill.

The first break is done on one pair of rolls, and the product is crushed, and then goes to be graded in the first section of the sifter *f*. From the sifter the break middlings are sent to the bin *e* to be passed through the second pair of rolls, where the break is kept very low. After these rolls the product is graded in the second section of the sifter. The flow of the break middlings is altered in a closed chamber so as to pass through the first break rolls.

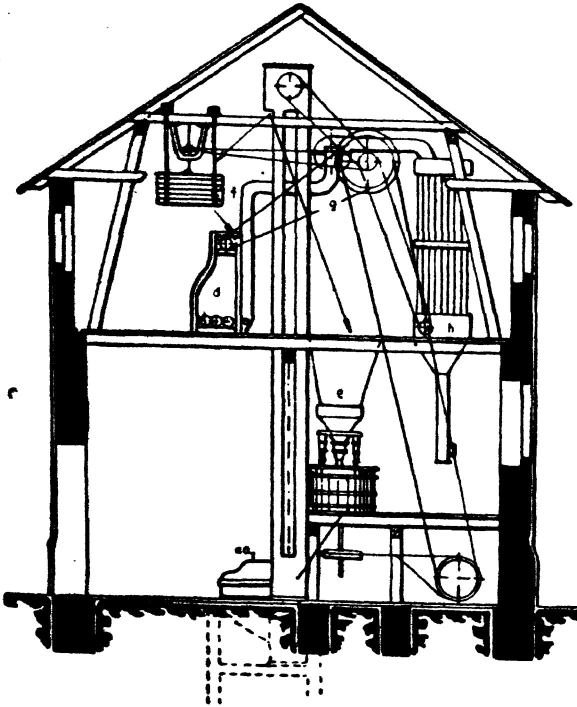

Fig. 518.

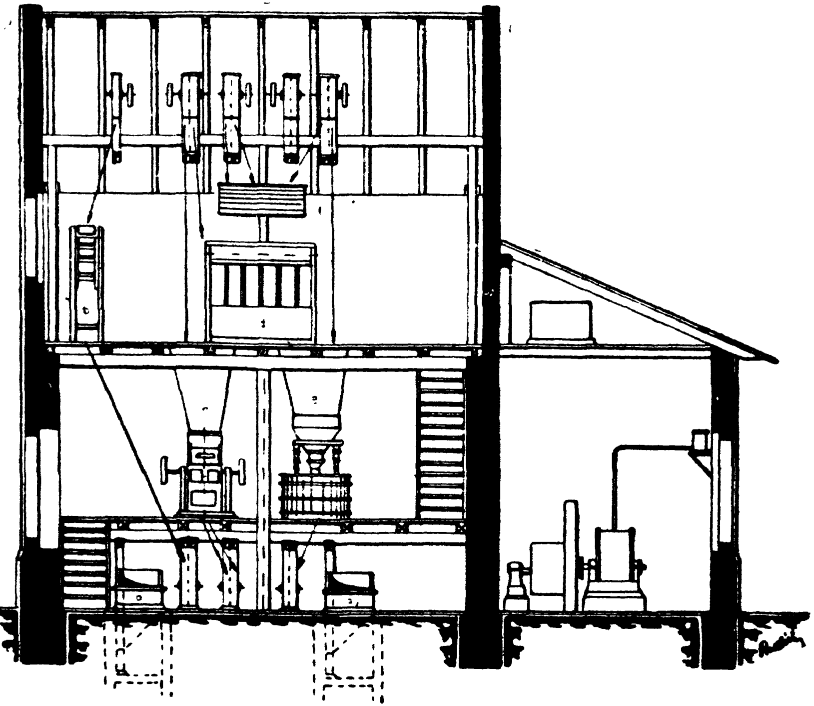

Fig. 519.

Thus, the product obtained here is sacked off, which allows of making four breaking passages.

In the breaking process most attention is paid to the production of semolina with the least produce of break flour, *i.e.* as high a grinding as possible is practised. The flour from the sifters is sacked off, while the middlings, the fine as well as the large, go to a new purifier with six divisions, where the product is graded according to quality. The pure middlings are packed, and the offals are sent to the millstone, where they are reduced, and then go to be graded in the third section of the sifter. The purifier fan drives the extracted bran down a spout into the dust collector *h*, whence it goes to the sack.

The middlings are used for baking bread, the remaining products, such as flour and other offals, serve as feed for cattle.

The arrangement of the machines is such that by increasing their number the milling process can be made quite automatic, which affords economy in working power.

Figs. 518 and 519 illustrate a cross and a longitudinal section of a mill for reducing 40 sacks of maize per day. This mill is operated by means of a 20 H.P. benzine motor with a belt drive to the main shafting.

On the first floor of the mill are stationed: storing bin (a, a_1), elevator bottoms, the main shafting, a four-roller mill 220 × 475 mm., and a 36-in. stone mill. In the garret apartment there are set : a separator *b*, a middlings grading plansifter *f*, a group purifier *d* with six sections, a fan *g*, a filter dust-collector *h*, the elevator heads, and a shaft receiving its motion from the main shafting and transmitting it to all machines on that floor.

VIII

SCHEME OF OATMEAL GRINDING

Oatmeal manufacture is one of the branches of a widely developed industry—the preparation of cereal foods. The corn, cereal, or breakfast foods are prepared of the grain of maize, oats, wheat, sometimes barley freed of the skin, crushed to a thin loaf, roasted or dried. They are used in almost every family for breakfast with sugar and milk—the maize and wheat dry, and the oats boiled.

In Russia oatmeal is known under the name of American flakes ("Hercules"), which have nothing in common with American "Quaker Oats" neither in quality nor in outward appearance.

Since crushed oats are sold by American manufacturers wholesale in boxes at *5d.* to *7d.* per lb., in barrels at *3d.* to *4d.*, and all the offals are sold as cattle feed, no less than £1 to £1, *4s.* is obtained per 1 cwt. of oats after the product is ready.

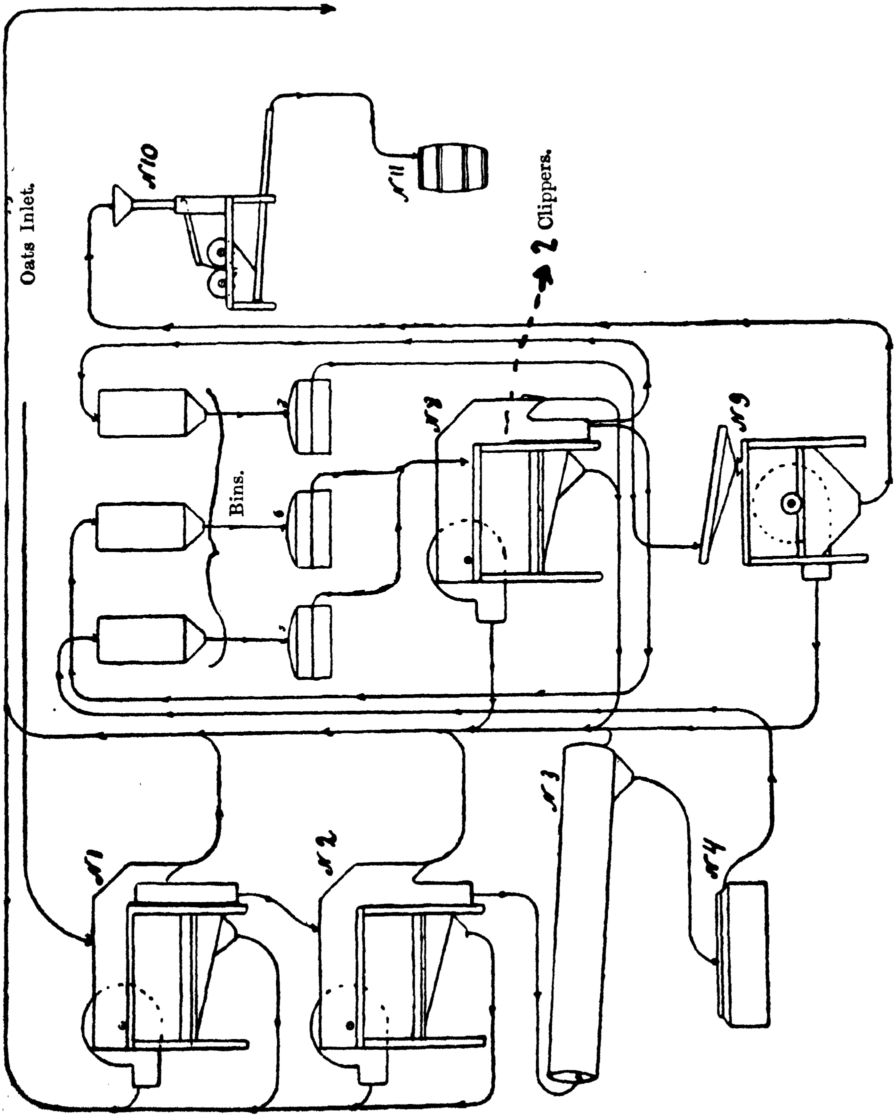

Fig. 520.

That proves that the manufacture is profitable, and one ought to become acquainted with it.

In Fig. 520 is shown the outline of a mill designed for a capacity of 20 sacks per day.

First of all, the grain goes to the separator No. 1 with two sieves. The first sieve bolts the oats separating large impurities, on the second fine impurities and dust are removed. The fan carries away the light dirt and poor grains. From here the stock goes to the grading separator No. 2, which separates away the small oats useless for production. On some of the mills the cleaning is performed with the aid of flat sieves with oblong perforations and an automatic brush for cleaning, or by means of a grading reel-separator No. 3.

These machines extract all fine impurities and sort away the large, heavy oats.

After a careful cleaning and sorting away of the heavy grain equal in size, it is dried in the dryer No. 4 if very damp to facilitate the hulling, and at the same time slightly roasted to give it a flavour.

The dryer generally employed is a metal pan for treating twenty barrels per day. The pan is 10½ ft. in diameter and up to 9 in. deep. It is cemented into the stove which is arranged under it. To prevent the grain from getting burned, it is stirred the whole time. One load of oats of some 8 cwt. is dried in three hours. The stove is built of brick; the pan is set on it with the aid of flanges in such wise that its bottom and sides are subjected to the effect of the hot air.

Well dried and roasted oats are very brittle and friable. They pass in succession through scouring grinders of artificial stone.

After each millstone passage (Nos. 5, 6 and 7) the grain goes to the separator with a sieve (No. 8, shell remover), the tails of which are guided to the stones, and the last one of them polishes the grain. After the stone No. 7 the grain goes to be finally freed of the integumental dust and the partly cut hulls, which is performed on the separator No. 9.

Now the grain is ready to be steamed and crushed. The steaming machine here is similar to the one used for feed. It works unintermittently. In America copper steaming cylinders of continuous action are employed. The flow of grain into the hopper at the top is regulated, because with a change in the height of the column of grain the steam introduced from below into the steam pipe will burst through the grain and steam it insufficiently. The grain in the steaming machine is continually stirred with a stirrer. The steamed grain passes to the rolls.

The steaming machine, the rolls, and the dryer are combined into one machine, No. 10, which economises space.

The process of crushing heats the product, and on leaving the rolls it is spread out in a thin layer in the cooler. This cooling dries it sufficiently for immediate packing in boxes or barrels.

In case the cooling alone appears to be insufficient to dry the oatmeal the steam is let into the pipes of the refrigerator and thus a final drying is attained.

IX

QUANTITY OF INTERMEDIATE PRODUCTS AND THE CALCULATION OF CORRESPONDING MACHINES

In computing the number of corrugations and the capacity of the break and rebreak mills we availed ourselves of the practical data, taking the average quantities of break and rebreak middlings. Now after we have sufficiently become acquainted with the general scheme of milling, we may define the dimensions of the roller mills for rebreaking the semolina, for the reduction of middlings, and the cleaning up of the offals in accordance with the quantity of the intermediate products.

In the plans examined we did not occupy ourselves with the estimation of the dimensions of the machines, acquainting ourselves only with the existing types of milling processes. Therefore we must now, at once, point out that the dimensions of the machines given in the appended milling diagrams are far from the correct calculation, especially as regards the dimensions of the roller mills.

It must be noted that for break as well as for reduction roller mills, practice often establishes one and the same size of rolls, having in view only the convenience of erection and economic considerations. These considerations, however, are incorrect and injurious to the business. In fact, if at a mill with a certain capacity one were to take rolls of a size normal for the third break, and for all other passages establish the same size, then, owing to the absence of proportion of the capacity of the mills with different passages, these mills will be either overloaded or underloaded. This is observed in fact in the mills of Russia and abroad, their builders not having proceeded on the basis of a correct calculation of the machinery.

Quantity of Intermediate Products.—We shall start with the more complex milling process—the high grinding. In F. Baumgartner and L. Graf's book there are given tables of the quantity of intermediate products, determined, according to the authors' words, from the results of detailed investigations of the milling processes in different years. The wheat, which was treated at the mills subjected to investigation, was the ordinary market grade.

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[1] Pp. 229–233 and 305–312.

Thus, the tables by Baumgartner and Graf hereto appended give us the average quantities of the intermediate products for high wheat grinding, the relation of the soft and the hard wheat having been 1 : 2. Approximately the reverse relation on the average is observed in Russia, where 60 to 70 per cent. of soft and 40 to 30 per cent. of hard wheat is generally ground.

In this way, with two-thirds of hard wheat and one-third of soft after cleaning there was obtained 96 per cent. of grain ready for milling, so that the average losses in cleaning were 4 per cent.

After eight breaking passages and one rebreak the results of Table LIII were obtained.

TABLE LIII

Breaking Process

Break.	Fed in 100 per Cent.	Break Flour Grade.			Dunst Grade.			Middlings Grade.			Rebreak Middlings.	Bran.	Loss.
		1.	2.	3.	1.	2.	3.	1.	2.	3.			
1st break .	96·0	...	...	0·25	...	...	0·25	...	...	0·25	0·5	...	...
2nd " .	94·75	...	...	0·25	...	0·5	...	...	6·0	...	1·0	...	...
3rd " .	87·0	2·0	...	...	2·0	...	...	24·0	...	...	2·0	...	...
4th " .	57·0	2·5	...	...	2·5	...	...	21·0	...	...	2·0	...	...
5th " .	29·0	2·0	...	...	2·0	...	...	...	7·0	...	1·0	...	...
6th " .	17·0	...	1·0	...	...	1·0	...	...	...	2·0	...	...	...
7th " .	13·0	...	...	1·5	...	...	2·0	...	...	...	...	...	...
8th " .	9·5	...	...	1·0	...	...	2·0	...	...	...	...	7·25	...
Rebreak .	6·5	...	...	...	...	0·75	...	...	...	...	...	...	0·25
Total . .	409·75	10·5 per cent.			13 per cent.			60·25 per cent.			6·5 %	7·25%	0·25

Thus, there were obtained 10·5 per cent. of break flour, 13 per cent. of dunst, 60·25 per cent. of middlings, 7·25 per cent. of large bran, and 0·25 per cent. loss. One must bear in mind, however, that the grades (1, 2, and 3) of break flour do not correspond in quality to the same grades of middlings and dunst. By denoting the break stock by the three grades, it is meant that each group of product is divided into three categories, according to quality, which is different in the flour, the dunst, and the middlings.

The process of grading the middlings and dunst according to quality, as we know already, is of very great importance, since from the moment the middlings are graded the grades and the quality of flour are computed.

TABLE LIV

GRADING OF MIDDLINGS

Break from which the Product is taken.	Per Cent.	* Best Middlings (Auszugsgries) Nos. according to Size.					Middlings, 2nd Grade (Mundgries) According to Nos.					Fine and Soft Middlings (Semmelgries) According to Nos.					Large Dunst (Pohlgries) According to Nos.					Fine Dunst (Dunst) According to Nos.			Offals.	Loss.
		1.	2.	3.	4.	5.	1.	2.	3.	4.	5.	1.	2.	3.	4	5.	1.	2.	3.	4.	5.	1.	2.	3.		
1st break	0·5	...	...	...	...	...	...	...	...	...	...	...	...	$\frac{1}{4}$	...	...	...	...	...	...	...	...	...	$\frac{1}{4}$	...	...
2nd „	6·5	...	...	...	...	...	1	1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	...	...
3rd „	26·0	3	3	3	2	2	2	$1\frac{1}{2}$	$1\frac{1}{2}$	1	1	1	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$1\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	...	...
4th „	24·25	2	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	2	1	1	$\frac{3}{4}$	$\frac{3}{4}$	1	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	...	...
5th „	9·5	...	...	...	...	...	1	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	1	1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	...	...
6th „	3·0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	2	$\frac{1}{4}$
Rebreak	4·75	...	...	...	...	...	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	...	...
Total .	74·5	5	$5\frac{1}{2}$	$5\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$6\frac{1}{2}$	$4\frac{3}{4}$	4	$3\frac{1}{4}$	3	$3\frac{3}{4}$	$3\frac{3}{4}$	$2\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{3}{8}$	$1\frac{3}{8}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$5\frac{1}{4}$	$2\frac{1}{8}$	$2\frac{1}{8}$	2	$\frac{1}{4}$
Quantity per Grade }		25 per cent.					$21\frac{1}{2}$ per cent.					$12\frac{3}{8}$ per cent.					$6\frac{1}{8}$ per cent.					$9\frac{1}{2}$ per cent.			...	...

Each break gives us a certain quantity of product, approximately uniform in quality. The products of the second, third and fourth breaks are the most closely related in quality.

In Table LIV we have the results of grading the middlings and dunst according to quality.

From the table it may be seen that the total quantity of purified middlings and dunst obtained was about 75 per cent., 2¼ per cent. being reckoned to the losses in dunst and offals.

The further process, rebreak of middlings and large dunst (in Russia this dunst—Pohlgries—corresponds to middlings of the utmost fineness) is clear by Table LV.

TABLE LV

Rebreak of Middlings (Auflösung)

Rebreak of Middlings (polishing)	100 Per Cent.	Flour per Grade.			Dunst per Grade.					Refuse.	Bran.
		1.	2.	3.	00.	0.	1.	2.	3.		
1st rebreak (best middlings—Auszugsgries)	25	1	...	...	10	13	...	...	...	1	...
2nd rebreak (2nd grade Mundgries) . . .	21+1	1	...	...	...	10	9½	...	...	1½	...
3rd rebreak (Semmelgries)	11⅞+1½	1	...	...	...	...	10	...	...	2⅜	...
4th rebreak (Pohlgries) .	6⅜+2⅜	...	1	...	...	...	5	...	...	2¾	...
5th rebreak . . .	1¾	...	...	¼	...	...	¾	...	...	¾	...
6th—cleaning up the bran	¾	...	...	⅛	...	...	¼	...	...	...	⅜
Total	...	3	1	⅜	10	23	25½	...	...	...	⅜

In this way, as we see, three grades of flour and three grades of dunst have been obtained. In the Russian granular grinding the 00, 0, and 1 grades of dunst could be regarded as a ready product—granular flour. But the Germans produce almost exclusively fine flour,[1] and therefore dunst 00, 0, and 1 is subjected to further reduction. Table LVI gives us a table of dunst reduction and the extraction of blue flour.

Table LVI shows the final result of milling. There are obtained

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[1] Only quite recently the preparation of granular flour has begun here and there in Germany.

TABLE LVI

Reduction of Dunst and Finishing the Hulls

Reductions and Scraping of Hulls—Dark Dunst.	100 Per Cent.	Flour in Order according to Quality.								Dunst.							Bran.		Loss.
		00.	0.	1.	2.	3.	4.	5.	6.	0.	1.	2.	3.	4.	5.	6.	1.	2.	
Dunst 00	10	5	...	...	...	...	...	...	...	5	...	...	...	...	...	...	...	...	...
„ 0	23+5	...	15	...	...	...	...	...	...	...	13	...	...	...	...	...	...	...	...
„ 1	9½+13	...	...	10	...	...	...	...	...	...	12½	...	...	...	...	...	...	...	...
„ 1	15¼+12½	...	...	10	...	...	...	...	...	...	17¾	...	...	...	...	...	...	...	...
„ 1	5¼+17¾	...	...	10	...	...	...	...	...	...	...	13	...	...	...	...	...	...	...
„ 2	13+2⅛	...	...	...	5	...	...	...	...	...	...	10⅛	...	...	...	...	...	...	...
„ 3	10⅛	...	...	...	...	3	...	...	...	...	...	...	7⅛	...	...	...	...	...	...
„ 4	6⅛	...	...	...	...	...	2	...	...	...	...	...	...	4⅛	...	...	...	...	...
Finishing the hulls	16+11 2/8	...	...	...	...	...	...	⅝	2	...	...	...	...	...	...	...	3	7¼	1
Total		5	15	30	5	3	2	⅝	2	...	...	...	...	...	...	...	3	7¼	1
Total quantity of flour obtained from breaks and rebreak of middlings (Tables LIII and LV) 15⅜ per cent.		...	...	3	...	6½	2⅜	3½	...	Large bran . . . . . 6¼ per cent. Medium bran . . . . . 3 „									
Final result of reduction—78 per cent. of flour		5	15	33	5	9½	4⅜	4⅛	2	Fine bran . . . . . 7¼ „ Losses in the whole process . 1½ „									

eight grades of flour, beginning with No. 00 and ending with No. 6, the sum total being 78 per cent.; there is 16½ per cent. of bran of all kinds, and the losses amount to 1½ per cent.

In this manner the whole process of high German grinding requires no less than twenty-three passages. If the Hochschrot and yet another rebreaking passage are to be set in addition, which is very useful, the total number of passages will be twenty-five.

Dimensions of the Machines.—As regards the number and dimensions of the bolting machines and purifiers, they may be easily selected in accordance with the quantity of intermediate products according to the tables of capacity we gave on pp. 388–390 and 421. For the rebreak (sizing) of middlings, reduction of dunst, and finishing of offals we offer the following Table LVII.

TABLE LVII

REBREAK OF MIDDLINGS, REDUCTION OF DUNST, AND CLEANING UP OFFALS

Passages in Order of Sequence.	Length of Rolls in mm. to One Sack per Twenty-Four Hours.			
	Porcelain Rolls.	Cast-iron Rolls.	Reduction of Dunst —Cast-iron Rolls.	Scraping of Hulls —Cast-iron Rolls.
1st rebreak .	1·30–1·50	1·40–1·65	......	......
2nd ,, .	2·25–2·65	2·50–2·85	......	......
3rd ,, .	2·25–2·65	2·50–2·85	1·30–1·90	1·90–2·10
4th ,, .	1·30–1·50	1·40–1·65	......	......
5th ,, .	1·10–1·35	1·30–1·50	......	......

The differential of the rolls for rebreak of middlings should be taken as 4 : 5 with the number of revolutions for the fast roll 200 to 210; for reduction rolls, the fast roll running at 230 to 235 revolutions, the differential is 5 : 6; and for rolls cleaning up the offals, the fast roll making 250 revolutions, the differential to be taken is 4 : 5.

Kettenbach gives the following table of dimensions of rolls for break, rebreak of middlings (Auflösung), and the reduction of dunst in different grinding systems for a 50,000 klg. capacity (Table LVIII).

TABLE LVIII

System of Grinding.	Break.		Rebreak of Middlings.		Reduction of Dunst.	
	Number of Passages.	Length of Rolls.	Number of Passages.	Length of Rolls.	Number of Passages.	Length of Rolls.
		mm.		mm.		mm.
High	6	9000	5	5000	8	7750
Semi-high . . .	4	7500	4	4500	6	6000
English	4	1000	4	6500	8	7500

The ordinary high German grinding, *i.e.* with six breaking passages, is given out here.

It must be noted that Kettenbach gives a capacity considerably below the established norm. According to our observations, for high grinding the following general working length of rolls may be given (Table LIX).

TABLE LIX

Process.	Number of Passages.	Length of Rolls in mm.
Break	8	8600
Rebreak of middlings	5	4500
Reduction of middlings and dunst .	9	6750

X

RUSSIAN GRINDING

As was mentioned before, Russian systems have been to a large extent borrowed from the Hungarians and Germans. The material difference between Russian high grinding and the Austro-German consists in the fact that the dunst Nos. 00, 0, and 1 corresponds approximately to the Russian coarse flour (granular), and is taken as a finished product. The Russian system not yet being stereotyped, the percentage of yields will also vary.

The Siberian system is also very characteristic, the peculiarity of which consists in that there are only four, seldom five, grades of flour made.

To illustrate the Russian system we shall give the percentages of the yield of flour in different parts of the country. Great inconvenience is offered to the comparison of the qualities of the grades of flour by the absence of uniformity in the brands. For this reason, when studying these tables one must compare not the brands or Nos., but the percentage of flour in connection with the general table.

VOLGA REGION

Hard and soft wheats were milled. The data refer to 1910 and 1911.

Mixture—Hard Wheat 58 per cent.
Soft Wheat 42 per cent. (Russian).

Grade.	Yield in 100 per Cent.
1st blue	23·00
1st red	4·00
2nd blue	18·75
2nd red	8·00
1st black	10·00
2nd black	3·00
3rd grade	5·75
4th ,,	6·75
5th ,,	3·00
Total amount of flour	82·25
Offal	16·75
Losses	1·00
Total	100·00

Mixture—Hard Wheat, 40 per cent.
Soft Wheat, 60 per cent.

Grade.	Yield in 100 per Cent.
0 blue	11·00
1st blue	7·00
2nd ,,	14·00
2nd red	4·75
1st black	14·00
2nd black	6·00
3rd grade	12·00
4th ,,	8·00
5th ,,	2·5
Total amount of flour	80·25
Offal	18·60
Losses	1·15
Total	100·00

SOUTHERN REGION

The southern region offers a great variety of grades and yields of flour, prepared mostly from local wheat. The data given below were obtained at the Ekaterinoslav District Farm and Industrial Exhibition, 1910.

WHEAT MILL, EKATERINOSLAV

1909

Granular flour No. 00 (including semolina, granular flour No. 0000 and No. 000)	22 per cent.
Soft flour No. 0	8 ,,
,, ,, No. 1	11 ,,
,, ,, No. 2	10 ,,
,, ,, No. II	8 ,,
,, ,, No. 3	8 ,,
,, ,, No. III	6 ,,
,, ,, No. IV	1 ,,
Total amount of flour	74 per cent.

WHEAT MILL, EKATERINOSLAV—*continued*

1909

Fine offal	2 per cent.
Coarse sharps and small bran	14 ,,
Broad bran	4 ,,
Total amount of offal	20 per cent.
Screenings from the grain-cleaning department (wild oats, barley, cockle, and scouring dust)	6 ,,

Thus the mill yields 74 per cent. of flour, 20 per cent. of offal, and 6 per cent. of losses in the grain-cleaning department.

1910

Granular flour No. 00 (including semolina, No. 0000 and No. 000)	20 per cent.
Soft flour No. 0	8 ,,
,, ,, No. 1	11 ,,
,, ,, No. 2	9 ,,
,, ,, No. II	8 ,,
,, ,, No. 3	8 ,,
,, ,, No. III	7 ,,
,, ,, No. IV	1 ,,
Total amount of flour	72 per cent.
Fine offal	2 ,,
Sharps and small bran	17 ,,
Broad bran	3 ,,
Total amount of bran	22 per cent.
Loss in the grain-cleaning department	6 ,,

The milling process of 1910 is the same as that of 1909; the wheat is dryer, and therefore the quality of the flour is better, but the yield of the first grade and several other grades is less. The total percentage of yields is smaller, but there is more fine bran and less large bran, as may be seen in the table. This is explained by easy abrasion of the bran coats on dry wheat. Therefore it would be useful to give a stronger dampening.

The wheat is very dirty, therefore the losses of the grain-cleaning department come up to 6 per cent.

WHEAT MILL, ALEXANDROVSK

I. *High Wheat Grinding*

Granular flour	No. 0000	0·54 per cent.	72·31 per cent. of flour.
,, ,,	No. 000	3·39 ,,	
Black	No. 00	13·91 ,,	
Red	No. 00	8·39 ,,	
,,	No. 0	8·02 ,,	
,,	No. 1	11·55 ,,	
,,	No. 2	9·67 ,,	
,,	No. 3	7·18 ,,	
,,	No. 4	5·62 ,,	
,,	No. 5	4·04 ,,	
Large bran		2·15 ,,	22·62 per cent. of bran
Fine ,,		20·47 ,,	
Broken grain and small wheat		2·11 ,,	5·07 per cent. of offal.
Wild oats and barley		1·00 ,,	
Scouring dust		1·96 ,,	

II. *Soft Wheat Grinding*

(Export flour)

Flour	No. 0000	6·6 per cent.		70·7 per cent of flour.
,,	No. 000	9·4 ,,	export	
"Hercules"	No. 0	48·5 ,,		
,,	No. 4	4·8 ,,		
,,	No. 5	1·4 ,,		
Large bran		2·6 ,,		24·9 per cent. of bran.
Fine ,,		17·5 ,,		
Dunst		4·8 ,,		4·4 per cent. of offals.
Scouring dust		1·4 ,,		
Broken grain		0·8 ,,		
Small wheat		1·4 ,,		
Weeds		0·8 ,,		Total 100 per cent.

III. *Soft Grinding*

(Without export flour)

Flour	No. 00	53·88 per cent.	70·08 per cent. of flour.
,,	No. 0	1·90 ,,	
,,	No. 3	5·80 ,,	
,,	No. 4	4·80 ,,	
,,	No. 5	3·70 ,,	

III. *Soft Grinding—continued*

Large bran	2·72 per cent.	25·12 per cent. of bran.
Fine ,,	17·60 ,,	
Dunst	4·80 ,,	4·80 per cent. of offals.
Weeds	0·90 ,,	
Small wheat	1·50 ,,	
Scouring dust	1·40 ,,	
Broken grain	1·00 ,,	

The above data from Niebuhr's mill are the average yields for the space of ten years (from 1900 to 1910). The yields in the Table II are obtained from mills adapted almost exclusively for export into ports on the Black and Mediterranean Seas.

WHEAT MILL, EKATERINOSLAV

The mill yields nine grades of flour, manufacturing brands which go to the London market. The average yields per grade are represented according to the data of 1909.

			Percentage of Yield.
Granular flour	No. 000		4·37 per cent.
Soft flour	No. 00	for export	20·49 ,,
,,	No. 0	for export	9·67 ,,
,,	No. 1		9·54 ,,
,,	No. 2		9·68 ,,
,,	No. 3		9·47 ,,
,,	No. 4		6·61 ,,
,,	No. 5		5·76 ,,
,,	No. 6		0·92 ,,
	Total amount of flour		76·51 per cent.
Fine offal			9·29 ,,
Large bran			11·24 ,,
	Total amount of produce		97·04 per cent.
Screenings loss			2·96 ,,
	Total		100·00 per cent.

WHEAT MILL, EKATERINOSLAV

Before packing the flour is graded, and to flour No. 1 is added the flour from the third break, to flour No. 2 that of the fourth break, to No. 3 of the second break, to No. 4 of the second and sixth breaks, and to No. H4 the flour from the first, sixth, and seventh breaks.

The yields of flour in percentages are given in the following table :

Flour, brand 000	6 per cent.
„ „ 00	19½ „
„ „ 0	4½ „
„ „ 1	11¼ „
„ „ 2	12 „
„ „ 3	10½ „
„ „ 4	7 „
„ „ H4	5¼ „
Total amount of flour	76 „
Finest offals	3⅛ „
Large bran	2⅝ „
Fine bran	11¼ „
Total amount of offal	17 „
Wild oats	1⅝ „
Weeds	¾ „
White dust	2½ „
Dark dust	2⅝ „
Total amount of screenings	7½ „
Total	100½ per cent.

Instead of the ordinary result of exactly 100 per cent. here we have 100·5 per cent. This means that the total weight in a correct calculation increases on account of the dampening of the wheat, which absorbs the moisture.

TABLE LX

Wheat Mill, Marioopol

Flour Grades	Belotoorka.	50 per cent. Belotoorka and 50 per cent. Banatka.
1st grade	6·50 per cent.	15·00 per cent.
2nd „	6·50 „	10·00 „
3rd „	6·50 „	12·50 „
4th „	28·00 „	11·25 „
5th „	11·25 „	11·25 „
6th „	10·50 „	10·00 „
7th „	6·50 „	6·50 „
Total	75·75 per cent.	76·50 per cent.
Sharps	5·50 per cent.	5·50 per cent.
Fine bran	7·75 „	7·00 „
Large bran	5·50 „	4·75 „
Offal in the scouring department	7·00 „	7·00 „
Dust and dirt in them	4·50 „	4·50 „

WHEAT MILL, VILLAGE ALEXANDROVKA, GOVERNMENT OF EKATERINOSLAV

The samples of milling are of the 1909 crop. The mill treats 90 per cent. of Ulka and 10 per cent. of Garnovka.

Semolina	2·5	per cent.
Flour, brand No. 000	2·5	,,
,, ,, No. 00	15·0	,,
,, ,, No. 0	10·0	,,
,, ,, No. 1	10·0	,,
,, ,, No. 2	10·0	,,
,, ,, No. 3	10·0	,,
,, ,, No. 4	7·5	,,
,, ,, No. 5	6·25	,,
Total amount of flour	73·75	per cent.
Fine sharps	1·25	,,
Fine bran	11·25	,,
Large bran	7·50	,,

The above tables of yields and flour brands through their variety and inconstancy greatly impede the progress of the Russian exporters on the foreign markets. For this reason, we ought most decidedly to adopt uniform brands. There is no doubt that a reduced number of grades and the definiteness of the brand will simplify the milling process, make it cheaper, and facilitate the competition of Russian mills on foreign markets.

CHAPTER IX

CONSTRUCTION OF MILL BUILDINGS

I

CONDITIONS DETERMINING THE CHARACTER OF BUILDINGS

IN milling practice there are two processes which determine the character of the buildings and the arrangement of the machines : the automatic and the intermittent. For this reason, before proceeding to describe the constructions of mill buildings, one should compare these two methods of milling.

In automatic milling, as the name itself proves, the complex milling process is performed without the assistance of human hands.

In the sack mill all the intermediate products, beginning with break and middlings and ending with dunst and flour, are sacked, sorted, and fed by hand into corresponding machines, where they are subjected to further treatment. Thus, the manual operation of a workman forms the connecting link in the independent work of the separate machines.

" Sack mills " are now comparatively seldom met with, and at a well-furnished sack mill one may see special devices—generally in the shape of bins with so-called caps—for the automatic performance of the different parts of the milling process, such as the breaking process, middlings grading, or reduction.

If, on the other hand, the arrangement of the mill is automatic, the whole process, starting at the moment the dirty grain goes into the storing bin and ending with the packing of flour per grade, is performed without the assistance of working hands. The separate products by means of various transporting devices, in the shape of bands, elevators, worms and spouts pass through all the stages of treatment, *i.e.* the whole operation is performed quite automatically.

In this manner, the continuity of the milling process is left intact. If a certain scheme of milling is accurately followed, both the automatic and the sack mill, provided they are furnished with a sufficient number of machines, are able to give equal results as regards the quality of the milled products. But here arises the question, Which way is the best to obtain these results ? which one of them is the most expedient, technically speaking, and more economical as regards the milling costs ?

Among the mass of millers, not only in Russia but also abroad, there are many partisans of the full sacking or semi-automatic mill. Therefore it is necessary minutely to consider the question, What mill should one build—a sacking or an automatic one ? First of all, it is an undoubted fact that every machine answers its purpose only when its work is perfectly definite both in quantity and in quality. A change in the quality of the material treated, overloading, and frequent half empty working, while the material is being changed,—all this has a detrimental influence on the results of the work and on the wear of the machine. All this is observed in the work of the sacking mill, in which, generally, there is no sufficient number of machines and apparatus and the process is not strictly established. In the sacking mill one and the same machine often serves for different purposes. In the medium sacking mill, for instance, there are often adopted the so-called "turn," with the aid of which one and the same roller mill and the bolting machine coupled to it treat products different in size and quality. Under such conditions neither the number of corrugations on the rolls nor the number of the sieves in the bolting machine can be common for different products, and therefore the quality of the work is not high.

The automatic mill operates according to a perfectly definite scheme of milling. A sufficient number of machines, every one of which performs a certain work, affords the possibility of establishing a definite set of dimensions for the machines, in accordance with a previously evolved and thought-out milling scheme. The whole work is performed evenly, and the corresponding products, mechanically blending, are automatically sent forward for further treatment.

In an automatic mill, having a definite milling scheme, the miller is always able to watch the general run of the process, to control at any given moment the expedience of the combinations provided for by the scheme. On the other hand, there is always provision made for the construction of alternative runs, owing to which the scheme becomes flexible, and this allows the varying demands of the market to be met, since it is possible to alter within certain limits the percentage of yields of the different grades of flour.

The sacks with the intermediate products, occupying all the open spaces in the sacking mill, and the shooting of these products by hand into the bins, result in the mill apartments being constantly filled with dust. Even with the most careful attendance it is impossible to avoid the escape of flour, which lowers the total percentage of the yield. That loss may be obviated only in an automatic mill, where the products travel through closed spouts, which, coupled with a suitable system of exhaust, make dustless operation possible not only in the clean half of the mill—the milling department—but also in the grain-cleaning division. By adopting filters one can make all the apartments of an automatic mill dustless, for, not only machines furnished with fans may be included in the general exhaust system, but such machines and apparatus as the trieurs, automatic scales, and elevators as well.

When selecting the type of mill, a circumstance of no less importance than the technical outfit is the economic side of the question, which touches the millers' most tender point—the cost of working the milling.

The most material element in the milling expenses is the cost of mill hands. If a large mill is taken, a parallel comparison of an automatic and a sacking mill shows a sharp difference. For instance, in a mill of the sacking type, with a 12,000 bushels of wheat capacity per day, the expenses in workmen during one shift amount to the round figure of seventy hands, while in an automatic mill of the same capacity the number of workmen is reduced almost fourfold down to eighteen men. That relation drops also with the lowering capacity, and, for instance, for a medium mill of 1750 bushels automatic in arrangement the number of hands does not exceed five or six, against the ten or twelve of the sacking system.

The numbers of hands given include only the persons taking part in the process of production, for instance, roller men, purifier men, &c., whereas the workmen occupied in supplying, loading of the wheat, the packing of the flour are not reckoned, as their number depends on local conditions—the situation of the mill, the mode of transport, &c.

The following table gives parallel data pertaining to the number of hands employed during one shift at a sacking and an automatic mill.

TABLE LXI

Capacity of Mill per Day in Bushels.	Number of Hands.					
	Sacking Mill.			Automatic Mill.		
	Milling Dept.	Cleaning Dept.	Total.	Milling Dept.	Cleaning Dept.	Total.
12,000 . . .	66	4	70	14	4	18
8000	36	3	39	9	3	12
5500 to 6000 .	24	3	27	7	3	10
4000	20	2	22	5	2	7
2700 to 3300 .	16	2	18	5	2	7
1700 to 2000 .	10	2	12	4	2	6
1000	6	1	7	3	1	4

As may be seen in the table, in the grain-cleaning department of the automatic mills there is employed the same number of hands as in the sacking mills, because the cleaning of grain at a sacking mill is generally performed automatically. But in the grinding department of the mill, the number of hands in changing from the sacking to the automatic mill makes a sharp bound, as we see in Fig. 521, which presents more strikingly the data of the appended table.

This diagram clearly shows that with the diminution of the capacity the difference drops, and attains an insignificant quantity in small mills.

To the milling expenses, which are absent in the automatic arrangement, must be added also the outlay in sacks for the intermediate products.

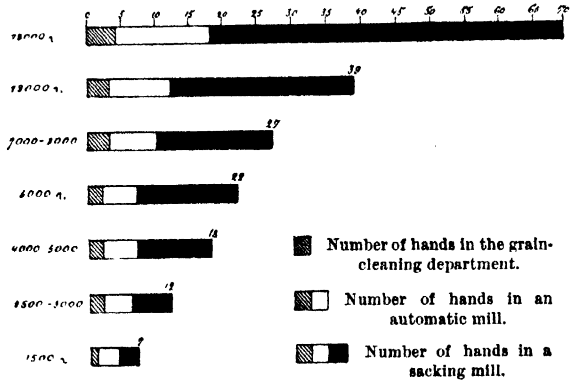


FIG. 521.

Besides the cost of working, one should reckon the cost of equipping the mill, which determines the capital charges.

The automatic mill requires a greater number of machines, the presence of which would exclude the necessity of a "return" to the machines which have already fulfilled one purpose. Consequently, the automatic mill requires far more machinery in the grinding section than the sacking one.

For example, we shall take a mill with 650 bushels of wheat capacity per day. In mills fitted out for sacking, very frequently owing to the use of "returns" the number of roller mills is limited to four, whereas an automatic mill of the same capacity to work regularly needs seven or eight roller mills. Parallel to the number of those mills the number of bolting machines and transport devices augments, which increases the costs of the plant. As the capacity increases, however, these expenses decrease. For a mill with 2000 bushels of wheat capacity per day, of the sacking type, eight is a sufficient number of roller mills, whereas an automatic mill needs but eleven mills.

In spite of the comparatively great difference in cost of fitting out an automatic and a sacking mill at the present moment, the erection of an automatic mill may be regarded as profitable as soon as its capacity amounts to 1000 or 1300 bushels.

Those against the automatic mill maintain, though without any foundation, that the flour produced by an automatic mill does not possess uniform qualities. Under the influence of that false opinion there sprang into existence a type of mills which find their place on the line between the automatic and the sacking mills. The peculiarity of these so-called semi-automatic mills consists in the fact that the whole process is performed automatically, but the flour is collected in sacks at the point of discharge out of separate bolting machines and then graded by hand and mixed in the blender to obtain the brands established on the market. But this is a palliative, which does not abolish the causes of non-uniformity of the flour.

In the meantime, not noticing it themselves, these opponents of the automatic system turn the above-mentioned argument, which has some real meaning in it, against themselves: namely, the sacking mill does not guarantee the uniformity of the consistence of flour, the whole control being based on the superficial visual sensations. But at the time of the night shift that becomes almost impossible even to an experienced miller.

To solve the question of the homogeneity of flour in the automatic mill, one must pay due attention to the methods of blending the grain, a no less important question than the cleaning of it. For the regularity and consistency of the final results, the uniformity of the intermediate products, middlings and dunst, is equally necessary. The ideal solution of the question is to erect elevators by the mills in which the grain is stored in silos, sorted, and the mill supplied with a mixture according to a certain recipe. Then the intermediate products too, being the result of a definite milling scheme, will be homogeneous.

Thus, for a mill of even a medium capacity the automatic type, unrestricted as regards the number and size of machines, is undoubtedly the most rational type, both economically and theoretically.

II

CONSTRUCTION OF MILL BUILDINGS

With the introduction of the automatic process in flour mills, material alterations in the construction of the mill buildings became necessary. Up to that time low mill buildings answered their purpose perfectly.

At the old (village) mills of plain grinding with water-wheels the plant consisted mainly of one stone mill and one bolting reel per wheel. For small country mills an insignificant building area by the water for the machinery was sufficient, while the remaining part of the building was free for other purposes and served as lodging to the miller.

The idyllic situation of the mill by the water, the rumbling torrent, and the roar of the mill, all wakened the creative powers in the poets, who sang praises to the outward picture of manual industry.

With the invention of the turbine at the large sources of water energy, plants consisting of several separate wheels were substituted by the turbine, owing to which the inner arrangement became more independent of the outer.

When steam power commenced its victorious march from England over all the civilised countries, and effected in all branches of industry the well-known great changes, flour milling could not remain behind in the general progressive motion.

The invention of the roller mill, and the adoption of steam-engines and other heat motors together with it, imparted a totally different aspect to the milling industry. The construction of mills, which up to that time was mostly in the hands of artisans, developed into a large industry, and by the efforts of mill-building firms, during the course of the last forty years there was evolved a certain form of arrangement of the mill apartments, which may be regarded as fairly standardized.

A Simple Mill Building.—Let us first examine the type of building of a simple mill for the peasant single grinding. Fig. 522 illustrates in a longitudinal section and plan a mill with one stone mill (on ball bearings), a combined grain-cleaning machine, a cyclone for dust collecting, and Soder's sifter.

The single floor building has a hursting on which the sifter is set. The stone mill is planted on a foundation on a level with the hursting.

On the overhead flooring, to which there runs a ladder, a cyclone and a grain-cleaning machine are stationed: under the flooring the main drive is placed, from which the motion is communicated to the elevator, the grain-cleaning machine, and the sifter. For the motor (in our case a

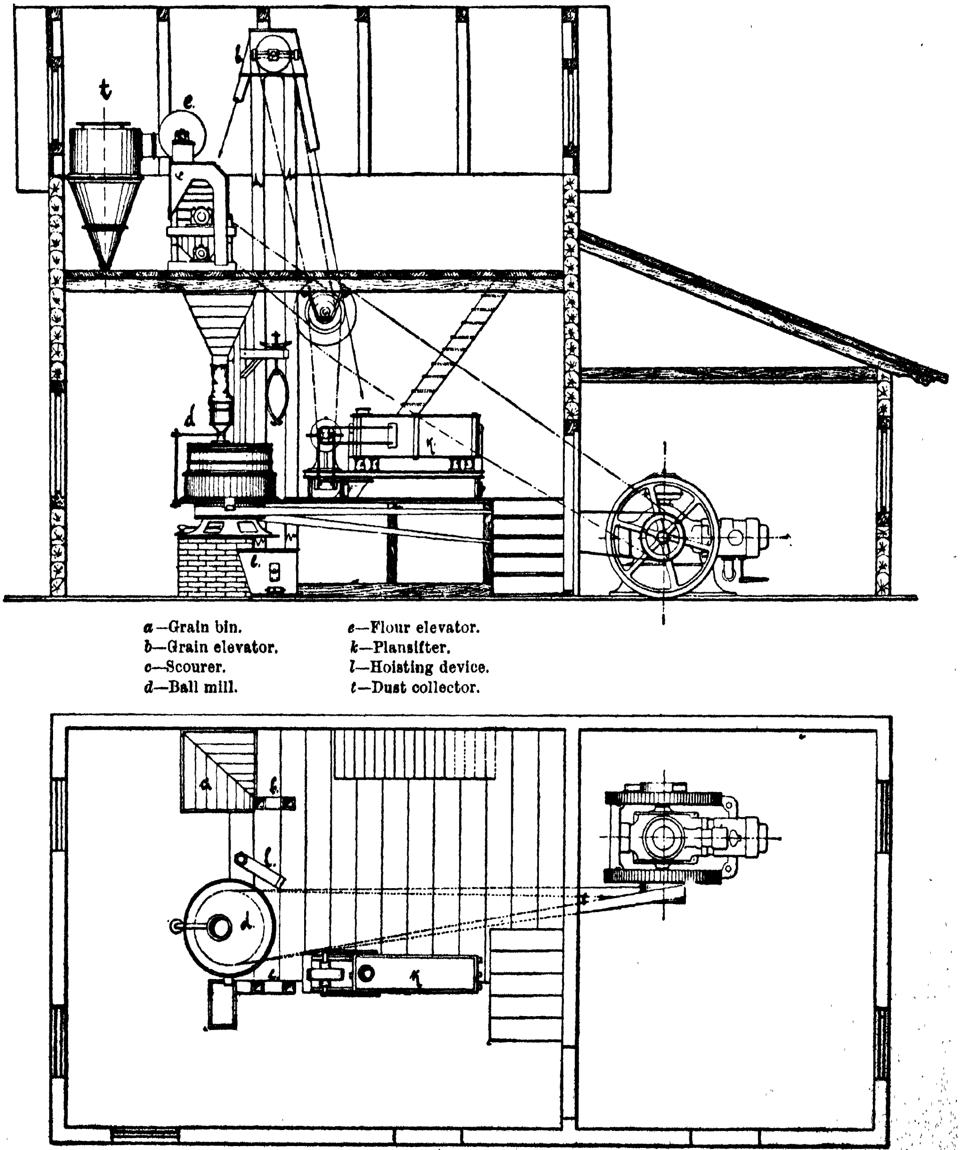


Fig. 522.

naphtha-engine, but it may be a steam-engine or a turbine) a special apartment, separated from the mill by a wall, is arranged. The building may be of stone, which is better as regards security against fire.

III

Buildings of Complicated Grinding Mills

In modern wheat or rye mills with automatic handling of the products we generally find four or five floors. The first (basement) floor is left for the main shafts, the second for the roller mills, the third is necessary for the purpose of communicating a sufficient incline to the spouts, the fourth for purifiers, and finally, the fifth for bolting machines. In rye mills there is no floor for purifiers.

The roller mills and stone mills, as well as the purifiers and bolting machines, are placed in straight rows along the building. For each roller passage there is a separate elevator, which runs through all the floors; besides that elevators are needed for other machines from which the product cannot be allowed to flow of its own accord. It is these transport devices which have a very considerable influence on the arrangement of the mill building and especially on the shape of its roofing.

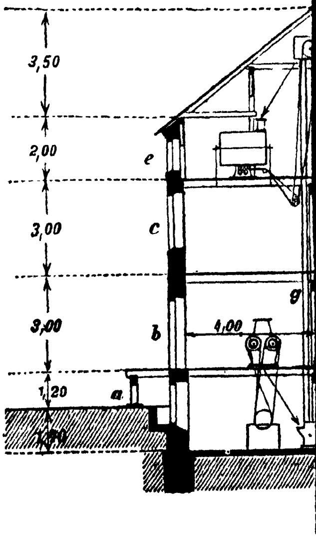


Fig. 523.

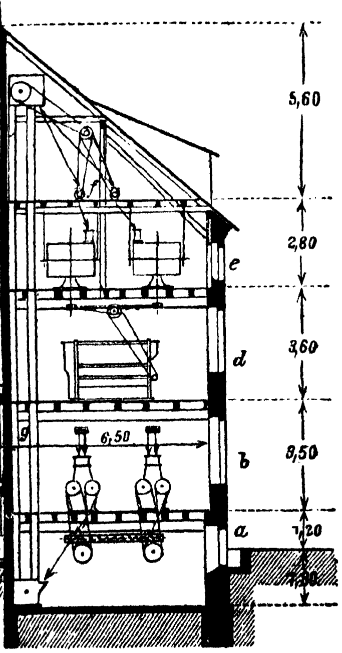


Fig. 524.

Let us now inspect the most typical mill buildings.

In Fig. 523 may be seen the transverse section of a mill with two rows of roller mills and two rows of plansifters. The elevators are set in the middle. Such an arrangement may be particularly recommended for rye mills, by reason of its cheapness, because from both the rows of mills the product by its weight, without the aid of worms, runs to the elevators as well as into the bolting machines. The roof of such a building should have a high ridge, so as not to increase the height of the floor holding the sifters for the sake of the elevators. The sole defect of such an arrangement of the outfit is that the elevators block up so much space in the centre of the mill building. The free passage between the machines and the inspection of their operation are impeded. For this reason, though such an arrangement is sometimes practised in wheat mills, it cannot be recommended, as the number of elevators here is still greater. Figs. 525 and 526 show us the cross sections on which out of the above considerations the elevators are arranged, not in the middle, but by the wall. With such an arrangement all the sections remain free in the middle and easily accessible to inspection. The elevators are set along the wall so as not to stand opposite to the windows. The walls of the top floor have to be sufficiently high for the elevators (here they are 5 metres high, while in the first case the height is only 2-metres), so that the roof is flat in shape. Such an arrangement of the building in practice appears to be the most efficient both for large and for small mills, and is therefore the one most frequently adopted.

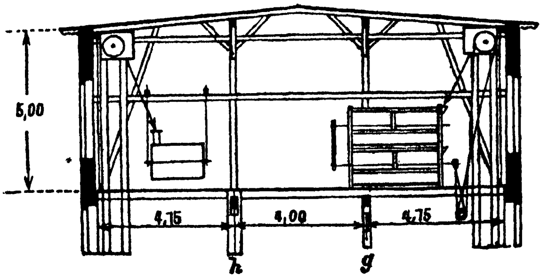


FIG. 525.

On Fig. 524 the mill building is divided by a longitudinal stone wall into two parts, of which one serves as the mill proper, and the other as a warehouse furnished with flour-blenders. If the mill has to be enlarged the warehouse may be used for setting the machinery in. There is no floor to allow of inclining the spouts; instead of the spouts there are worms set over the mills. The double slope roof leaves sufficient space for the high elevators and detachers, which are situated over the sifters of the reduction rolls. With such a construction of the building one has to make much use of the worms, but by disposing the machines rationally along the building their number may be considerably reduced.

Fig. 527 presents a cross section of a large modern mill. The height of the building here is quite considerable. The ground floor is so high that the product of itself runs to the elevators from both rows of mills, The floors for the spouts and the cleaning department are also sufficiently high, so as to have the product travel automatically if possible everywhere, requiring the least quantity of power for transport. The ceilings of the building are of a peculiar construction (*A*, Fig. 529—this construction comes from England). Here steel joists are laid across the building at about 2½ metres distance from each other. On these joists there lie narrow beams, and the whole is covered with a solid layer of square beams some 10 cm. thick, on which there is another layer 2½ cm. thick. Such ceilings are comparatively expensive, but their advantage lies in the fact that the ceiling beams are nowhere in the way. The

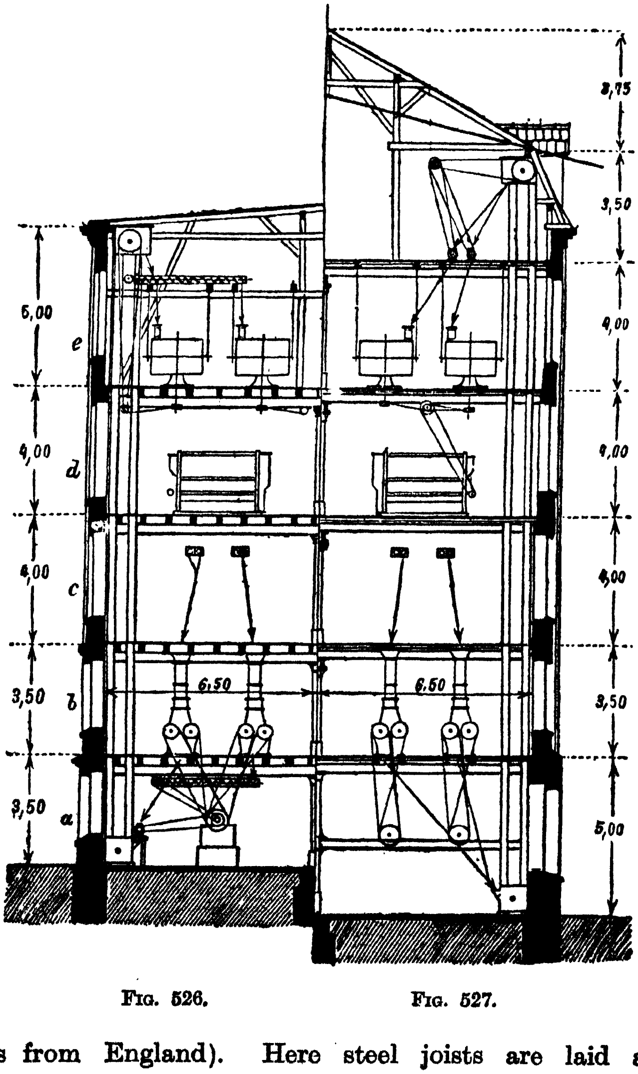


Fig. 526. Fig. 527.

suspended bearings of the main shafts are attached directly to the iron joists.

Altogether the construction of the ceilings in mill buildings has assumed a very peculiar shape, which depends on the disposition of the machines, and the practical utilisation of space in the mills.

On Figs. 525 and 528 (transverse and longitudinal sections) we see a framing of joists often used in other buildings too. The cross pieces *a* are timber beams with supports *b* at the fulcrums of the columns; these supports are designed to shorten the length of the unsupported part *c*, in consequence of which the beam has a more rigid span. The supports *b* are strengthened with rafter beams *d* or attached to the beam *a* by means of bolts *e*, which produces the same result and is often considered to be more convenient. The joists *f* are disposed at a distance of 0·8 or 1 metre from each other. Care should be taken that these joists are set exactly vertically over each other in all the floors. The columns supporting the ceilings are either single like *g*, or double like *h* (Fig. 525). When using timber joists and cross pieces the distance between the supporting columns should not be over 4 or 4½ metres in longitudinal and in transversal direction. The breadth of the building being 8 or 12 metres, there are consequently two or three rows of columns.

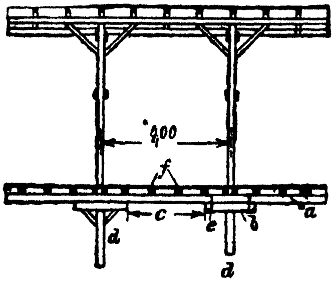


FIG. 528.

For mills with a capacity of 240 sacks per day such an arrangement is advantageous, as its erection costs comparatively little. But for mills of larger dimensions this arrangement is disadvantageous as regards the most economic use of the area of the buildings. As we see in Fig. 525, the rows of columns allow of freely setting in the 4·15 metre spans only three rows of mills and sifters, whereas with the Fig. 526 construction of ceiling there is space for four such rows. In Fig. 526 there is a row of columns only in the middle, the distance between the columns and the walls being 6½ metres. For such a span the timber cross beams of the limit size would be too weak, and therefore the cross pieces here are I-beams, while the timber ceiling joists run down the length of the building with a distance of 4 metres between the fulcrums. The roller mills and sifters of the second row are connected with elevators by means of transverse worms. The advantage of the sifters over reels and centrifugals as regards economy of the area occupied is clearly seen here, for, with centrifugals, it is quite impossible to instal in the same space a machine doing the same work or to keep at the same time the dressing surface as accessible to inspection as when furnished with sifters.

The danger of fire that threatens the mill, led to the necessity for constructing fireproof buildings. The machines and apparatus as well as the transport devices of the fireproof mills have no wood parts whatever. Not only the walls, ceilings, and coverings of the building have to be of fireproof materials, but the doors and windows as well.

The buildings of a fire-resisting mill, *i.e.* properly speaking the walls, are erected of ordinary brick. Only comparatively recently in America attempts at complete ferro-concrete buildings or steel constructions with a brick shell have been made. As regards ceilings, there are two types: solid ferro-concrete (*B*, Fig. 529) and with concrete arches (*C*, Fig. 529) between the longitudinal iron beams. The last construction is the heavier of the two, and is therefore inferior to the first.

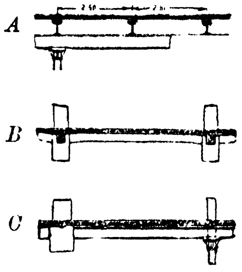


FIG. 529.

Such in a general outline are the constructions of mill buildings answering the requirements of modern technics.

IV

CONSTRUCTION OF AMERICAN MILLS

The originality of American technics shows itself also in the construction of mill buildings.

A more or less normal type of an American mill building, approaching the European construction, is given in Figs. 530 and 531, which illustrate the cross section of the grain-cleaning department and a longitudinal section through the grain-cleaning and milling departments. The principal difference from the European constructions of buildings lies in the fact that the ground floor is considerably higher. That is necessitated by the type of roller mills used, which need overhead shafting hung from the ceiling and special tension pulleys for the flexible gearing.

On the ground floor the flour is packed, on the first the roller mills are disposed, on the second the suspended filters, on the third the purifiers, on the fourth the centrifugals and vertical scouring bran dusters for freeing the bran of the flour remaining in it, on the fifth sifters.

The grain-cleaning department is supplied with hard and soft wheat by the band conveyors *SBC* and *HBC*. That wheat is hauled up by the elevator and of itself flows into the worm *C* 10. This worm distributes

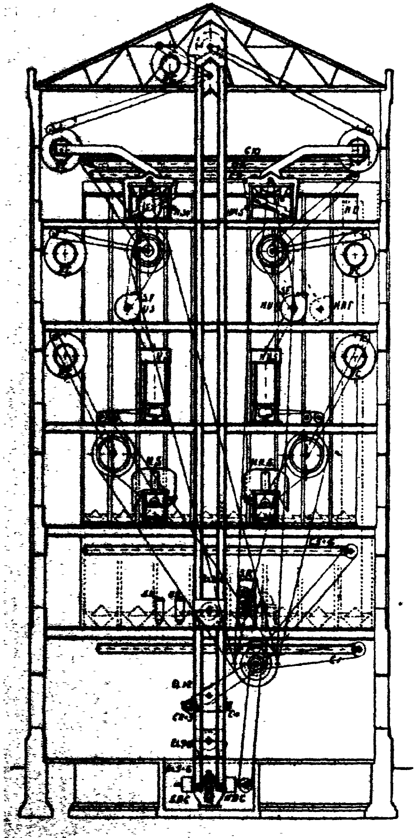


FIG. 530.

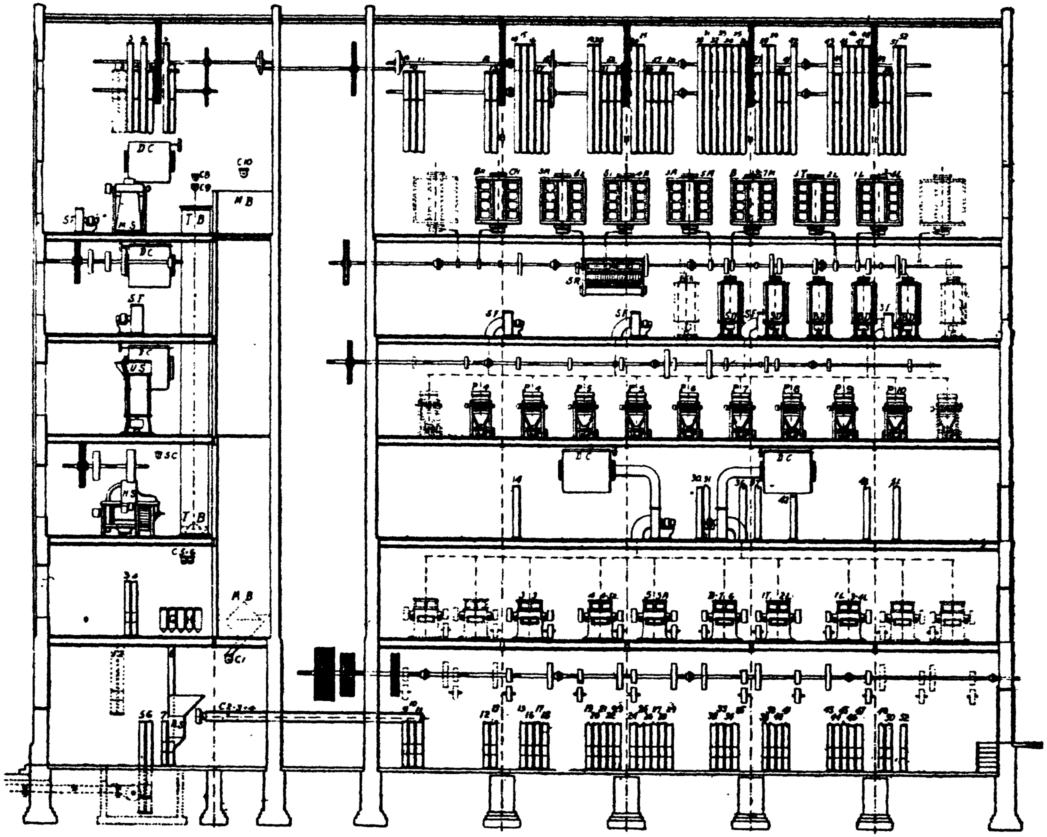


FIG. 531.

the grain to the bins *MB*. In proportion as it is needed, it is let out of the bins into the worm *C* 1 and passes to the automatic scale *AS*, whence it pours into the elevator 7, and is then carried up to be cleaned.

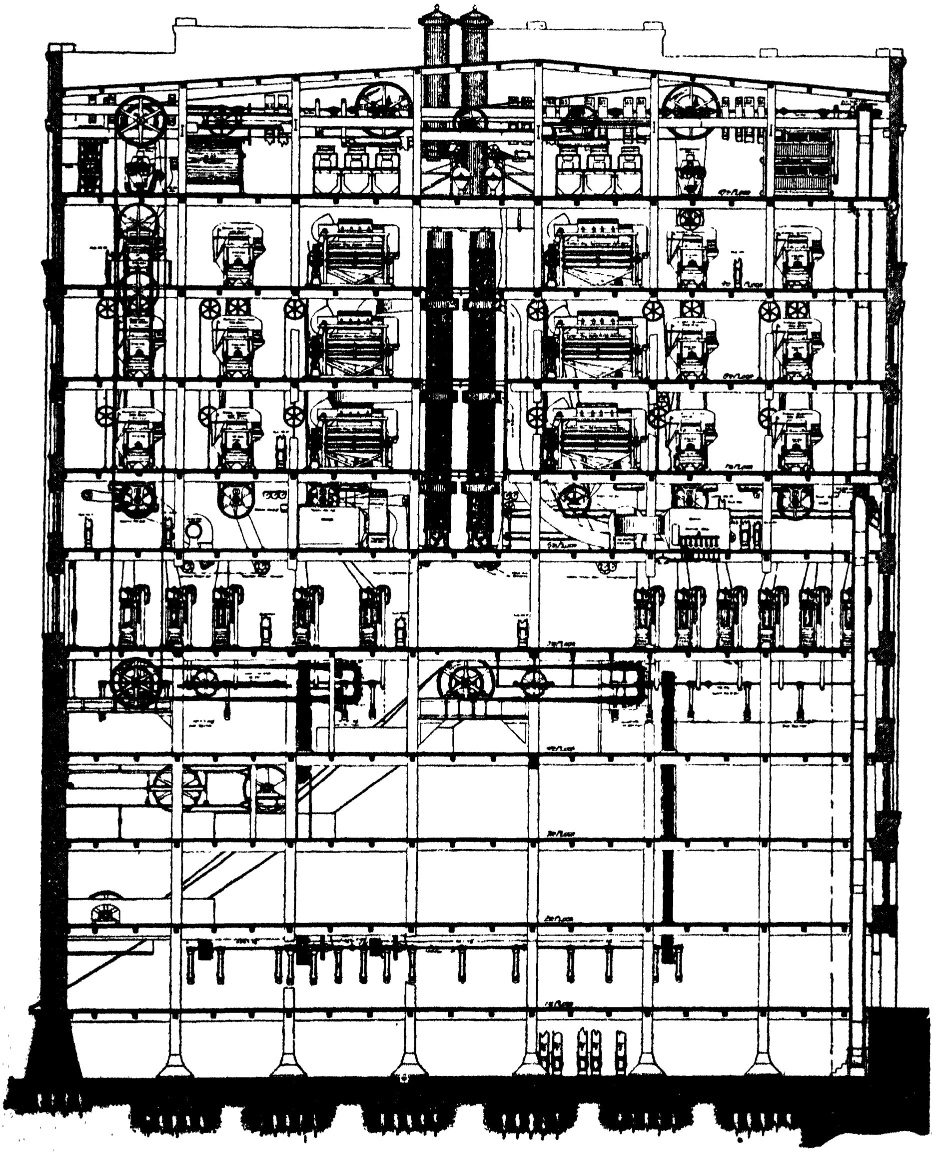


FIG. 532.

In cases where the scale of output goes far beyond the limits of the ordinary dimensions, the American mill buildings are amazing in their size and originality. Figs. 532, 533, and 534 show us the sections of an American mill belonging to Hecker Jones Jewell in New York, started in 1908, and working mostly for export.

The capacity of the mill is 8000 sacks of wheat grist per day. To

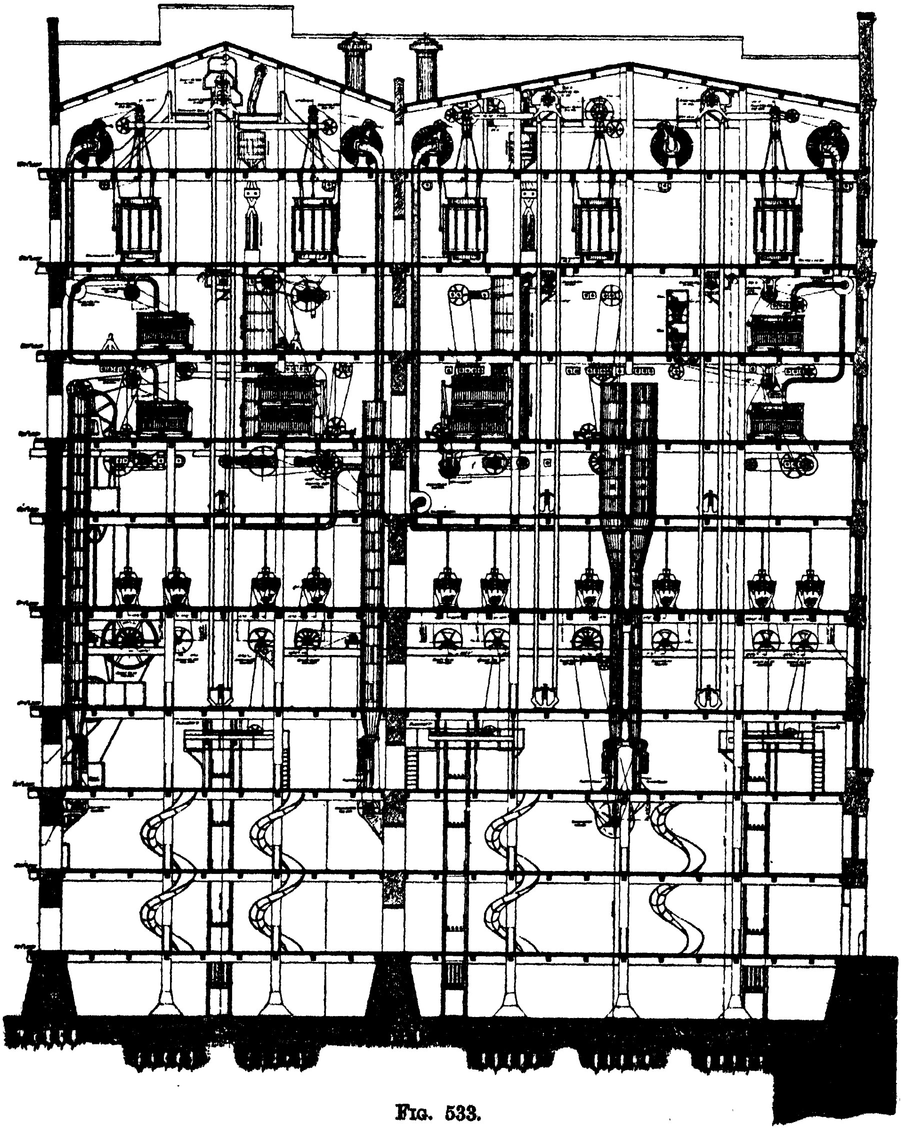


FIG. 533.

give an idea how big that mill is, it is sufficient to say that there are 115 four-roller mills 250 × 900 mm. in size in it, and it is brought into operation by two compound steam-engines of 1800 and 1000 indicated horse-power.

The concrete foundation of the mill is laid on concrete piles. The underground floor serves for the boots of the elevators. The first, second, and third floors do duty as temporary stores for barrels of flour, the third and partly the fourth floors being for packing. The transportation of sacks and barrels to the second and first floors is performed by conveyors. The fourth floor contains the driving machinery, the fifth is for roller mills, the sixth for the transmission drive and for the corresponding deflection of the spouts, the seventh and eighth for purifiers and centrifugals, the ninth for sifters, and the tenth is the garret for star filters. The milling department (Fig. 533)

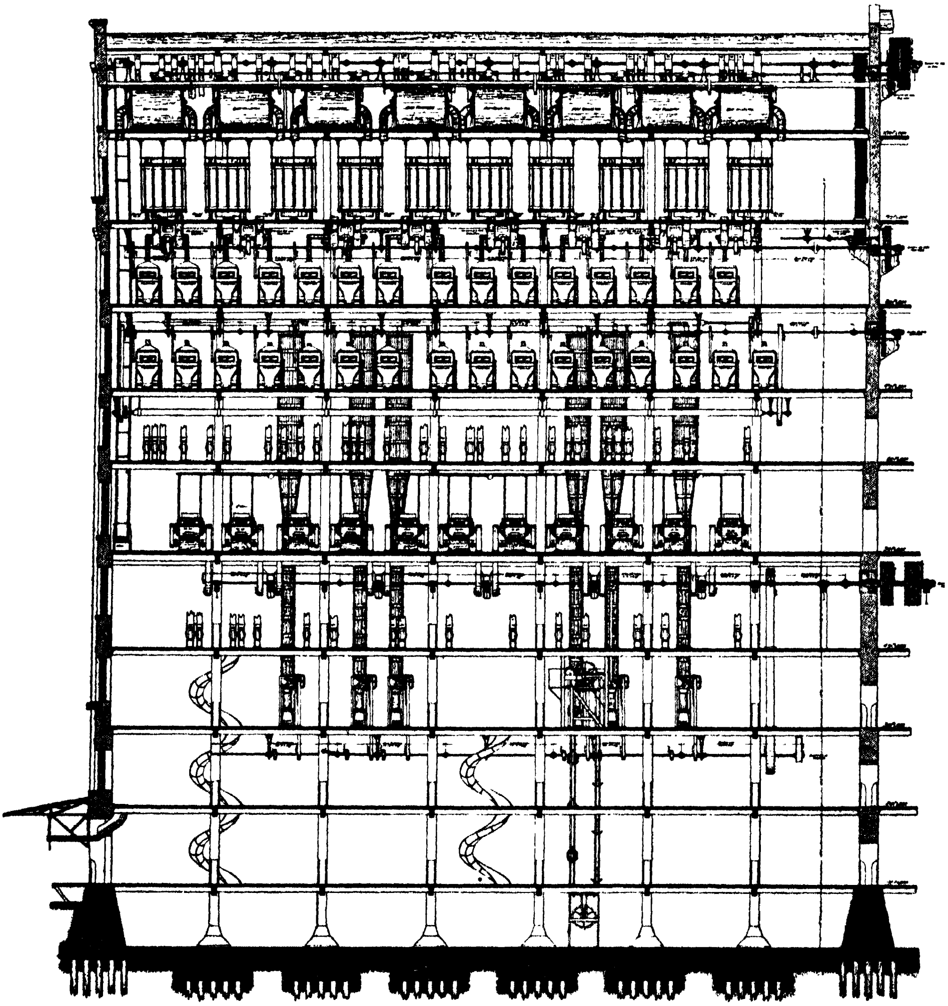


FIG. 534.

is divided by a party-wall into two separate mills (4800 and 3200 sacks).

The grain-cleaning department (Fig. 532) has a washing plant and roller mills on the tenth floor for the reduction of the broken grain and screenings to feed. On the fifth floor there are set the feed and part of the bran packers for the stock which is transmitted from the milling department.

The longitudinal section of the mill is shown on Fig. 534. The mill is built according to the fireproof type.

Worthy of notice is the truly American rapidity with which that mill was erected. The construction of the mill building, the elevator to it (for 500,000 bushels of grain), and the full equipment were ended in eight months. The building was started on the 1st of May, 1907, and on 2nd January, 1908, the milling operation was in full swing.

V

Plans of Mills

The longitudinal and transversal sections of the mills we have examined illustrate to a certain extent their general plan. But it is necessary to give a general outline of the distribution of machinery and also of the position of the prime motor.

In Fig. 535 may be seen the plan of the ground floor, where *A* is the grain-cleaning department, *B* the milling department, *C* the engine room, and *D* the boiler plant. This plan shows that the necessity of securing the mill against fire compels the constructors to isolate the engine room from the mill proper. The position of the engine room pointed out is convenient in so far that it occupies a small area together with the mill building. But its inconvenience lies in the fact that a series of roller mills by the windows looking on to the wall of the boiler room *D*, is in the dark. It is better to arrange the boiler room down the longitudinal axis of the engine room, if space permits.

Further, it is necessary to isolate by a staircase the grain-cleaning department from the milling, to prevent fires, which generally break out in the former, from penetrating into the latter. In this plan, as well as in others, we see that from the landings of the staircase the doors open into the milling and grain-cleaning departments. That is the ordinary planning in Russia and in Western Europe. It is inexpedient, however, in case of fire, because the flames can easily leap from door to door across the landing on the staircase. It is better to have balconies made opposite to the landings, which afford communication between the grain-cleaning department and these landings, and to have the wall of that department quite blind, leaving one door from the landing to the balcony and one into the milling department.

To return to the engine-house, it should be noted that the area it occupies is considerably reduced when an internal combustion engine is employed, and there is no need for space for the boilers.

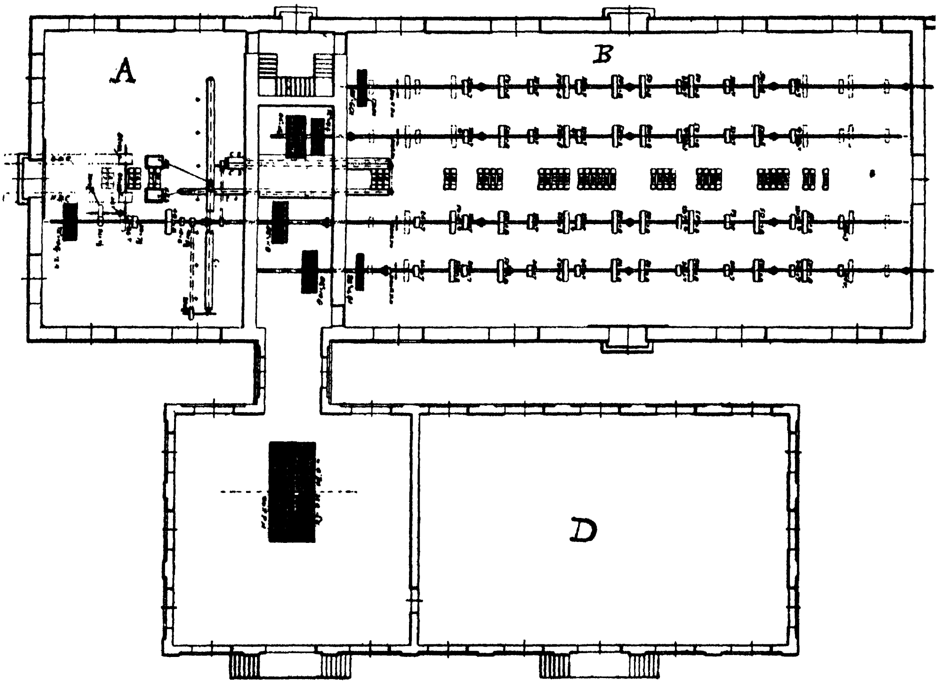


Fig. 535.

Fig. 536 illustrates the plan of the first and second floors in a wheat and a rye mill with a silo: *A* is the milling department of the wheat mill, *B* the stairway, *C* the common wheat and rye grain-cleaning department, *D* the milling department of the rye mill, and *E* an elevator with rectangular silos.

The plan of the second and the following floors shows that part of the stairway is occupied by bins for tempering the grain. The flour bins are marked *a*. In the same plan of the second floor there are shown two types of disposition of the roller mills, in a chess-board order and along the general transversal line.

In the arrangement of the roller mills, as well as of other machinery,

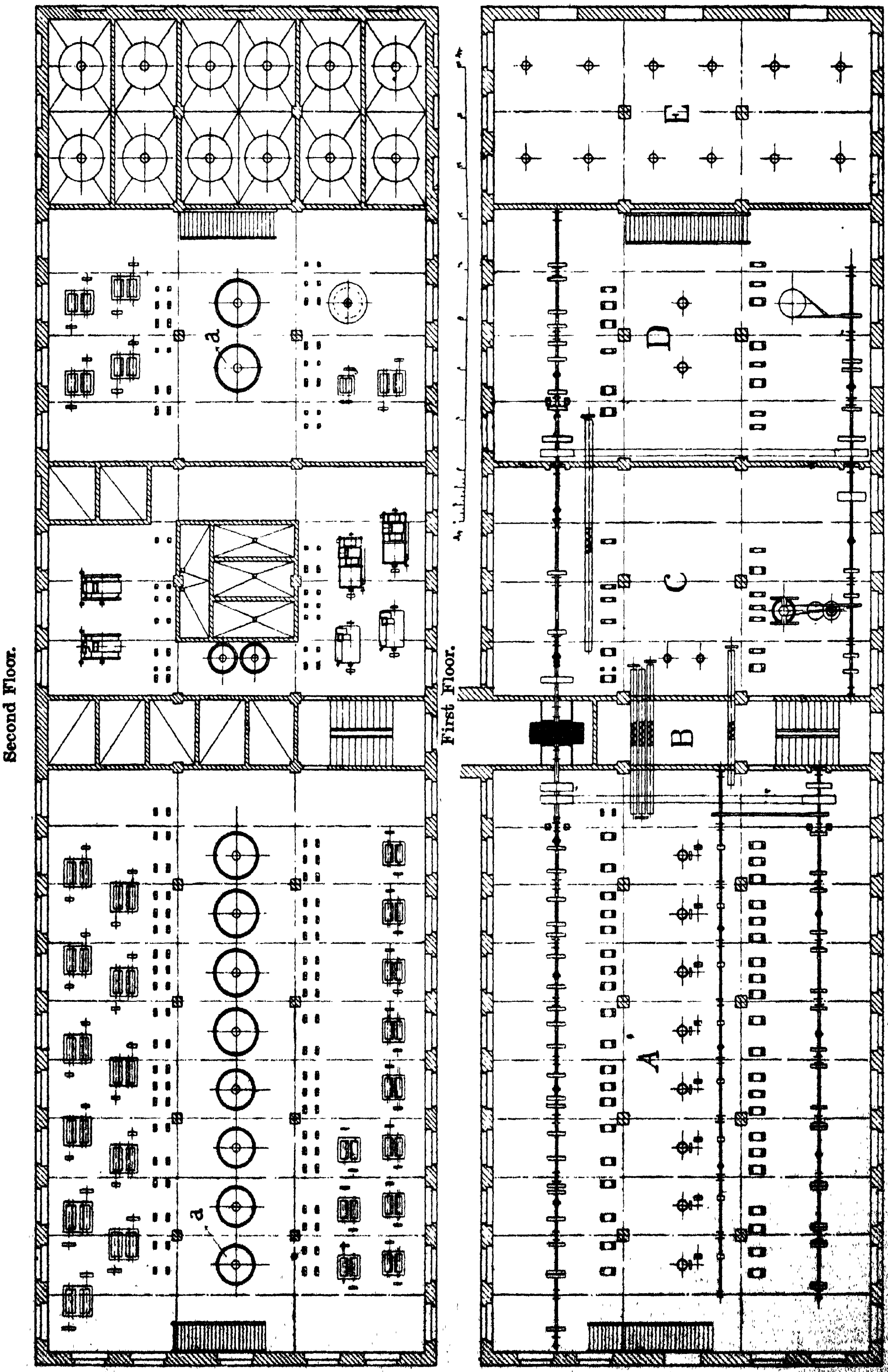


FIG. 536.

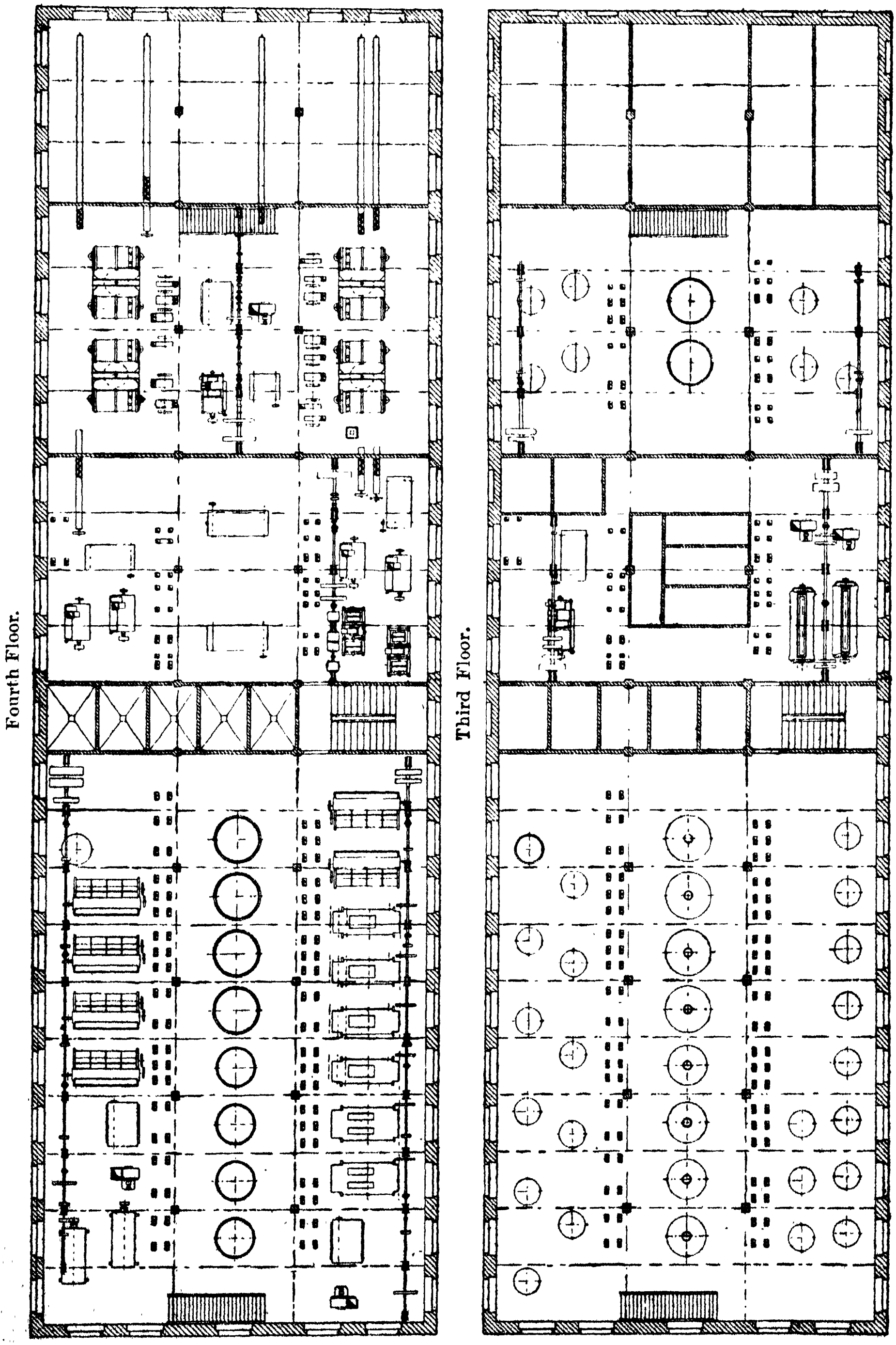
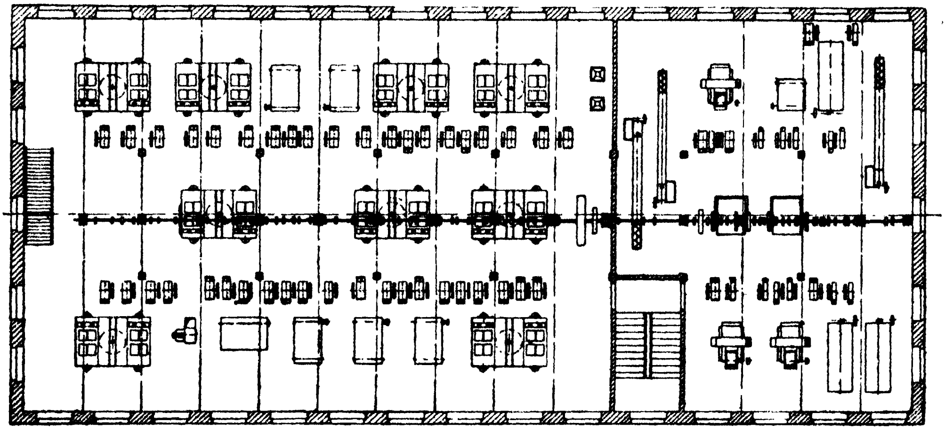


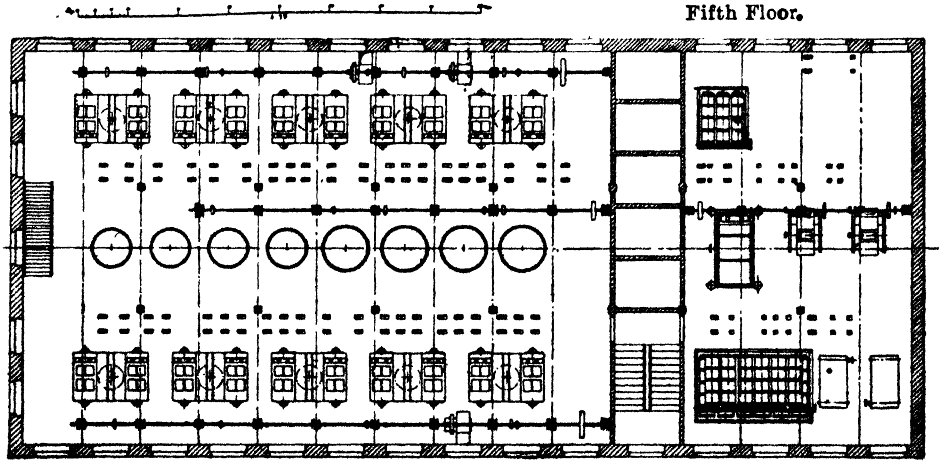
FIG. 537.

one should be guided by their accessibility from all sides, which guarantees a free inspection and allows repairs to be done *in situ.*

With the third and fourth floors (Fig. 537) the rye mill and the grain elevator end. On the fourth floor of a wheat mill are set the purifiers, and on the same of a rye mill the sifters; the fifth and sixth garret-floors of a wheat mill contain sifters (Fig. 538).



Sixth Floor.



Fifth Floor.

Fig. 538.

The above plans represent the scheme for an 800 sacks per day mill, drawn up by the firm of Dobrovy & Nabholtz for a South Russian mill.

CHAPTER X

THE COST OF ERECTING AND OF WORKING MILLS

I

The Mill Building and Equipment

Russian general practice, and consequently literature also, give no materials whatever from which the average data concerning the area required for a mill may be deduced, not to mention its costs per certain capacity. This is explained by the fact that Russian milling conditions as a whole are so different, that the building firms very often ignore the types of mills and milling standards established in Western Europe.

It is equally impossible to give the average costs of a mill equipment according to its capacity, as the prices of the machinery and of erection also fluctuate within wide limits.

In Germany, where, as we have seen, a definite type of mill has been evolved, and the prices for machinery and labour are almost without variation, the average costs are deducible.

We append here Kettenbach's table, which gives us the capacity per day, the total area of a wheat and a rye mill, including the mill building, and the full cost of the building machinery and equipment in German marks.

TABLE LXII

Capacity per 24 hours in Kilograms.	Total Area of the Mill in Square Metres.	Cost of Erection in Marks.	
		Wheat Mill.	Rye Mill.
20,000	700	200,000	150,000
30,000	900	300,000	240,000
40,000	1250	400,000	300,000
50,000	1500	500,000	380,000
60,000	1800	600,000	450,000
80,000	2100	800,000	600,000
100,000	2500	1,000,000	750,000
120,000	3000	1,200,000	850,000
150,000	3500	1,500,000	1,000,000
200,000	4000	2,000,000	1,500,000

The data of that table are taken from practice, but we presume that the quantities here are rounded off with great approximation, since according to the table the costs of one klg. of capacity for small as well as for large wheat mills is one and the same, 10 marks. whereas that cost ought to drop with an increase in the capacity of the mill.

The truth of this statement may be proved by Kettenbach's other tables, where the costs of a full equipment of an automatic mill yielding one sack per 24 hours are given.

TABLE LXIII

COST OF EQUIPPING A WHEAT MILL

Capacity per Day (24 Hours).	Cost per 1 Sack per Day.
200 to 400 sacks = 20,000 to 40,000 klg.	350 marks
400 ,, 800 ,, = 40,000 ,, 80,000 ,,	320 ,,
800 ,, 1,200 ,, = 80,000 ,, 120,000 ,,	300 ,,
1,200 ,, 2,000 ,, = 120,000 ,, 200,000 ,,	280 ,,

TABLE LXIV

COST OF EQUIPPING A RYE MILL

Capacity per Day (24 Hours).	Cost per 1 Sack per Day.
— to 100 sacks = — to 10,000 klg.	450 marks
200 ,, 400 ,, = 20,000 ,, 40,000 ,,	260 ,,
400 ,, 800 ,, = 40,000 ,, 80,000 ,,	240 ,,
1,000 ,, 2,000 ,, = 100,000 ,, 200,000 ,,	220 ,,

This is more clearly shown in the diagram, Fig. 539. On the horizontal line the capacity of the mill per day (from 10,000 to 200,000 klg.) is marked, on the left-hand side vertical (ordinate) the total cost of equipment in 1000 marks, on the right-hand vertical the cost per one sack per twenty-four hours in marks. The uninterrupted line (———) running upwards denotes the diagram of cost of equipping a wheat mill; the semi-dotted line (—. —. —. —) the cost of equipping a rye mill.

The diagram drawn in the broken line (— — —) gives the cost of equipment per sack per 24 hours for a wheat mill, and the dotted line (- - - - -)

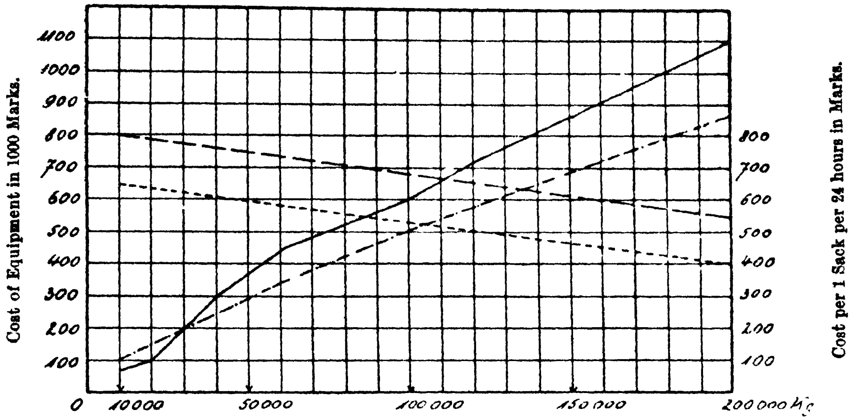


Fig. 539.—Capacity per 24 hours.

for a rye mill. It is clearly seen here that with the rise in the capacity of the mill the cost of equipment per unit of capacity drops.

II

Calculation of Working Expenses

Motive Power.—Before defining the cost of the motive power which constitutes the main expenditure in working the mill, the data of the

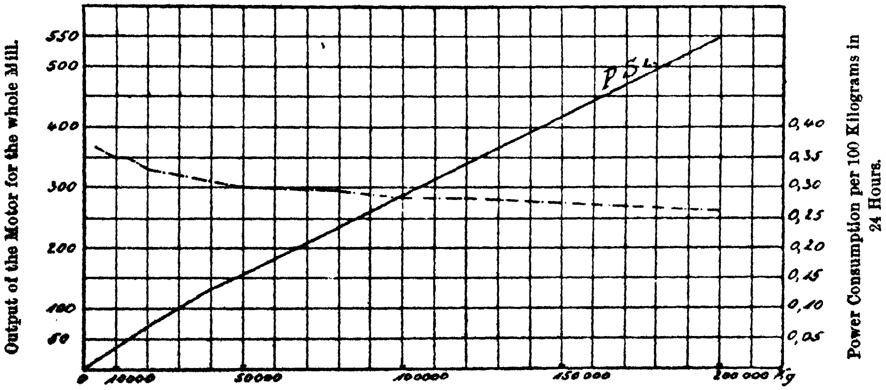


Fig. 540.—Capacity of Mill.

power consumption in accordance with the mill capacity should be noted briefly.

In Fig. 540 we have a diagram of power consumption in effective horse-power for automatic wheat mills of from 10,000 to 200,000 klg. capacity. The. uninterrupted line (————) represents the output of the motor, the horse-power of which is shown on the left-hand side ordinate up to 550 H.P. ; the semi-dotted line indicates the power consumption for 100 klg. per day. The last diagram shows that with the increase in the capacity of the mill the power consumption to a unit of capacity drops from 0·35 H.P. for a 10,000 klg. per day mill almost to 0·25 H.P. for a mill with 200,000 klg. capacity.

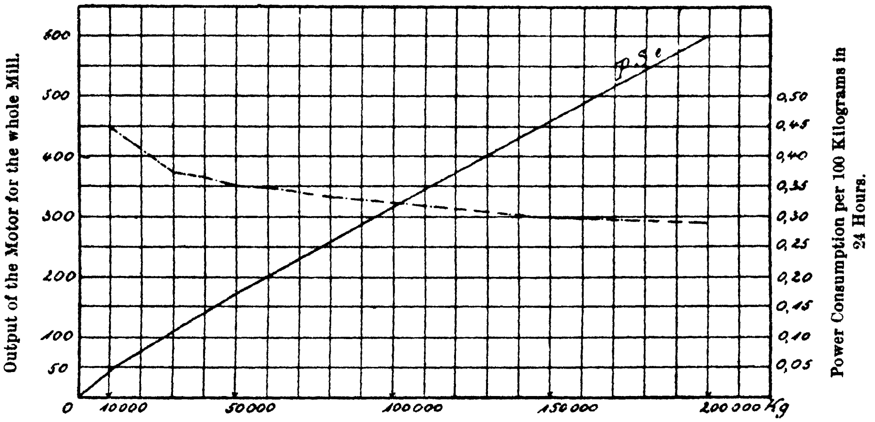


FIG. 541.—Capacity of Mill.

The diagram, Fig. 541, gives the power consumption of an automatic rye mill.

The diagrams examined represent the power consumption in automatic high grinding mills according to German data.

In Russia the motive power, depending on the character of the grinding, is expressed in the following table :

TABLE LXV

Number of H.P. per 1000 Poods in 24 Hours.	Kind of Grinding.
23 H.P.	Single grinding
27 ,,	Scoured ,,
30 ,,	Break ,,
35 ,,	Bolted ,,
40 ,,	Sifted ,,
50 ,,	Dressed ,,
55 ,,	High wheat ,,

It should be noted here that the power consumption for high grinding includes also the consumption for electric lighting.

Number of Hands.—A less substantial part of the working expenses constitutes the payment of the workmen. In an automatic mill that expenditure forms a very small part of the sum total of working costs.

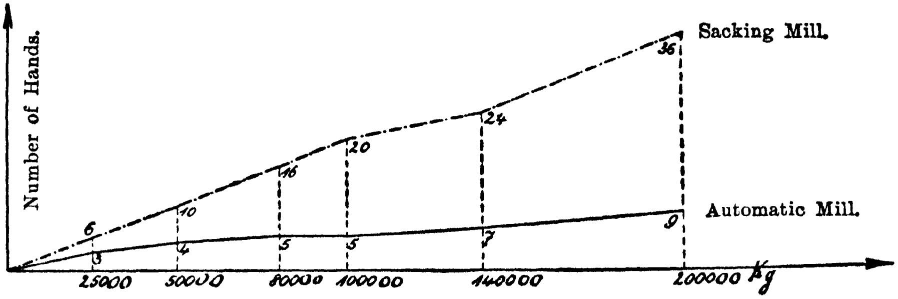


FIG. 542.—Capacity of Mill.

The diagrams given here represent the average of hands in the German mills.

Fig. 542 gives a diagram of the number of hands in the day shift for the sacking and the automatic mills, and Fig. 543 the number of hands in the night shift.

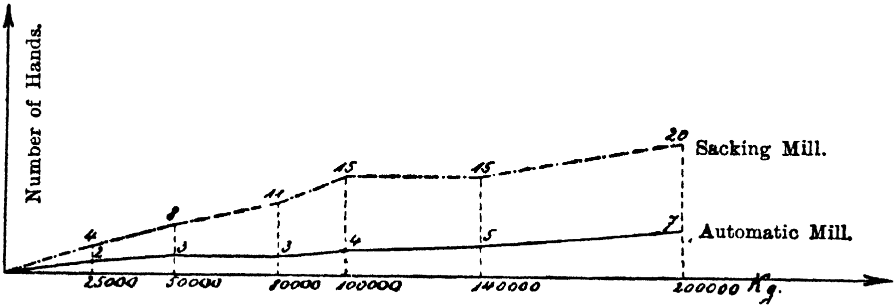


FIG. 543.—Capacity of Mill.

As we see from the diagrams, the night shift demands a less number of hands. That is explained by the fact that in the night time the work of unloading the sacks out of the mill, and often of packing of the flour, is discontinued.

III

SELECTION OF A PRIME MOTOR

One of the most important questions in making out a project for a mill is the question of selecting a prime motor, since a large part of the working expenses of the mill is taken up, as we remarked above, by the production of motive power.

When choosing a motor for the engine plant one has previously to solve the question concerning its power, which is found by summing up the total power required by all the mills and machines of the given plant. In some cases, when an enlargement of the output is expected, to the initial power a reserve is added, which discounts the presupposed enlargement. The desirability, and in some plants the necessity, of a reserve motor is also taken into consideration.

All the difficulty, however, of selecting a motor lies not in the question of the power in connection with the reserve motor or the presupposed development of the produce, but in the selection of the type of motor.

The variety of motors offered by modern technics makes the choice of a type of motor sometimes a rather difficult problem. Besides the questions of a special character, connected with local conditions and peculiarities of the given plant, there comes up the question of a correct economic calculation of the working expenses.

In technical literature one is often warned against drawing up general formulæ and recipes, according to which, in a most simple manner, the suitability of this or that motor engine can be found. Nevertheless the attempt to generalise the data, which to a certain degree elucidate the above-mentioned questions, cannot be regarded as inexpedient.

At such factories—as some of the chemical fabrics, breweries, and saw-mills, where besides the motive power the engine-house has also to supply the caloric energy for the heating sources which serve for drying and other purposes—the question concerning the selection of a motor engine is solved simply in favour of the steam plant, and in these cases the problem of the economic calculation is considerably simplified.

In such cases where the power plant has to supply only the motive power, the circumstances resulting from local conditions and the character of production are most essential.

The reliability and simplicity of the work must be considered, the quantity of space occupied by the engine, the possibility of enlarging the output, rapid starting, the possibility of overloading and of the best adjustability, as well as the danger involved in different respects by the operation.

It is evident that the coexistence of all these conditions or even only of several in one motor is impossible, and the solution has always the character of a compromise, it being necessary at the same time to reckon with the working expenses of some one or other kind of plant.

When estimating the working expenses, there comes into relief the question of the uninterrupted or intermittent work of the motor, which greatly influences the correlation of the direct and indirect expenses in operation.

Turning now to the question of summing up the working expenses, we must note that the indirect expenses, which consist of the expenses in respect of depreciation of the plant and of the interest for the deduction of the capital expended on the plant. These are reckoned out in each separate case in accordance with the engine supplier's conditions of credit.

When choosing a motor it has to be decided first how many days in the year the mill will be working, whether it will run continuously day and night during the week, with a halt on Sunday, or work days only.

To define the efficiency of any particular motor one must reckon out : (1) the first cost, and (2) the working expenses.

In calculating the first cost one has to find out :

1. The price of ground occupied by the power plant.
2. The costs of the power plant and its outfit.
3. The costs of the motor and its setting, including the costs of the foundation, erection, and the trial starting.

The working expenses should be divided into two groups :

A. *Indirect Expenses,* consisting of the following classes :

1. Interest for the price of the site occupied by the power plant (4½ to 5 per cent.).
2. Interest on the capital spent on the building and full plant (4½ to 6 per cent.).
3. Depreciation of the building (2½ to 3 per cent.).
4. Depreciation of the plant (8 to 10 per cent.).
5. Insurance premium (2 to 2½ per cent.).
6. Repairs of the building (½ to ¾ per cent.).
7. Repairs and upkeep of the plant (1½ to 2 per cent.).

B. *Direct Expenses*

1. Cost of fuel.
2. Engineer and the rest of the staff attending the plant.
3. Expenses in lubrication and cleaning of the plant.

In this way knowing the costs of the plant and the working expenses, the efficiency of this or that motor may be defined.

The main expenditure for an engine plant is the cost of fuel. Therefore to decide upon the kind of motor for the projected mill, one must know the prices of different fuels. Further, one should inquire of the firms the price of motors and boilers suitable to the given locality; if a steam plant is in view, the price of foundation for a normal ground and outfit as well as the guaranteed expenses per hour-power. Having all these data in hand, it is easy to define what motor will be most advantageous, taking into consideration all direct and indirect expenses.

When testing the motor strictest attention should be paid that the guaranteed consumption of fuel is correct. For that purpose it is best to call in a disinterested expert, who will subject the motor to a trial and test its power and consumption of fuel per horse-power per hour.

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