MODEL STEAM LOCOMOTIVES

Their Details and Practical Construction

By

HENRY GREENLY,

Assoc. Inst. Loco. Eng.
Author of "Model Engineering"

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AUTHOR'S PREFACE

THE writer began his professional and journalistic work in connection with model locomotive engineering about the year 1900. His early book on Steam Models, published at a time when the making of a satisfactory working model had only just become general, has long been out of print, and may be considered to have performed a service to the model engineering craft in that it pointed out the likely methods of obtaining success.

In writing the present work, which aims at presenting a comprehensive survey of the whole subject, it has been possible to illustrate numerous types of locomotives by reproduced photographs of actual models, most of these models having been amateur-made. This fact alone shows the interest taken in the subject, and the author appreciates the compliment such model work pays to the many hundreds of designs prepared by him during the past twenty or thirty years for both home-workers and model-making firms.

The author has to thank all those model-makers who have sent him photographs of their work. He wishes also to mention his indebtedness to his friend, Mr. W. J. Bassett-Lowke, for several interesting pictures, and would like to place on record the valuable assistance rendered by his daughter Elenora in the preparation of the major portion of the finished drawings here reproduced.

Owing to the immensity of the subject and to the enormous amount of detail involved in the construction of a working model locomotive, it has not been possible to include many complete designs in this volume. The author possesses a large number of full-size blue-print diagrams of complete locomotives, which drawings can be used in conjunction with the components here illustrated and described. He can also be readily approached through the publishers.

Although there has been considerable increase in model locomotive work since this book was first issued, only minor corrections have been found necessary in the text of this edition. The principles of the steam locomotive remain the same in spite of all the progress made. This development is reflected mainly in the greater efficiency obtained in the recent L.M.S.R. " Royal Scot " and G.W.R. " King " type locomotives. Careful designing rather than revolutionary changes has so far been the rule, however. The poppet valve and cam reversing gear are on trial against the piston valve and Walschaert's motion. In the model world the writer designed for the late Count Zborowski his largest model, $\frac{1}{3}$rd scale Pacific engines which are now operating quite successfully on the Romney, Hythe, and Dymchurch 15-inch gauge railway, a line which the writer has recently equipped throughout.

H. G.

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Model Steam Locomotives

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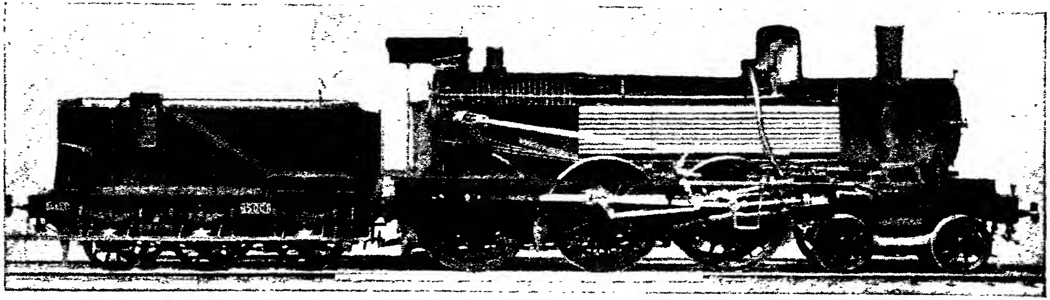
Introduction. — The model locomotive is the most popular of all working miniatures. This is due to the interest displayed in the locomotive itself, and also to the fact that this type of prime mover is self contained ; it includes the machinery for converting the heat of the fuel into useful work, and carries with it the necessary generator, fuel and water.

Model engineers approach the construction of a model locomotive from different points of view. Some do not look to the completion and running of the engine so much as to the pleasure that will be derived from the making and assembling of the parts and in the appearance of the finished machine. Others prefer to see a model locomotive at work. As in real practice, the labour of construction should be a means to an end. Endeavour should be made to obtain the maximum power on the given gauge, and there is no need to follow any particular prototype, so long as the exterior design is one which would be reasonable in real practice.

The beginner in model locomotive work should not be too ambitious. In preference to selecting at the outset an elaborate design, he should adopt one of a simple nature.



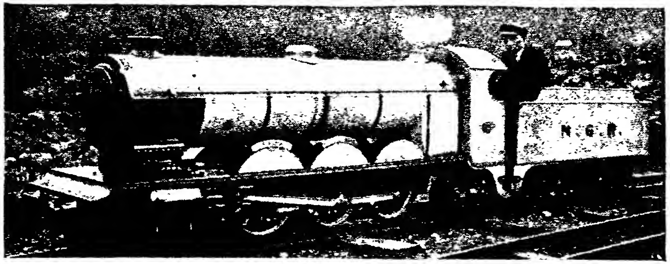


Fig. 1 (above).—An Exhibition Model in Section, made to a scale of 1·2 in. to 1 ft.

Fig. 2 (below).—Eskdale Light Railway Model Pacific Engine.

Choice of Scale and Gauge

The history of the working model locomotive, as it is now understood, would be difficult to trace. No doubt ever since the inception of the steam locomotive, models have been made and treasured. Among miniature locomotives of note made in the early days of the "iron road" there are but few successful examples.

Scale replicas can be made to serve historical purposes, and are made either in full or partly in section.

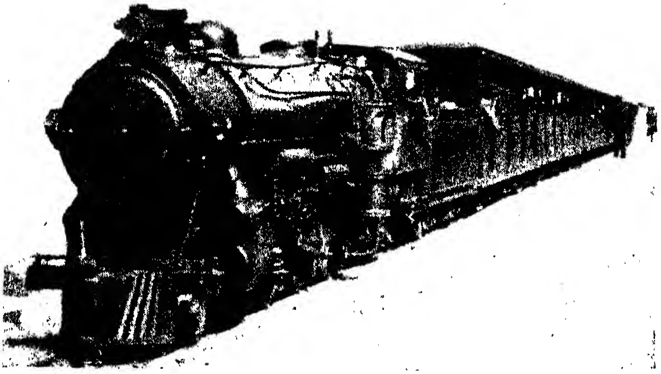


Fig. 3.—The Largest American Model Locomotive: One-third Full-size Pacific Engine.

Museums and private collections all over the world contain large numbers of models. These models are, however, not within the scope of this work. They are usually made without any regard to cost by skilled workmen from the working drawings of the original.

The Choice of Scale and Gauge.—The sizes of the model locomotives with which it is proposed to deal in this book will to a certain extent be limited to those built for amusement. The larger sizes are of such proportions

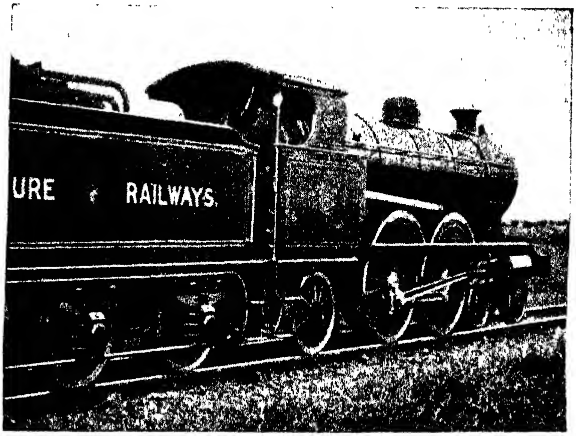


Fig. 4.—The "Little Giant" 15-in. Gauge Express Locomotive.

Fig. 5.—Another American Model with Staff.

as to render the finished machines capable of really useful work for exhibition and estate purposes.

Some years ago Sir Arthur Heywood built a miniature railway, of 1 ft. 3 in. gauge, for the Duke of Westminster's estate at Eaton Hall. This not only served to interest the visitors to his house, but proved a commercial success, connecting the Hall with the neighbouring main line of railway, and saving a considerable amount of the previous annual expense of carting coals and supplies. The 3-in. scale express engine, such as designed by the writer for pleasure park railways, are amongst the largest model locomotives made, and are capable of duties up to a hundred miles a day, with an average load of 50 passengers. One engine—that at Rhyl, Marine Park—ran 6,800 miles the first season without any overhauling, and carried 120,000 passengers, on a track one mile in length, and after eight years is still in service. The capacity of a 2-in. scale locomotive is, of course, much less, but a tank engine of this size has hauled, over a track one fur-

Fig. 6.—⅛th Scale Model G.C.R. Engine (Sir Aubrey Brocklebank Driving).

long in length, 3,000 passengers in a day of 10 hours. The 2-in. scale engine is the largest size recommended for amateur construction. The gauge is a safe one, and engines of this size are easy to handle. Speeds up to 15 miles an hour can be obtained without trouble, and suitable track materials are procurable. Where the curves must be reduced to below 50 ft. radius a 1½-in. scale locomotive must, under ordinary circumstances, be adopted. The standard gauge for this scale is 7¼ in., and many

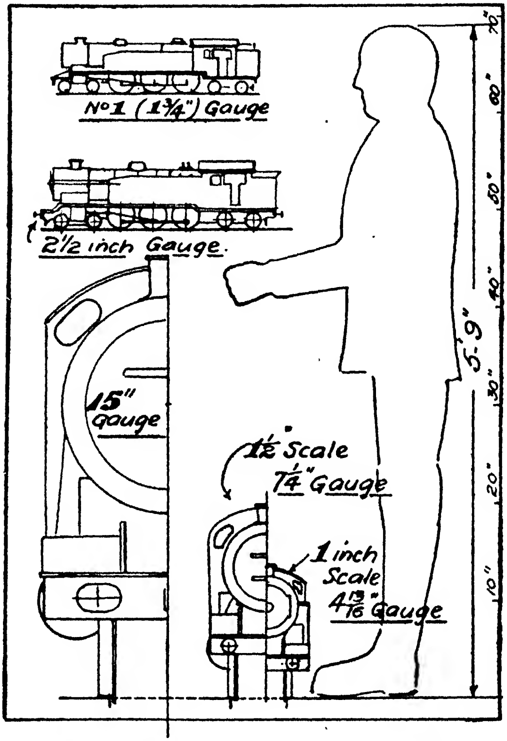


Fig. 7.—Relative Sizes of Standard Gauge Working Models.

highly successful engines of all types have been built to run on it.

Although it is quite possible to make a good working model steam locomotive with an internally fired boiler with the 1¾ in. gauge, the smallest size which is at present recognised as generally successful is the 2½-in. gauge ½-in. scale engine. Even on this gauge the prototype chosen should provide a boiler of large diameter, 3 in. outside being the minimum.

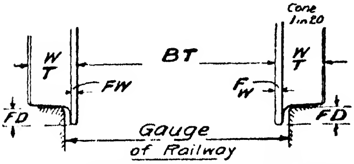


Fig. 8.—Wheel and Tyre Dimensions. (*See* Table II.)

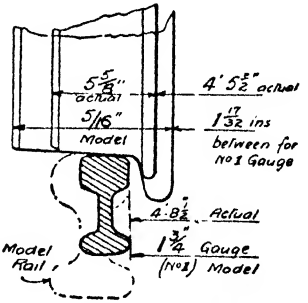


Fig. 9.—Real and Model Tyres to Same Scale.

Gauges are now standardised—except, perhaps, for 1¼-in. scale engines—and the table given in Table I provides useful and important particulars in each size. The photographic reproductions (Figs. 1 to 6) are representative scale model locomotives. The diagram, Fig. 8, is a key to the wheel and rail dimensions, which have been, by the efforts of the writer, accepted as standards. Those which refer to flange and tyre dimensions are not scale replicas of the original.

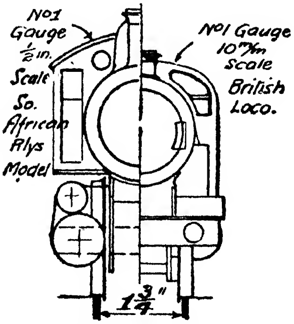


Fig. 10.—Comparison of Two No. 1 Gauge Models.

The impossibility of such a course is graphically demonstrated by the diagram, Fig. 9, which depicts to the same scale, a full-size and a working-model wheel tyre superimposed on one another.

There is a tendency among many model locomotive builders to increase the loading gauge (see Figs. 10 and 11) to that of the American and Continental dimensions. There is no objection to this where the engines are modelled on "free-lance" lines. Another method of obtaining a large engine on a given gauge is to adopt the Colonial standard 3 ft. 6 in. gauge, which has a loading gauge of 12 ft. 10 in. by 8 ft. 9 in.

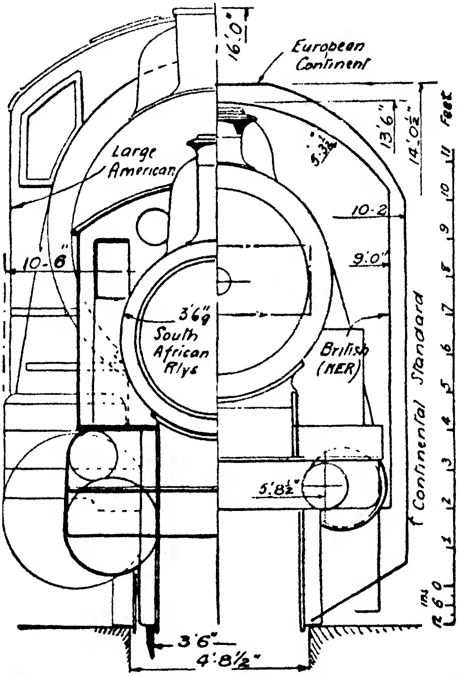


Fig. 11.—Loading Gauges of Various Countries.

TABLE I

Scale	Rail Gauge	Tonnage Coefficient	Radius of Curve		Speed Av. Max.	Weights of Average Passenger		Boiler	Fuel	British Loading Gauge
			Min.	Average		Loco.	Train			
			ft. in.	ft. in.	m.p.h.	lb.	lb.			
10 m/m	1¾ in. (45 m/m)	13	3 6	4 6	3	8½	18	Plain or water tube	Spirit	90 × 135 m/m
11¼ m/m ($\frac{7}{16}$ in)	2 in.	7	4 0	6 0	4	14¼	30	" "	"	99 × 149 m/m
½ in. ($\frac{17}{32}$ or 13·5 m/m)	2½ in.	5·41	5 0	7 ft. to 10 ft.	5	19	40	" "	Spirit, charcoal, petrol	4¾ in. × 7¼ in.
$\frac{11}{16}$ in.	3¼ in.	2·4	8 6	13 0	6	45	100	Water tube or loco type	"	6¼ in. × 9¼ in.
¾ in.	$3\frac{17}{32}$ in.	1·82	10 0	16 0	7	60	150	Loco-type	Charcoal or coal	6¾ in. × 10⅛ in.
1 in.	$4\frac{13}{16}$ in.	·775	15 0	25 0	9	120	300	" "	Coal and coke	9⅛ in. × 13½ in.
1¼ in.	6 in. to 6½ in.	—	20 0	30 0	10	190	500	" "	"	11¼ in. × 17 in.
1½ in.	7¼ in.	·228	35 0	60 0	12	450	1,200	" "	"	13½ in. × 20¼ in.
2 in.	$9\frac{9}{16}$ in.	·096	50 0	80 0	15	980	1½ tons	" "	"	18¼ in. × 26 in.
3 in.	15 in.	$\frac{1}{64}$th to $\frac{1}{50}$th	80 0	120 0	25	33 cwt.	4½ "	" "	"	2 ft. 3 in. × 3 ft. 4½ in.
3·25 in.			100 0	150 0	30	42 "	7 "	" "	"	2 ft. 6 in. × 3 ft. 8 in.
4 in.		$\frac{1}{27}$th	200 0	500 0		35 "	8 "	" "	"	3 ft. 1 in. × 4 ft. 5¾ in.

Tonnage Coefficient.—These figures give the scale equivalent of the tons actual of the prototype. For example, every pound avoirdupois of the model multiplied by the coefficient = scale tons. In 2½ in. gauge a 19 lb. model = 19 × 5·41 = 102 scale tons.

Curves.—The minimum radius may be used for points, sidings and curves on slow-speed lines; for fast running use the average radius as the minimum.

Loading Gauge.—Where the American loading gauge is desired, use a scale equivalent of 10 ft. wide × 15 ft. When the latter is adopted solid-fuel boilers may be employed for engines of smaller gauge than that stated above: the same remark applies to models of narrow gauge (Cape Govt. Rly.) locomotives.

Where it is desired to build an engine of the smallest possible size to haul a passenger, it is better to build a model of a *small* type of engine to a large scale. For instance, a 1½-in. scale model of, say, an old Brighton or L.N.W.R. single, or even one of the G.W.R. broad-gauge engines, would give much more satisfaction than an inch scale model of a huge Pacific-type engine. The cost, weight and nominal power would be about equal, but the gauge of the 1½ in. engine would be safer and more comfortable for driver and passenger. In addition, the larger engine would give much less trouble in the matter of steam-raising and in the attention required.

TABLE II

Railway Wheel and Tyre Dimensions

Gauge	*BT*	*WT*	*FD*	*FW*
No. 0 ($1\frac{1}{4}$ in.)	27·5 m/m	7 m/m	2·25 m/m	1 m/m
No. 1 ($1\frac{3}{4}$ in.)	39·75 m/m	7 m/m	2·5 m/m	1·25 m/m
No. 2 (2 in.)	45·5 m/m	7·5 m/m	2·5 m/m	1·25 m/m
$2\frac{1}{2}$ in. Gauge	$2\frac{9}{32}$ in.	$\frac{5}{16}$ in.	$\frac{7}{64}$ in.	$\frac{3}{64}$ in.
$3\frac{1}{4}$ in. „	$3\frac{1}{32}$ in.	$\frac{3}{8}$ in.	$\frac{9}{64}$ in.	$\frac{1}{20}$ in.
$3\frac{1}{2}$ in. „	$3\frac{9}{32}$ in.	$\frac{13}{32}$ in.	$\frac{9}{64}$ in.	$\frac{1}{20}$ in.
$4\frac{13}{16}$ in. „	$4\frac{1}{2}$ in.	$\frac{9}{16}$ in.	$\frac{5}{32}$ in.	$\frac{5}{64}$ in.
$7\frac{1}{4}$ in. „	$6\frac{3}{4}$ in.	$\frac{13}{16}$ in.	$\frac{3}{16}$ in.	$\frac{1}{8}$ in.
$9\frac{1}{2}$ in. „	9 in.	$1\frac{1}{16}$ in.	$\frac{1}{4}$ in.	$\frac{9}{64}$ in.
15 in. „ (scale model)	14 in.	$1\frac{7}{8}$ in.	$\frac{1}{3}$ in.	$\frac{11}{32}$ in.
15 in. „ (heavy types)	$13\frac{3}{4}$ in.	$2\frac{1}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{16}$ in.

Note : Rails may be laid over-gauge on sharp curves to an amount equal to FW.

CHAPTER II

Locomotive Types

The model locomotive builder, before he commences the preparation of the working drawings for his proposed engine, should acquaint himself with leading features of the numerous types of locomotives in general use. Even though he has decided on a particular design he should consider carefully the advantages and disadvantages of the chosen design when reproduced to the scale he has adopted for his railway. The half tones and drawings (Figs. 12 to 46) of actual working models, together with the brief descriptive notes on each class, are intended to assist the reader in this direction. Where a photograph has not been obtainable a diagram is employed to illustrate the characteristics of the type.

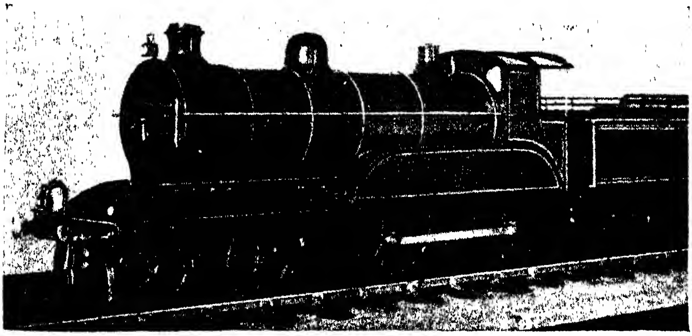


Fig. 12.—4—4—0 Model Express Locomotive.

Types of Locomotives.—Locomotives may be classed generally under two heads:

TENDER ENGINES, which have a separate carriage for fuel and water, and

TANK ENGINES, which are self-contained locomotives with water tank and fuel bunkers all placed on the one frame.

Tender engines are used for long distance trains and tank engines for local passenger, goods and shunting purposes. Of late years large "tanks" for fast passenger-train working have come into vogue.

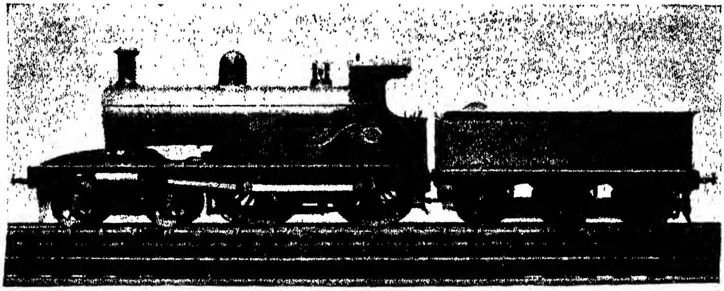


Fig. 13.—Model 3½-in. Gauge L.S.W.R. 4—4—0 Locomotive.

There are subdivisions in each class, made according to the work for which they are designed. The American method of classifying by the arrangement of the wheel base has latterly come into more general use. The illustrated Table No. III (p. 34) gives particulars of most existing types and the names by which some of the classes are also known, independently of their numerical classification. The centre figures in the notation system indicate the coupled wheels, and those at each end the carrying or bogie wheels. Where no small carrying wheels are present an "O" signifies their absence. The notation presumes that the locomotives have the usual tender unless the suffix "tank" or "T" is employed to denote that they are tank engines.

The 4—4—0 Type.—In England the favourite type of express engine is the four-coupled bogie, or 4—4—0 type locomotive, which, by the way, is termed in America the "American type" locomotive. The latter name, however, presumes the use of outside cylinders. Fig. 12 illustrates a model of a typical example of British practice. The cylinders and frames are inside. A variation of the design is seen in the outside cylinder engine No. 593, used

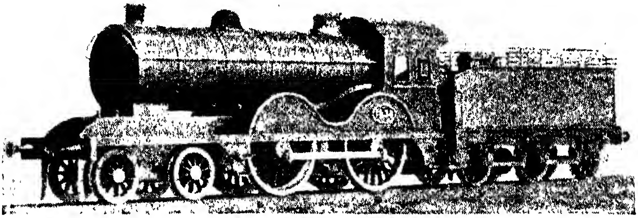


Fig. 14.—Model 4—4—0 N.E.R. Engine.

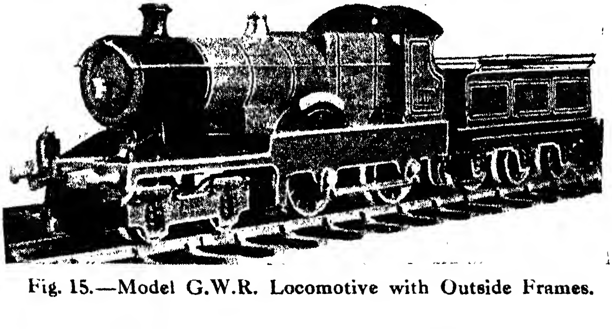


Fig. 15.—Model G.W.R. Locomotive with Outside Frames.

on the L.S.W.R. and illustrated in Fig. 13, the American version of which was shown in the previous chapter, in Fig. 5.

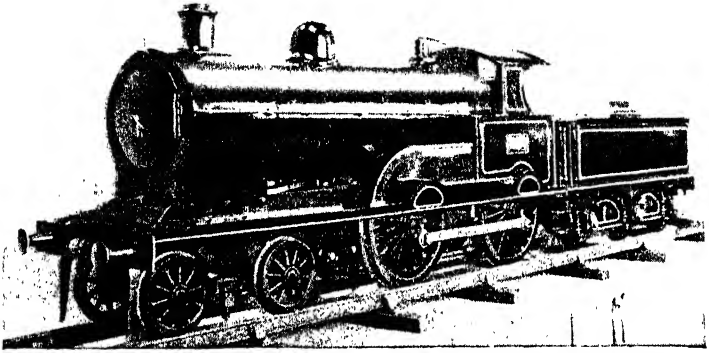


Fig. 16.—Modern L.N.W.R. 4—4—0 Locomotive ("George V").

The chief objection to the 4—4—0 type is that the length of the firebox is often limited by the distance between the coupled wheels. This objection is not so weighty in the case of small models in which oil or spirit firing is usually adopted as in larger engines where a deep firebox for burning solid fuel is essential.

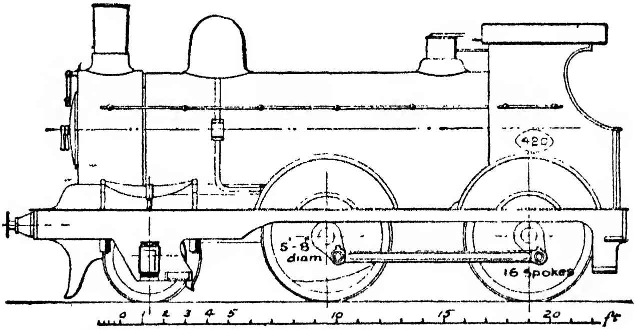


Fig. 17.—Diagram of G.E.R. 2—4—0 Locomotive.

The smaller model may be provided with a shallow firebox which can be extended backwards well over the trailing axle. However, if a prototype which has a coupled wheel base of over 9ft. is modelled no trouble will ensue, more particularly if the cylinders are placed outside and the consequent absence of a crank axle enables a slightly longer firebox than is otherwise possible to be employed. Further, if a high-pitched boiler and moderate-diameter wheels are used an inclined grate will entirely get over the difficulty.

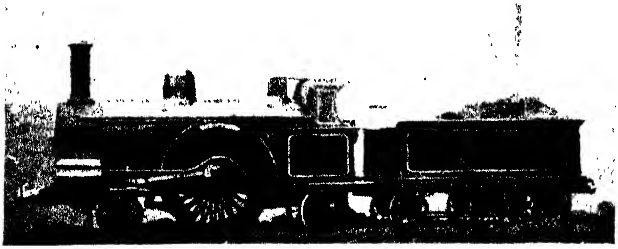
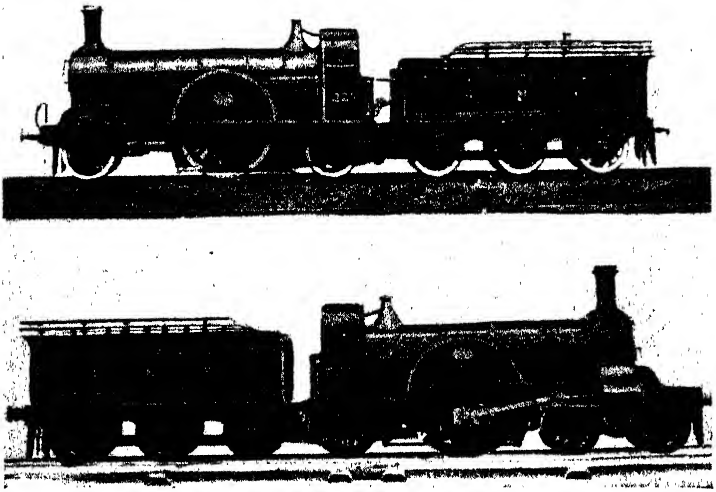


Fig. 18.—Model of the Famous L.N.W.R. "Lady of the Lake."

Another drawback to the type is that the bogie wheels are often, in many British examples especially, of large diameter, and if modelled to scale reduce the flexibility of the wheel base. If, as in the N.E.R. engine illustrated in Fig. 14, the bogie wheels are small and the frames are cut away over these wheels, this trouble to a great extent disappears.

Outside cylinder engines which drive on to the first pair of coupled wheels are usually arranged, as in the L.S.W.R. engine No. 593, with the connecting rod inside the coupling rod. This throws the crosshead very close to the tyre of the trailing wheel of the bogie and seriously limits the lateral play required on curves. It is therefore recommended in such cases that in the model the "big end" be connected to the crank pin outside the coupling rod, the centres of the cylinders being extended to suit. This will increase the clearance between the crosshead and the bogie wheel.

Outside-framed, or rather double-framed, engines, as used on the G.W.R. (see Fig. 15), have no advantages over single-framed locomotives unless, as is only to be recommended in smaller models, the inside frames are eliminated altogether or considerably modified in outline.



Figs. 19 and 20.—Two ½ in. Scale Models of Old G.N.R. Single Locomotives.

The Four-coupled Six-wheeler. — The four-coupled bogie engine was the outcome of an older and still more English type of locomotive, the 2—4—0 type, as largely used on the G.E. (Fig. 17) and L.N.W. railways. No advantages can accrue in the matter of flexibility by the copying of this type. However, a fair amount of lateral play may be provided if cylinders with valves on top are employed, and a model locomotive so arranged should be quite as free on a sharp curve as a bogie engine, but would not, perhaps, be quite so steady. In real practice many such engines have leading radial trucks with fairly stiff side controlling springs. Except in locomotives of this type having small driving wheels—known sometimes as "mixed traffic" engines—a long, deep grate is not practicable.

A firegrate which slopes to the forward end may also be used with advantage in these engines, the back end extending over the trailing axle as already mentioned.

The Six-wheeler-single Type.—The day of the single-wheeled express locomotive is past. However, in model work very good results can be obtained from such engines, as the weight which may be placed on the driving axle is not limited by considerations of rail strength. The engine depicted in Fig. 18 is a model of a six-wheeled single, designed by Mr. J. Ramsbottom for the L.N.W.R. Simplicity in construction is perhaps its only feature from a model-maker's point of view. It is a suitable locomotive to model where the builder desires, for reasons of safety and comfort, not only the largest gauge, but, to reduce cost and labour, the smallest possible engine. A 1½ in. or 2 in. scale model, built on the lines of this engine, would be little larger or heavier than a model of a modern 4—6—0 built to a scale of 1 in. to the foot, and would probably prove much less expensive.

In all singles the firebox is more or less unlimited in length and depth. Of course the driving wheels, where they are large in diameter, limit the size of the boiler barrel, but the recent rebuilds of the G.C.R. and G.W.R.

7 ft. 8 in. singles, with their high-pitched boilers, show what can be done in the direction of increasing the boiler power of a single.

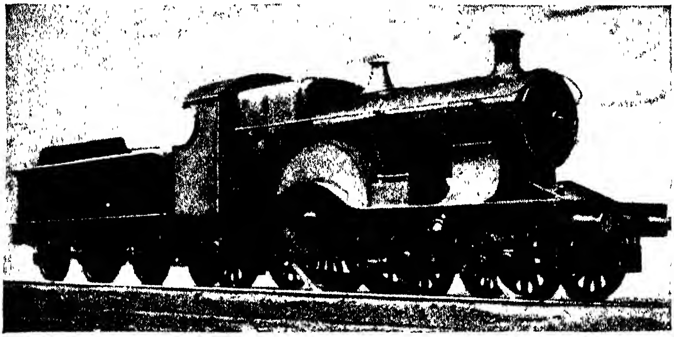


Fig. 21.—The G.W.R. Bogie Singles.

The 4—2—2 Type.—The model of the G.N.R. single (Fig. 20) shows a type of 4—2—2 engine fitted with driving wheels of the largest dimensions used in recent years, that

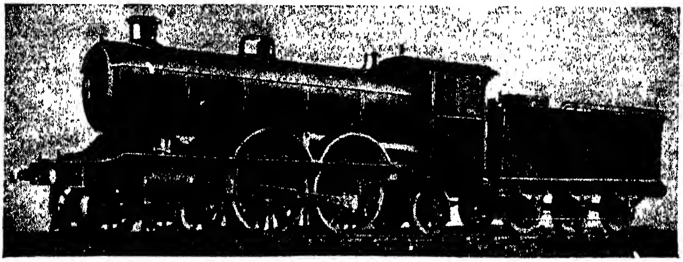


Fig. 22.—Atlantic 3½ in. Gauge Model Locomotive.

is to say, 8 ft. 1 in. diameter on tread. The boiler is, of course, limited in all directions except in length of firebox, and in this particular example the trailing wheel of the front bogie has very little lateral play owing to the close proximity of the crosshead and slide bars. In a model the cylinders should be placed a little wider apart than in the prototype. The lower piston speed of such a large wheeled engine has to be considered, and if this G.N.R. locomotive is modelled, high-pressure comparatively small-bore cylinders, and efficient superheating are advisable. The previous remarks may be applied to the other "single" models illustrated in Figs. 19 and 21.

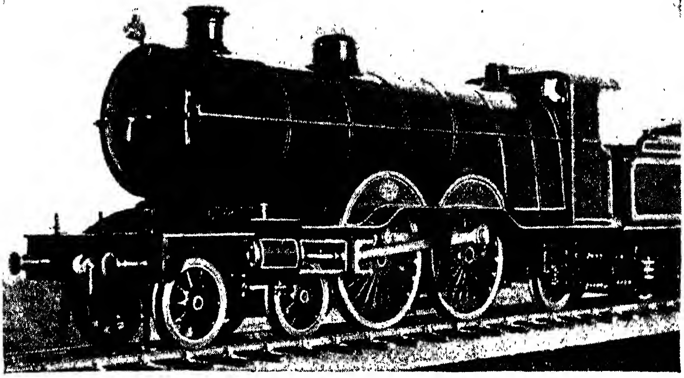


Fig. 23.—Model of the G.N.R. Large Atlantic Type.

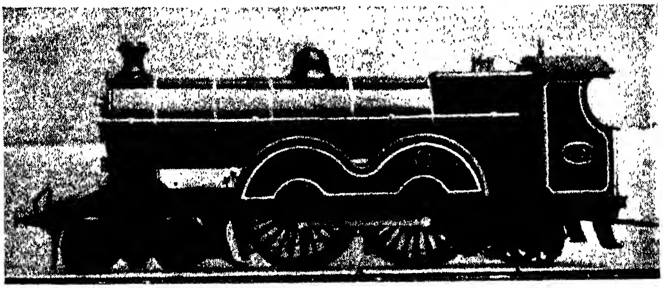


Fig. 24.—Model L.Y.R. 4—4—2 Locomotive.

The 4—4—2 Type.—For fast trains the later develop-

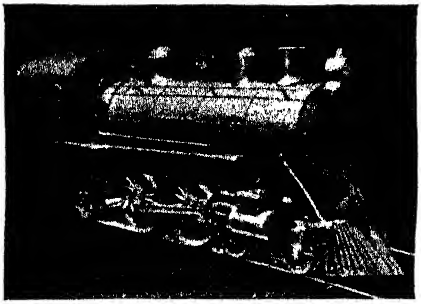


Fig. 25.—Model of one of the Original American Atlantics.

ments of locomotive engineering have produced the "Atlantic," or 4—4—2, type machines. The "Atlantic" has many of the advantages of the bogie single express engine. The rigidity of the coupled-wheel base is a negligible quantity; the firebox may be of great length, or, as in the case of the G.N.R. No. 251 class, a wide firebox (Wootten type) can be fitted over the trailing carrying wheels. Indeed, the "Atlantic" may be considered as a development of the 4—2—2 type, and the coupled wheels being of moderate diameter, the great drawback of the single wheeler disappears.

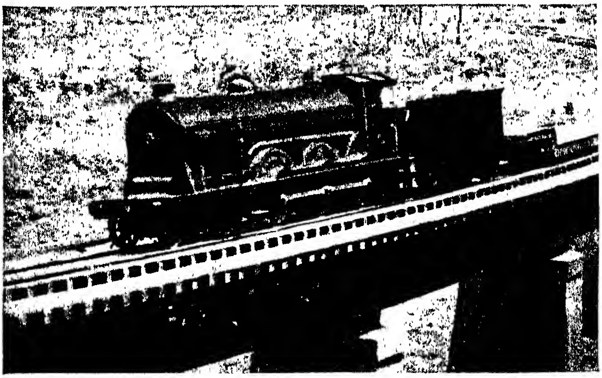


Fig. 26.—Model 7¼ in. Gauge Locomotive "Cardean" (Caledonian Railway).

The L.Y.R. 4—4—2.—The English modification of the true "Atlantic," as exemplified in the L.Y.R. 4—4—2 engines (see Fig. 24), increases both the wheel base and the length of the boiler barrel, and thus does not assist modelling.

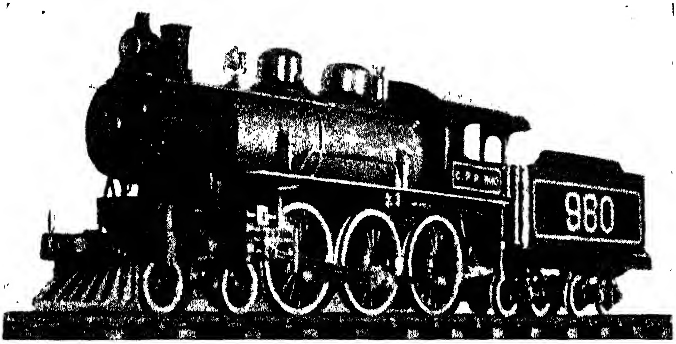


Fig. 27.—American Model 4—6—0 Locomotive.

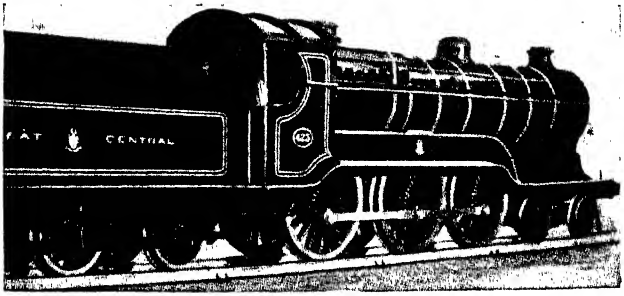


Fig. 28.—Model G.C.R. "Sir Sam Fay" 2½ in. Gauge Locomotive.

The 4—6—0 Type.—The 4—6—0 type locomotive is well represented on English railways. Both the outside and inside cylinder classes are the outcome of a desire for more adhesion and greater heating surface than the 4—4—0

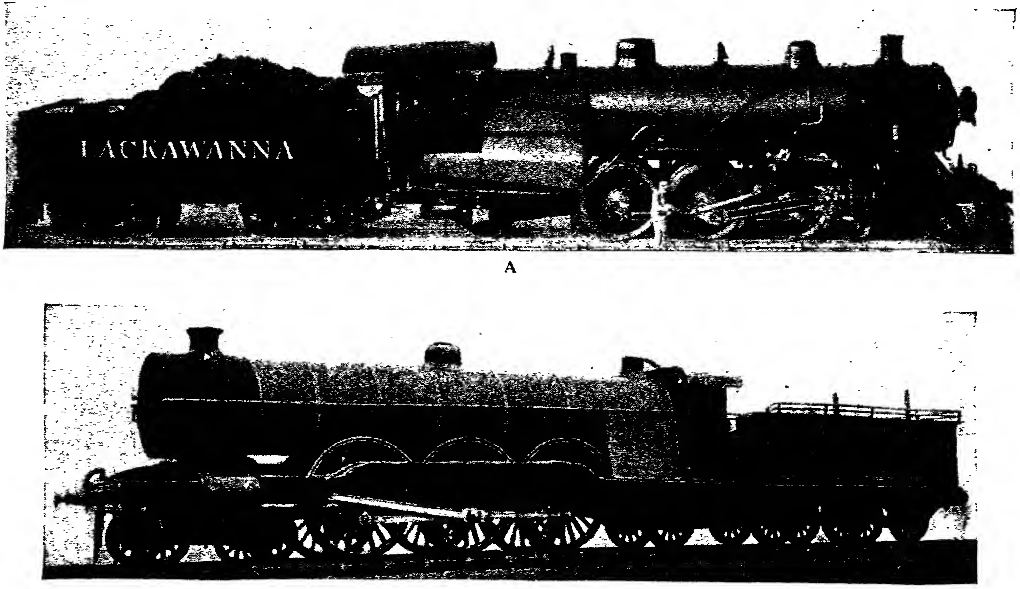


Fig. 29.—Model Pacific Engines: A, American; B, British.

type provides. In the former class the extra coupled wheel is placed between the bogie and the driving wheel, and to reduce the rigid wheel base the trailing coupling rod may

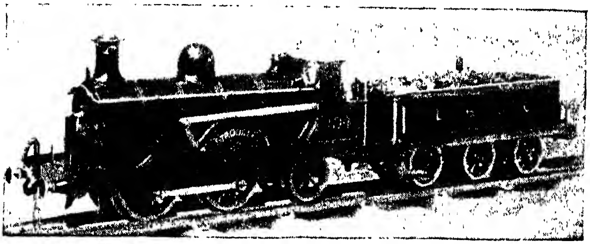


Fig. 30.—Model of the 0—4—2 L.B.S.C.R. Locomotive "Gladstone"

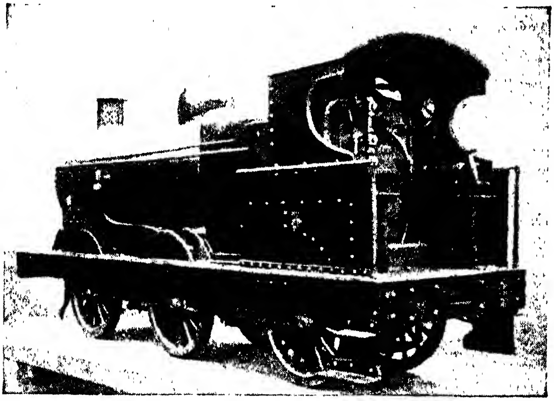


Fig. 31.—Model of a Standard British 0—6—0 Goods Locomotive.

be shortened if small wheels are used. In the inside cylinder class the front end is unchanged, three pairs of coupled axles being used instead of two. In both classes a shallow grate is an essential feature, particularly in the case of express engines with large driving wheels. The

4—6—0 type is therefore at a disadvantage in large scale examples, where it is essential that a coal-fired boiler should be employed. Small-gauge models of the Caledonian and G.C.R. "Sir Sam Fay" types are preferable to engines with the outside cylinder arrangement (see Fig. 6), so long as the front bogie can be provided with ample traversing movement. The mechanism is well forward in these engines, and a long firebox, with a large number of methylated-spirit wicks or elongated or duplicated oil burners, may be fitted. The water-tube boiler is the most suitable generator for this reason.

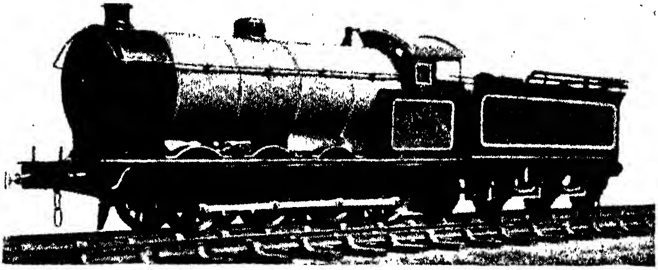


Fig. 32.—An Eight-coupled Goods Locomotive.

Fig. 33.—Model 7¼-in. Gauge "Mogul" Goods Locomotive.

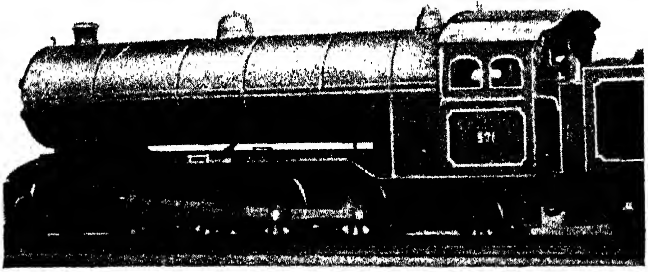


Fig. 34.—Model 2—8—2 Goods Locomotive.

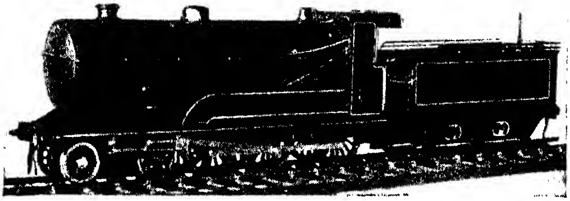


Fig. 35.—A "Fast Goods" 4—6—0 Locomotive.

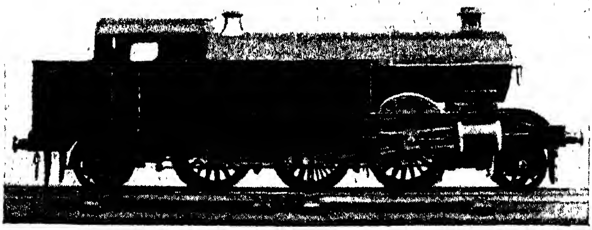


Fig. 35A.—Model British 2—6—2 Locomotive.

C

The 4—6—2 Type.—The "Pacific," or 4—6—2 type locomotive, as exemplified by the G.W.R. "Great Bear," has all the characteristics of an "Atlantic" locomotive. The additional pair of coupled wheels are usually placed behind the driving wheels. Under ordinary circumstances the type should only be adopted where the curves of the railway are of ample radii, and comparatively small driving wheels are an advantage unless the massive proportions

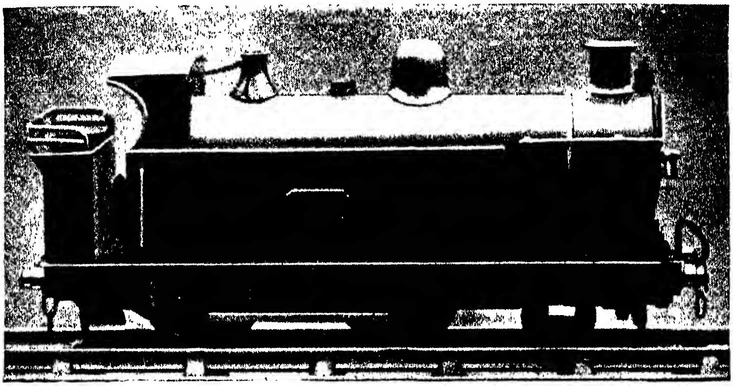


Fig. 36.—Model 1¼ in. Gauge 2—4—0 Locomotive.

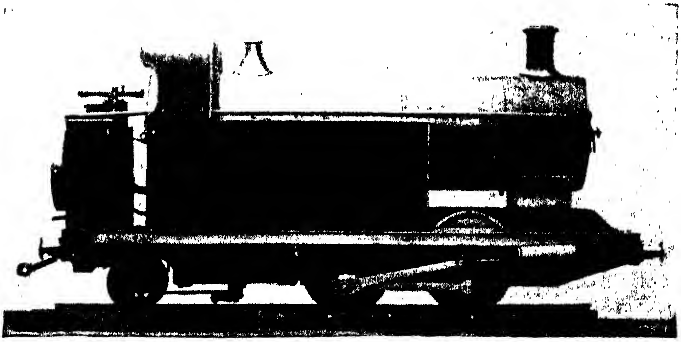


Fig. 37.—Powerful Coal-fired 0—4—2 Locomotive.

of a modern American engine can be copied. While the increased length of boiler barrel certainly adds to the capacity and length of run, a proportionate degree of added evaporative power must not be expected from the longer tubes. A model based on the G.W.R. "Great Bear" must also not be expected to make a satisfactory locomotive if fitted with a water-tube boiler and a short, wide firebox. As in the case of the 4—6—0 type, a long firebox is to be desired, which feature the "Great Bear" does not provide.

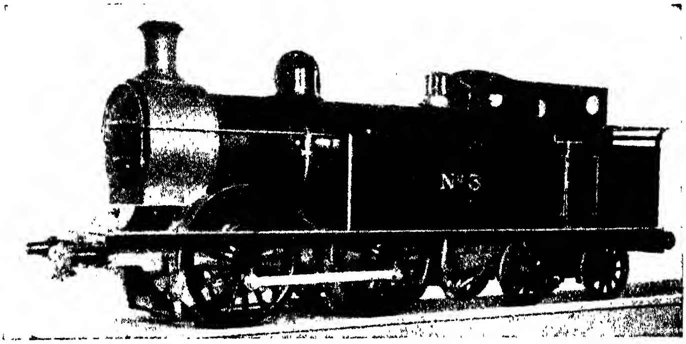


Fig. 38.—Model 0—4—4 Suburban Traffic Tank Engine.

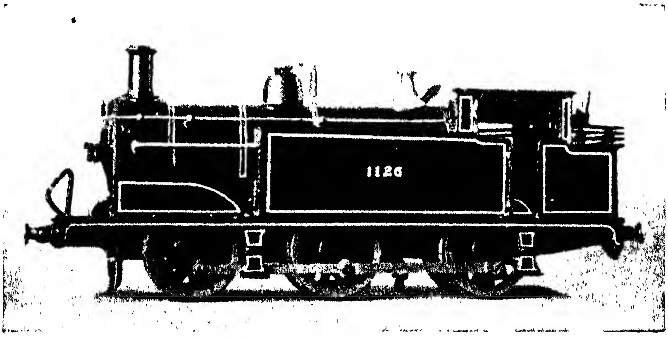


Fig. 39.—Six-coupled Engine Built by Mr. A. F. Brough.

Obsolete Types.—There are several types of engines still running on British railways which may be considered as obsolete, but which have some good points. The "front coupled" engines on the L.B.S.C.R. and L.S.W.R. (Fig. 30) are types of such engines, and have all the good points of the single engine in the matter of firebox design without the drawbacks of the large wheel.

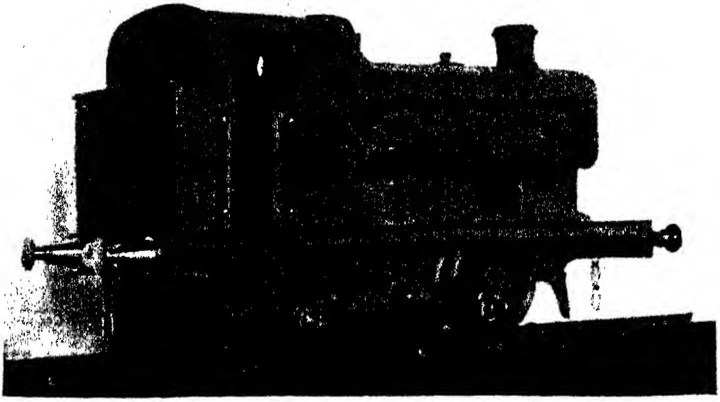


Fig. 40.—Shunting Tank Locomotive.

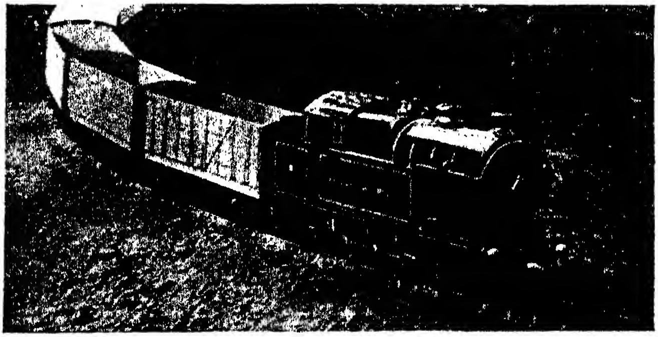


Fig. 41.—Model 0—8—2 L.Y.R. Locomotive.

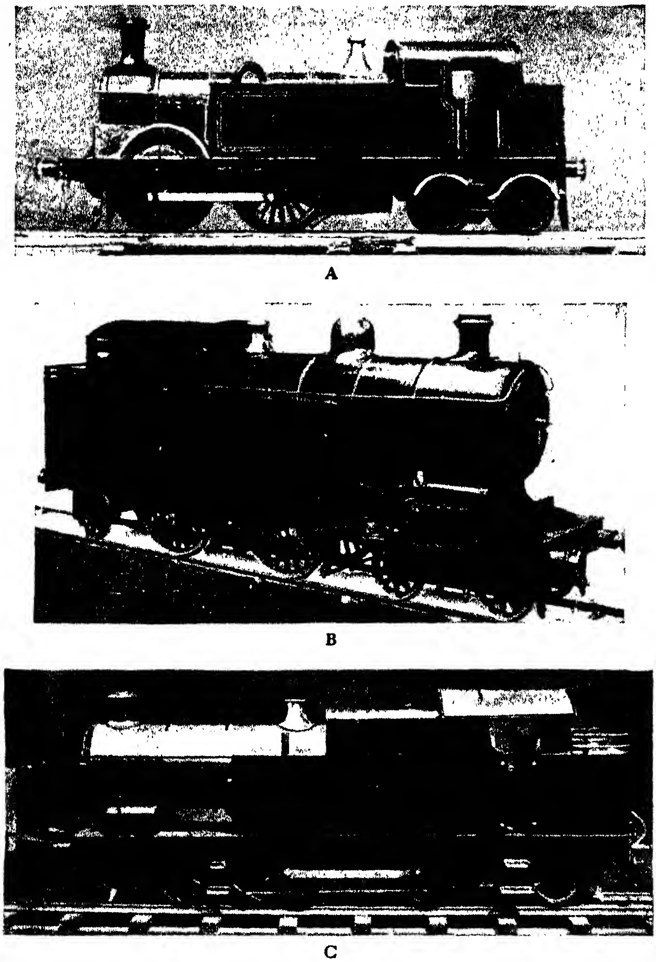


Fig. 42.—A, G.N.R. 0—4—4 Model Locomotive made by Mr. Kenneth Leech; B, Model 4—4—2 Locomotive made by Mr. G. W. Vickerage; C, Model G.W.R. 2—4—2 Locomotive made by Mr. E. Brough-Hughes.

Goods Locomotives.—Several types of these are illustrated in the half tones Figs. 31 to 35. The 0—6—0 and 0—8—0 type tender goods engines make excellent working models. Further, the inside cylinder 0—6—0 locomotive lends itself to modelling as a single cylinder engine. The relatively small size of the coupled wheels creates no difficulty at the trailing ends in respect to the firebox. In a six-coupled engine the centre pair of wheels should have thin flanges (or none at all for a model railway with very sharp curves), while the eight-coupled may have flangeless tyres on second pairs of wheels and the trailing wheels arranged with plenty of side play.

The 2—6—0 Type.—Recent years have seen the revival of the "Mogul" engine on British railways. The latest example of 2—6—0 on the G.N.R. is a first-class prototype for a model up to the point where the limitations of the narrow firebox are felt. In the case of the 2—6—0 with outside cylinders a much more flexible engine than the standard 0—6—0 can be obtained with very little extra labour. With a 2—8—0 type the first and third axles may be rigid, while the second and fourth coupled wheels may be provided with blind tyres and side play respectively.

The 2—6—2 Type.—The 2—6—2 type tender engines have been used in America. They offer certain advantages in model work, but are hardly elegant types when modelled on the lines of British practice. A very fine engine of this type made to suit the standard 1¾ in. gauge by a friend of the author's was designed in the American style. This locomotive is also remarkable for being the first *solid fuel* model built in this very small size. It proved highly successful on test as well as in external appearance. A tank engine built with this 2—6—2 type wheelbase designed by Mr. Kenneth Leech is illustrated in Fig. 35A.

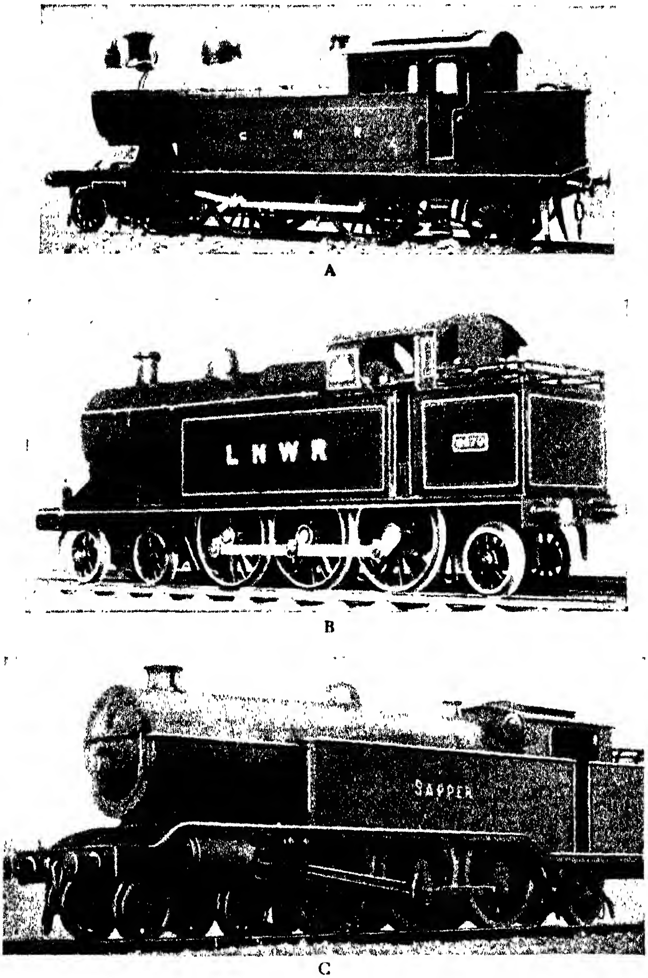


Fig. 43.—A, Four-coupled Engine built to Author's Design; B, Model L.N.W.R. Inside Cylinder, 4—6—2 Locomotive; C, Model L.B.S.C.R. 4—6—2 Locomotive with Outside Cylinders, made by Sergt. H. S. Holman, R.E.

Tank Locomotives.—Tank locomotives are a very general class on railways in this country, and of late years have been made in proportions capable of handling long distance express trains. The wheels, boiler and cylinder arrangements are often interchangeable with types of tender engines; indeed, many large tank engines are simply tender engines with an extra pair or two pairs of wheels placed astern, and the frames arranged to carry side water tanks and a coal bunker.

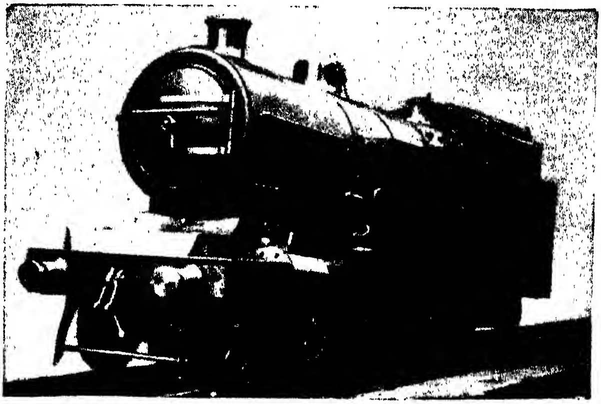


Fig. 44.—A 1 in. Scale 4—6—2 Fast Passenger Tank Locomotive.

A simple type of tank engine with the 2—4—0 wheel arrangement is shown in Fig. 36. It is to all intents and purposes a small version of a 2—4—0 tender engine with side tanks and a lengthened frame to carry a back bunker. Similar engines of the 4—4—0 type are in existence.

The advantage of a tank engine in a model is that the whole engine is self contained. No difficulties are met with in regard to the pipes conducting water and fuel to the engine, which in a tender locomotive must be made flexible between engine and tender. The use of a closed cab, however, introduces some drawbacks in firing a solid fuel model. A removable cab roof or back plate is usually found to be the best solution to this difficulty.

One interesting and useful type of tank engine is the front coupled engine. As exemplified in the 0—4—2 machine (Fig. 37), the smallest amount of work is involved in comparison with the power obtained. It can therefore be well recommended as a large-scale garden-railway model where first cost and time in construction are to be saved. Such a model in 7¼ in. or 9½ in. gauge is only a few feet long, and can be driven with ease from a following truck. A large garden is sufficient to accommodate a continuous railway. A development of this front-coupled type of tank locomotive, viz. the 0—4—4 engine, is a great favourite on British railways for local passenger service, and a model is illustrated in Fig. 38. It has the advantage over the smaller front-coupled engine

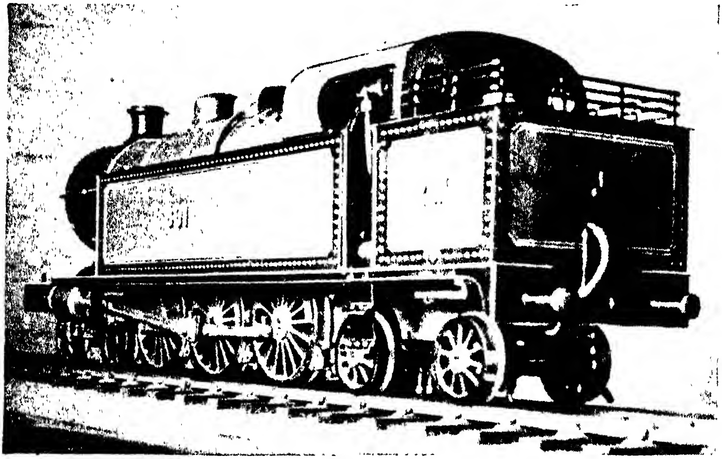
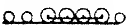


Fig. 45.—Model 4—6—4 "Baltic"-Tank Locomotive.

(Fig. 37) in that the bunker is larger, and should therefore be adopted in preference for smaller gauges. The 2—4—2 type engine is quite as good as the 0—4—4, but suffers in the matter of limitations of firebox equally with the 4—4—0 tender engine. The same applies to the 4—4—2 model. However, in tank engines the driving wheels are usually of reduced diameter, and the firebox can therefore be extended backwards over the trailing coupled axle.

TABLE III

Classifying Notation of Locomotives

	0—4—0	Usually Tank Engine.
	0—4—2	Mixed Traffic or Tank.
	0—4—4	Suburban Tank.
	2—2—2	Six-wheeled Single.
	4—2—2	Bogie Single.
	2—4—0	Old Express Locomotives.
	4—4—0	Four-coupled Bogie.
	4—6—0	Six-coupled Bogie.
	4—6—2	"Pacific" Type.
	4—4—2	"Atlantic" Type.
	0—6—0	British Goods or Tank.
	0—8—0	British Eight-coupled Goods.
	2—6—0	'Mogul" Goods.
	2—8—0	"Consolidation" Goods.
	2—10—0	" Decapod" Goods.
	2—8—2	Goods or Tank.
	0—6—2	Usually Goods Tank.
	2—6—4	Usually Tank Engines.
	4—8—2	Heavy Goods.

Other Types.—The characteristics of the 0—6—2 and 0—8—2 tank engines are those of the six-coupled and eight-coupled tender goods engines. The bunker room on such engines is usually ample.

Although it is not a known prototype on British lines,

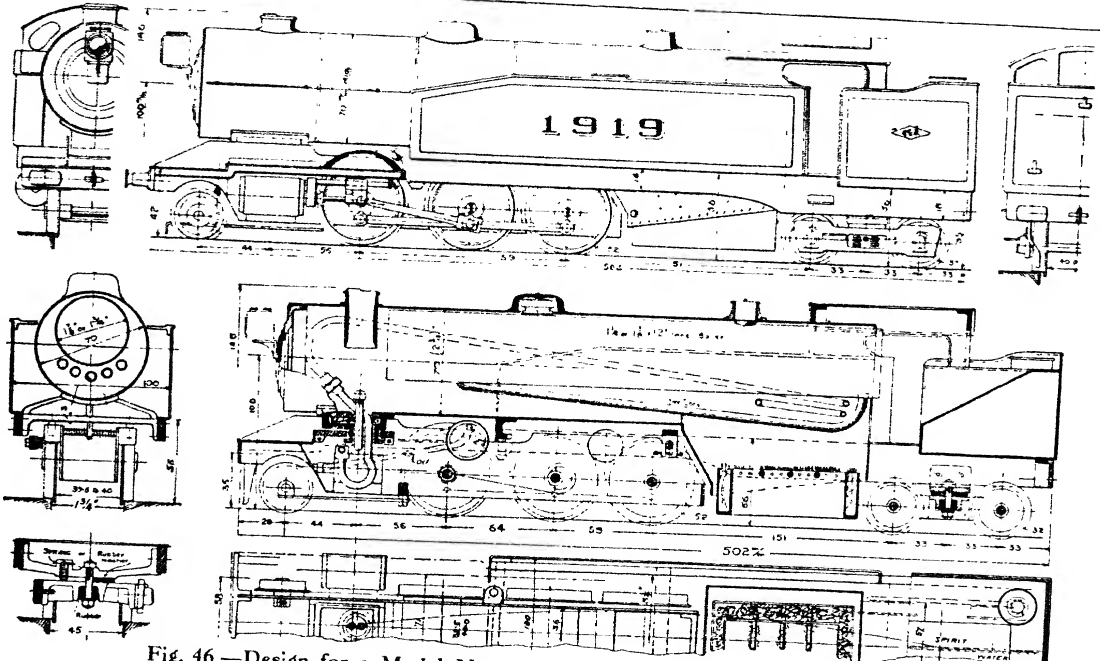


Fig. 46.—Design for a Model No. 1 Gauge Articulated Tank Locomotive.

a 4—4—2 type tank engine with outside cylinders driving on to the trailing coupled wheel would make a good engine for a road with sharp curves. The "Baltic" tank (4—6—4) has appeared on several British railways.

The 2—6—4 type outside-cylinder engine is perhaps the best type of passenger or mixed-traffic tank engine that a model-maker could design where solid fuel is to be used. The firebox can be made of almost any width or length, and the flexibility of the wheel base is remarkable. In fact, side controlling springs are necessary in the trailing bogie to ensure stability on the straight track. Otherwise the engine might tend to travel crab fashion.

Final Points in Selecting a Design.—All cases under consideration (whether of the tank or tender-engine variety) should be examined with reference to its flexibility on curves, in addition to its suitability for fitting with a boiler fired by any particular form of fuel. The best method of doing this is to cut a template out of card or sheet metal representing the sharpest curve of the railway, also one of a reverse or "S" curve. This should be laid against the wheels at the line of rail level, and the amount of traverse or play required by each wheel then observed.

Articulated Locomotives.—These are among the latest types of models to become popular. The Fairlie, Garratt and Mallet types are all worthy of consideration where great power, coupled with flexibility of wheel base, is desired. Quite recently the author has evolved a class of articulated tank engine which has only one motor bogie. The point of articulation is directly under the smokebox, so that the least difficulty is occasioned in arranging the steam pipes. The exhaust needs no special joints, while in small models the steam pipe may be coiled and allowed to bend. In capacity the firebox is not limited by frames.

CHAPTER III

The Principles of Model Locomotive Design

It is presumed that the reader is acquainted with the action of the piston in the cylinder of the locomotive and with the mechanism employed to transmit the work done to the wheels of the engine. From this point, study should be made of the various means of reversing, and an understanding of the functions of the slide valve obtained, but before proceeding to such detail it is necessary to know something of the principles involved in estimating the power of a locomotive.

Draw-bar Effort.—A locomotive is required not only to move itself, but to propel a train; only the power which is delivered to the train is useful. While the horse-power of a locomotive is sometimes calculated, particulars of its "draw-bar pull" is much more useful knowledge.

For a goods engine travelling at low speeds a high initial draw-bar effort is required. In an express engine it is desirable that this pull on the train should be maintained at the highest speeds. For this reason larger driving wheels are adopted for express engines. In goods engines the draw-bar pull is increased at the expense of speed, by using small-diameter coupled wheels in conjunction with cylinders of the same dimensions as those of a passenger-train engine of equal power.

It will be understood that there is a limit to the number of revolutions that a wheel and its attendant machinery will attain, and the economical speed of a goods engine is therefore low. If it is pushed beyond that speed the whole of the power developed will be absorbed in moving the mechanism of the engine and in rolling resistance. The accompanying diagram (Fig. 47) shows this. The dotted line gives the draw-bar pull of an eight-coupled goods engine and the full line that of a "single-wheeled" express engine at various speeds. It will be seen that although the express locomotive could not start so heavy a train as a freight engine, at 70 miles an hour its energy is not wholly absorbed in internal friction, and there is something left for hauling the train. The goods engine has a draw-bar pull of 10 tons (sufficient for a 1,000-ton train), but simply "fizzles out" at 55 miles per hour.

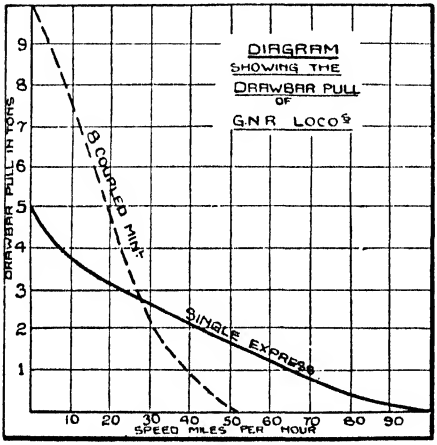


Fig. 47.—Comparative Diagram Showing Draw-bar Pull of Express and of Goods Locomotive.

Rolling Resistance of Model Trains.—The rolling resistance of a model train varies with the size, and while the diameter of the driving wheel does not affect the question of draw-bar pull so much in a model as in the full-size prototype, the principle remains true. To enable the reader to estimate the load a model will haul it may be said that 1 lb. draw-bar pull will be sufficient to start a 25-lb. train, in small sizes, and in larger engines the ratio varies from 1 in 30 to 1 in 35.

Model Locomotive Design

The formula universally employed for estimating the tractive effort of a "two-cylinder simple" locomotive is—

$$\text{Tractive force in lbs.} = \frac{D^2 \times S \times P}{W}$$

Where

D is the cylinder bore in inches
W is the driving wheel diameter in inches
S is the length of stroke in inches
P is the pressure in lbs. per square inch.

It is also usual to reckon on the basis of only 70% or 80% of the boiler pressure. In model work 60% may be adopted. For four-cylinder compound engines the formula may be altered by substituting for the factor D^2:

$$2\,H^2 - \frac{H^4}{L^2}$$

Where H is the high-pressure cylinder diameter
L ,, low- ,, ,, ,,

Two-cylinder compounds would be half this amount.

If only one double-acting cylinder is employed, or if the engine is a two-cylinder compound, the result obtained from the above formula will have to be halved, while if four simple cylinders are used the tractive effort will be twice as much as the first formula gives.

By the use of the above formula not only can the values of various dimensions of cylinders and driving wheels be compared, but the proper ratio of tractive force and weight on the coupled wheels may be determined. In real locomotive practice the maximum tractive effort is generally arranged to bear a proportion of 1 in 4 or 4½ of the weight available for adhesion, that is, the total weight on the coupled wheels. In small work the author has found that slipping will not occur on a dry rail if the tractive force does not exceed ⅓ of the adhesive weight, and as a guide to the probable weights reference should be made to the tonnage coefficient given in Table 1. This coefficient gives the "tons actual" that each 1 lb. or 1 cwt. of the model represents in the prototype.

The Size of the Cylinders.—The size of the cylinders of a model locomotive should not be finally fixed without the consideration of other points, otherwise the cylinders may prove to be so small that a high steam pressure is required to do the necessary duty, or so large as to unduly drain the boiler of steam. A high steam-pressure is wasteful in the following respects:

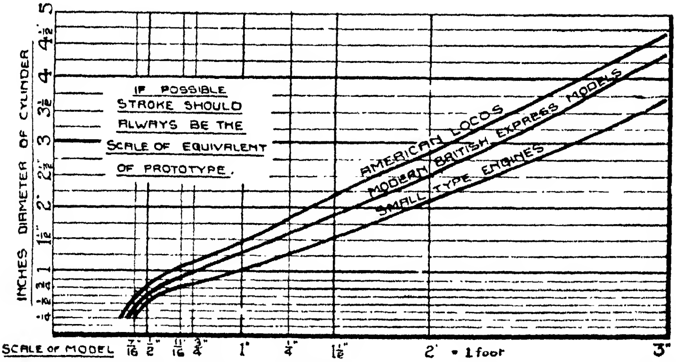


Fig. 48.—Diagram giving Cylinder Proportions for Various Gauges.

(a) There will be increased leakage past piston and valve-spindle glands, etc.

(b) There will also be no commensurate gain in using a high pressure since the average model locomotive does not use steam expansively.

(c) A stronger and heavier boiler is required. This condition will be found to reduce efficiency.

Of course, high pressure is a lesser evil than a very low one, because—

(d) A low pressure involves a large volume and violent ebullition, and consequently priming (which produces a still further disturbance in the boiler) may occur if the cylinders are of too large capacity.

(e) A given volume of steam at low pressure contains less heat than the same volume at a higher pressure.

Cylinder condensation, which has a cumulative effect, may therefore be induced by the use of too low a pressure. Furthermore, it must be borne in mind that the temperature of the steam varies with the pressure, therefore a low steam-pressure means that the steam is nearer the liquefaction point.

To enable the reader to determine the size of the cylinder for any given gauge, the curves shown in diagram Fig. 48 may be used. The three values for (1) large-model built to American loading gauge, (2) modern express engine, (3) small shunting engine or old-fashioned model with small boiler, are represented by the different lines. The cylinder capacity may, of course, be always added to in proportion to any increase of heating surface over the normal, always provided that such addition to heating surface is attended by a proportionate increase in grate area. In fact, the whole success of a model locomotive, assuming an equal quality of workmanship, choice of suitable material, and soundness in design and construction of the boiler, depends on the ratio of grate area, heating surface and cylinder capacity. To eliminate formulæ a few values are given in Table IV, this including suitable steam pressures.

Wet and Dry Steam Compared.— One other point which is a highly important factor in the success of the model locomotive involves a practice which the writer has advocated for over twenty years. In a model steam engine the highest degree of superheat the material of the cylinder will allow should be employed. In small engines using brass or gunmetal cylinders this degree of superheat is not particularly high, and may not be more than necessary to maintain dry steam. Wet steam is very conducive to cylinder condensation.

Table IV

BOILER PROPORTIONS AND HEATING SURFACES

Water-tube Type

(Working Pressure 40 lb. to 60 lb.)

Gauge of Loco.	*Inside Boiler*	*Outer Shell*	*Heating Surface*	*Water Tubes*	*Cylinders*
1¾ in.	1⅝ in. to 1⅞ in.	2⅜ in. to 2½ in.	50 to 60 sq. in.	3 to 4 (¼ dia.)	7/16 in. × 20 m/m
2½ in.	2 in. to 2¼ in.	3 in. to 3¼ in.	70 to 80 sq. in.	4 to 5 (¼ dia.)	⅝ in. × 1 1/16 in.
3½ in.	2⅞ in. to 3 in.	4 in. to 4¼ in.	90 to 120 sq. in.	5 to 7 (¼ dia.)	¾ in. × 1¼ in.

Loco. Type

(Large)

Gauge	1¾ in.	2½ in.	3½ in.	8½ in.
Cylinders	7/16 in. × 20 m/m	11/16 in. × 1 1/16 in.	13/16 in. × 1 7/16 in.	15/16 in. × 1⅜ in.
Heating Surface	63 sq. in.	120 sq. in.	180 sq. in.	200 sq. in.
Grate Area	7½ sq. in.	13 sq. in.	16 sq. in.	18 sq. in.
Working Pressure	40 lb.	40 to 60 lb.	50 to 60 lb.	50 to 60 lb.
Space above Firebox Crown	1¼ in.	1½ in.	2 in.	2½ in.
Boiler Diameter	2½ in.	3½ in.	4½ in.	4½ in.

Gauge	4¾ in.	7¼ in.	9½ in.	15 in.
Cylinders	1¼ in. × 2½ in.	1⅞ in. × 3½ in.	2⅝ in. × 4½ in.	4½ in. × 7 in.
Heating Surface	500 sq. in.	1,000 sq. in.	3,100 sq. in.	10,000 sq. in.
Grate Area	26 sq. in.	70 sq. in.	132 sq. in	880 sq. in.
Working Pressure	60 to 75 lb.	70 to 80 lb.	80 to 100 lb.	100 to 125 lb.
Space above Firebox Crown	2½ in.	3½ in.	5 in.	17 in.
Boiler Diameter	6 in.	8 in.	11½ in.	20 in.

The writer has found that attempts to take advantage of the expansive force of steam are not usually attended with any overall economy in small models, therefore calculations of probable steam consumption based on an early cut-off are not attained in practice, and should not be considered. Compounding also shows little or no economy in steam or fuel. Steam engineers are well aware of the great increase in cylinder condensation which follows attempts to expand steam in a single cylinder, and it hardly needs mentioning that the model engine is an extremely wasteful steam user. This is in a large measure due to the following circumstances:

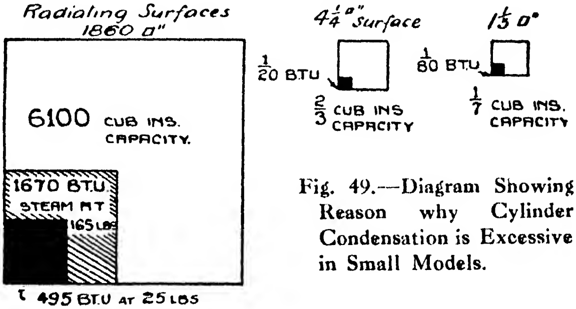


Fig. 49.—Diagram Showing Reason why Cylinder Condensation is Excessive in Small Models.

The surface of a solid body does not vary in a direct ratio to its capacity. The cooling surfaces of a model cylinder are therefore much greater in proportion to its capacity than that obtaining in a full-size engine. To emphasise this fact, and to show one cause of the excessive cylinder condensation present in a model, the diagram (Fig. 49) has been prepared. It will be seen that whereas in a large engine the heat in the cylinder bears a proportion of 1 to 1.1 of the radiating surfaces, in a model engine the proportions are entirely different. One unit of heat in a model may be dissipated by no less than 80 square inches. In the diagram the lower rectangles represent the amount of steam in cubic inches, the black portions the units of heat at 25 lb. pressure. These diagrams are proportioned to a given amount of cooling surface, and show the relatively small amount of heat the model engineer has at his disposal.

Cylinder Condensation.—Cylinder condensation in a greater or lesser degree being inevitable, the question resolves itself into one of palliatives. A reduction in heat losses may be obtained by—

(1) Increasing the pressure. Success will accompany this up to a certain point. In any case, scale pressures must be exceeded. In a $\frac{1}{2}$-in. scale model $\frac{1}{24}$ of the real locomotive pressure (i.e. $\frac{1}{24}$ of 180 lb. = 7.5 lb. per sq. in.) would be of no practical use.

(2) Superheating or drying the steam. Superheating is a term given to the heating of steam to a temperature above the normal at which steam at any given pressure is generated.

(3) Lagging all parts containing steam with non-conducting material, such as felt or flannel. Asbestos is a non-conductor of lesser value, and is more of a fire-resisting material.

(4) Increasing the piston speed. This can be done by using a small driving wheel and employing a cylinder with a long stroke. In very small engines (for Nos. 0 and 1 gauges) much success has been obtained by using a single cylinder, either geared two or three to one to the driving axle or a single directly-connected cylinder of long stroke operating on a very small driving wheel. A fly-wheel is used on the cylinder shaft.

Steam Pressures.—Reverting to the subject of steam pressures in small models, the boilers are usually unlagged, and a very high pressure is not likely to prove so economical as a moderate one owing to the greater difference between the temperature of the boiler and that of the outer atmosphere. In the course of aircraft-engine research it was found that a stove-enamelled surface radiated more heat than a plain metal surface. This point should be remembered as being contrary to expectations. All boilers in which the space taken up by the lagging can be spared, and which may have to work out of doors in cold weather, should therefore be lagged.

Only on large engines, i.e. those above 1½ in. scale, can any saving in steam be effected by linking up, and even then efficiency is only obtained where linking up is combined with efficient steam drying or superheating. When steam is expanded liquefaction occurs—more heavily where only saturated steam is used—and if, as the writer has seen suggested, a large cylinder with the valve cutting off at a point early in the stroke is used, cylinder condensation will assume a high proportion and all the expected economy will disappear, if the engine is not rendered an absolute failure.

In such cases where an existing engine with large cylinders has to be made to work successfully, the ill-effects of cylinder condensation may be mitigated by superheating and also wire-drawing the steam by using a very small port in the regulator. This will also tend to superheat the steam and will prevent the priming which always attends excessive cylinder condensation.

Compounding will therefore not increase efficiency very much, if at all, and a compound system should only be used on the largest of models, and where the use of four cylinders is desired, for the simple reason that the prototype of the model has four cylinders, which may or may not be compounded.

Two-cylinder Systems. — The two-cylinder system would appear to offer the best chance of success, but it is quite out of date. Next to this the Smith three-cylinder system (one high pressure and two low pressure) is suitable for model locomotive work, but requires three sets of valve motion. The steam pressure model of a compound locomotive should not be less than 70 to 80 lb. per square inch, and the cut-off should, in full gear, be as near to 85% of the stroke as possible. Re-superheating may be adopted for the middle stage (i.e. receiver stage). The ratio of the cylinder capacity should not exceed 1 to 2¼. Unless very high pressures are available an early cut-off in the high-pressure cylinder will be fatal to success.

The Point of Cut-off.— In all normal two-cylinder locomotives it is essential that the point of cut-off shall not be less than 80% of the stroke in full gear to ensure starting. An earlier cut-off is obtained by linking up the reversing gear. The effect of linking up is to make the engine run with less "knock," and large model engines are always linked up when once under way. Any economy obtained by this means of expanding the steam is quite as high in a model as that which would result from the most efficient compound system.

CHAPTER IV

Boiler Design

THE earlier difficulties of the model locomotive builder in making a boiler which would steam an engine continuously have disappeared; the questions which now arise are those of relative convenience and efficiency.

Although great liberties may be taken with regard to the proportions of a model locomotive boiler, the same or even more care as that exercised in real practice must be taken in providing means to ensure the maximum evaporation of the water, viz., in smokebox arrangements, grate area, furnace capacity, tube area, steam tightness and in the completeness of the combustion of the fuel. All these features and functions are more important where the orthodox type of generator, known as the "loco-type boiler," is adopted. Again, the dimensions of the boiler of a railway engine are bounded by certain limits of height, length and width, and the designer of the model will be handicapped in the same way as locomotive engineers of this country are at the present time. The adoption of the American loading gauge would, of course, help the model-maker. The same advantage is present when a model is based on the overall dimensions of one of the Colonial narrow-gauge systems.

In designing a model locomotive, it may be said that all types have merits and demerits in strict accordance with the manner in which the wheel frame and cylinder arrangements affect the boiler, more particularly with reference to the proportions of firebox and the methods of firing. With regard to the simple "pot" boilers fitted to toy steam locomotives and to small engines in No. 1 and No. 0 (1¼ in.) gauges, it may be said that their success is entirely due to the use of a well-ventilated and relatively large flame of a spirit lamp and boilers constructed of very thin material. The last is a very important item. The overall efficiency of these boilers is low, but with cylinders made with extreme care and delicacy such engines are made to work very successfully. Any attempt to copy such models in a rough, amateurish manner with heavy tubes and castings is doomed to failure. There is a middle course, by using a thin copper silver-soldered boiler with one or more water tubes, which will be considered later. It must, however, be noted that the above type of model, although it may have the exhaust conducted up the chimney, does not require or avail itself of that essential function of a real locomotive, namely, the inductive action of the exhaust steam on the fire. The flame of the "outside-fired engine" either burns in open air or the draught is a natural one.

The Diameter of the Boiler.—Returning to the "scale model," as it is sometimes called, the first problem that arises is in the diameter of the boiler. The diagram (Fig. 50) shows the three main conditions arising from restrictions in rail gauge. The old single-wheel express engine had (due to its large wheel diameter and low-pitched boiler) a barrel limited by the distance between the tyres, as at A. The sketch B shows the normal conditions now obtaining in coupled express locomotives. The diameter of the boiler barrel is bounded by the top of the driving wheel flanges and therefore, with a given gauge, by the height of its centre line and the diameter of the driving wheels. In the case of a goods engine the wheels do not affect the boiler barrel, but in the matter of firebox width greater freedom is obtained. With reference to the sketch C, where the firebox is entirely clear of coupled wheels, the same arrangement may be adopted. The carrying wheels would be of small diameter, special designs of main frames being used under the firebox.

The ideal requirements of a model boiler are as follows:

(1) It should provide for a good circulation of the water.

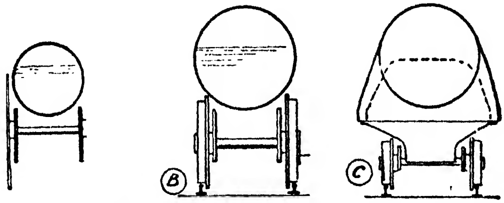


Fig. 50.—The Restrictions of Loading Gauge and Rails.

(2) Ample ventilation of the fire to ensure complete combustion.

(3) The largest possible range of water and a sufficient capacity for a good reserve of steam.

(4) Furnace or firebox should be ample, the definition of the word "ample" depending on the type of boiler and fuel used, also the size of the model.

(5) Efficient smokebox arrangements, with due regard to the fuel employed.

(6) The plates and thickness of tubes should not be heavier than necessary. Unless this recommendation is observed it is impossible to steam a loco-type boiler or its equivalent with a methylated spirit lamp. This fault, in conjunction with a

neglect of the induced draught of the exhaust, was the cause of all the early failures.

(7) Reduction in the number of joints, and, in the case of copper loco-type boilers especially, good fitting; and

(8) Equal strength in all parts, with a factor of safety varying from 6 to 10.

Types of Boilers.—Model locomotive boilers may be divided into four types: (a) the plain cylindrical pot-boiler, (b) the water-tube boiler which was invented by Mr. F. Smithies in 1900 and with the early development of which the writer had much to do, (c) the loco-type boiler, and (d) the flash steam generator.

Outside-fired Boilers. — With regard to the first type, supplementing the remarks already made as to the necessity for extreme lightness, it is essential that such boilers should be heated over their whole length, and that the barrel should be pitched as high as possible above the level of the rails, otherwise there will not be sufficient height for the flame of the lamp. The vaporising lamp (this lamp does not work well under a fierce induced draught, therefore difficulties may occur if it is applied to internally fired engines) is perhaps the best of all spirit lamps for this purpose. This question of height is the one difficulty in making scale working models in No. 0 (1¼ in.) gauge. Abnormal types of locomotives are therefore usually chosen as prototypes in this gauge.

One of the most satisfactory arrangements of plain boiler is that shown in Fig. 51. A tank engine with long tanks is adopted, and the latter are used to conceal the flame of the lamp, which, of course, burns under natural draught. One or two water tubes may be added, but to allow this material to be used all joints should be silver soldered.

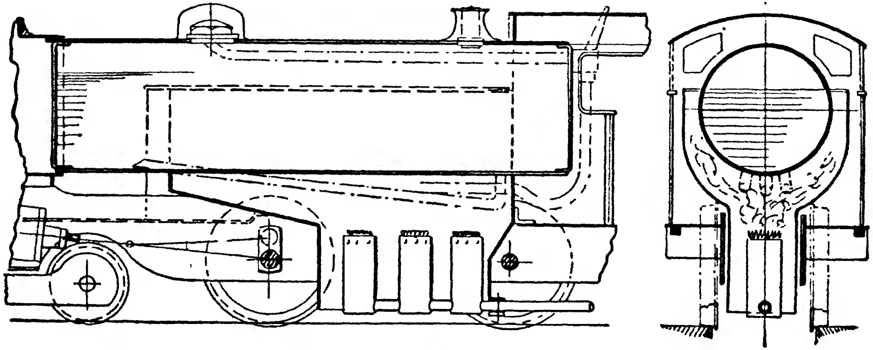


Fig. 51.

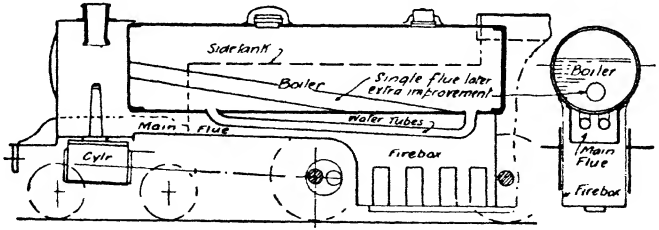


Fig. 52.

Fig. 51.—Outside-fired Boiler fitted to a Tank Locomotive.

Fig. 52.—Early Water-tube Boiler with Enclosed Firebox.

Water-tube Boilers.—The arrangement of the water-tube boiler which immediately preceded Mr. F. Smithies' most successful type is illustrated in Fig. 52. It consists of a plain cylindrical boiler, one or more water tubes with an enclosed furnace, and a rectangular flue tacked to the underside. A plain spirit lamp was used, and the whole was fitted to a 3¼-in. gauge engine (a small gauge in those days) having a single cylinder. Induced draught was employed. The scheme is of no great value for locomotives under 2½ in. gauge owing to restriction in flame height, unless abnormal proportions for the locomotive are adopted.

The striking characteristic of the Smithies boiler is the simplicity of the boiler proper and its encasement in a shell having the usual external features of the loco-type generator. Another point of intrinsic value is that the whole of the boiler is encased in the heated gases, the loss of heat by radiation through the outer casing not affecting the steaming of the boiler in any way. Of course, the use of water tubes ensures perfect end-to-end circulation. This gets over one of the chief drawbacks to the ordinary loco-type flue-tube boiler which has little or no natural circulation in this direction. The only undesirable attribute of the Smithies generator is the rapid burning of the paint or enamel which occurs where boiler casings are not lined with a separate shell, especially near the firebox. To get over troubles in this connection a *thick* inner casing of sheet iron, covered with a thin brass lagging is used, the space between where the two casings touch being packed by asbestos millboard to prevent conduction. The remaining air spaces form the best non-conducting scheme. Where a metal lining is impossible use a heavy gauge of material for the outside casing and

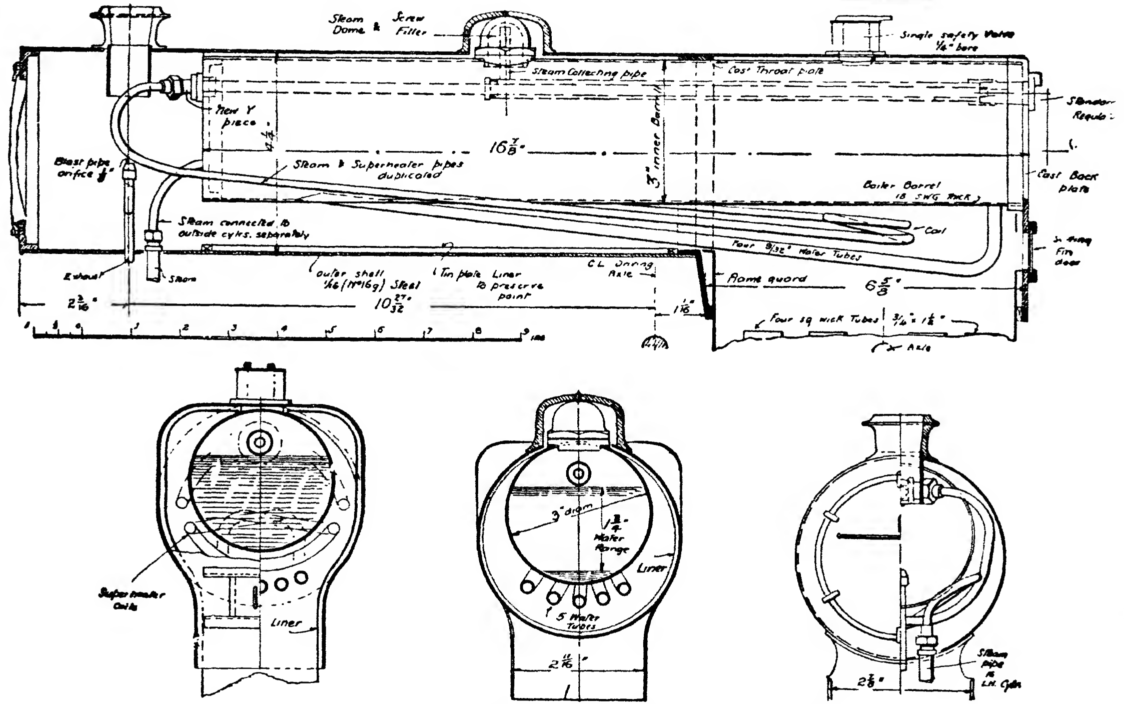


Fig. 53.—Standard Water-tube Model Locomotive Boiler.

protect it at the firebox with a local liner of asbestos card. It is essential to success in all cases to provide the lightest inner boiler shell and tubes that can be worked.

Fig. 53 shows various sections of a standard water-tube model lomocotive boiler.

The diagram, Fig. 54, shows the relative water capacities of three types of boilers, and remembering its extreme simplicity and high-speed steaming the Smithies boiler comes out particularly well. In small scales the plain outside firebox cannot be made as large as otherwise desirable because of the height above wick level required for the flame. Fig. 55 shows a large water-tube boiler.

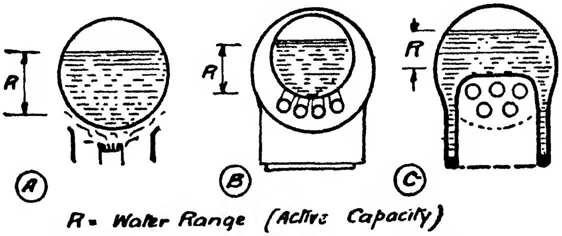


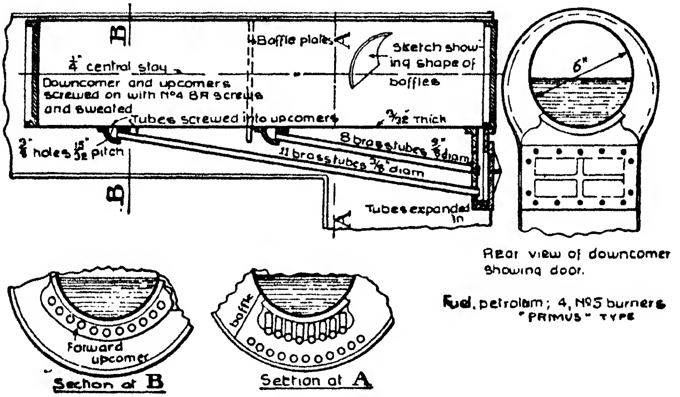
Fig. 54.—Relative Water Ranges of the Three Types of Model Boilers.

The following are conditions which tend towards success in a model locomotive water-tube boiler:

(1) Narrow firebox of the greatest length rather than width. This is especially important where a spirit wick lamp is used. The barrel should not be too long. A good proportion is one where the firebox length is not less than that of the barrel.

(2) Proportions of inner and outer barrel should in no case exceed 3 to 4 (measuring inside the outer barrel), while a ratio of from 2 to 3 to 5 to 7 gives the best results. Always increase the diameter of the outer casing in preference to the inner one.

(3) The boiler should not be choked with water tubes, so that a well ventilated flame is obtained when, during steam raising, the smokebox door is opened, the boiler working under natural draught. This more or less applies to spirit-burning engines of 2½ in. gauge, and smaller, where auxiliary methods of inducing a draught are considered troublesome. Small gauge locomotives work well with from two to five ¼-in. or $\frac{3}{16}$-in. water tubes, which should be of thin gauge material. The use of a cast downcomer is not essential, and a cast back-plate is a matter of convenience for screwing in fittings rather than an aid to efficiency.



Rear view of downcomer showing door.

Fuel, petrolum; 4, No5 burners "PRIMUS" TYPE

Fig. 55.—A Large Model Water-tube Boiler.

The value of the water-tube type in very large sizes has not been very conclusively proved. A boiler (Fig. 55) made with straight tubes fitted in downcomer and upcomers and fired with several "Primus" paraffin vaporising burners was built to the author's drawings over ten years ago to make an unsuccessful engine more efficient. It certainly improved the running, but the real trouble lay in the cylinders of the engine, and these were never put right.

Loco-type Boilers.—Undoubtedly the locomotive-type fire-tube boiler has the great merit of being true to scale and realistic, and therefore much favoured by skilful model builders. For large passenger-carrying models it has no compeer, while there is a growing section of experimenters who favour the use of solid fuel and have made quite a success of loco-type boilers in gauges as small as No. 1 (1¾ in.). Solid fuel is very manageable, and with a well-made and proportioned boiler, efficient cylinders and proper blast arrangements, the most successful models can be made. At the Manchester Model Exhibition of 1913 a 2½-in. gauge Pacific engine (see Fig. 280, page 229) was shown working by the writer. It was kept in steam six or seven hours a day for three days; it could be left at any moment for considerable periods.

A successful loco-type boiler may be obtained by—

(1) A large grate area.

(2) A large boiler diameter to provide sufficient tube heating surface and ample range of water. Diameter should, if possible, be above normal. In smaller models length is not a drawback where solid fuel is used, as it helps the water range of the boiler.

(3) With a coal fire a deep grate at the tube-plate end is desirable. Where charcoal is used the fuel may be heaped, and therefore the total capacity of the furnace is important. With coal the capacity below the level of the tubes or "brick arch" line should be considered.

(4) The inner firebox plates and the tubes should be of the thinnest material consistent with strength, handling in construction and resistance to corrosion. All flat surfaces must be stayed, and except in the smallest sizes little or no allowance should be made for the natural stiffness of the plates in calculating the amount of support given by the stays.

(5) Tubes should be neatly spaced, the following being suitable sizes:

Nos. 1 and 2 gauges ...	⅜ in. to 7⁄16 in.
2½ in. gauge	⅜ in. to ½ in.
3¼ in. and 3½ in. gauges ...	½ in. or 9⁄16 in.
1 in. scale	9⁄16 in. or ⅝ in.
1½ in. scale	⅝ in. or ¾ in.
2 in. scale	¾ in. or ⅞ in.
3 in. scale	⅞ in. or 1 in.
15 in. gauge light locos ...	1¼ in.

(6) Where long tubes are necessary employ the larger diameter stated. Water tubes in the firebox are only desirable where oil burners or spirit lamps are employed for firing.

(7) Heating surface should not be obtained at the expense of the water and steam spaces at the sides of the firebox and above the crown. In small boilers the level of the crown should be below the centre line of the boiler, and only in the largest models above this level (see Fig. 56).

(8) In small engines the adoption of a higher pressure than really required by the cylinders is an advantage if means such as the use of a small regulator orifice are provided to keep the pressure back in the boiler. This "wire-drawing" of the steam

superheats the supply and also prevents the violent ebullition in the boiler which either attends or creates priming and excessive cylinder condensation. An unsuccessful over-cylindered engine may often be made workable in this way, possibly with the addition of a good superheater and a sharp blast.

(9) Efficient smokebox arrangements are indispensable to complete combustion of solid fuel. The smokebox must be quite airtight.

Blast Pipes.— With regard to these, as mentioned above, satisfactory results can only be obtained where the most is obtained from the exhaust steam after leaving the orifice of the blast pipe. The diagram (Fig. 57) gives the best average proportions of blast pipe and chimney. It may also be remembered that where the height required by the diagram is not obtainable a reduction may be obtained by making the internal diameter of the chimney smaller or making the blast nozzle annular.

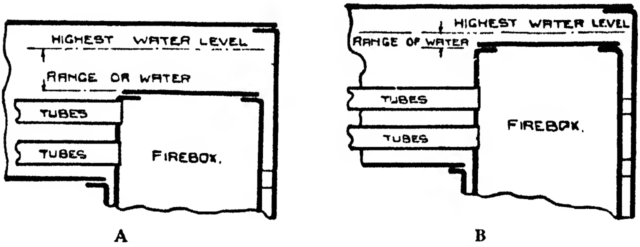


Fig. 56.—Design of Firebox Crowns. A, Correct; B, Incorrect.

The area of the blast pipe should be $\frac{1}{30}$th that of the cylinder for cylinders $\frac{3}{4}$ in. bore and below; $\frac{1}{25}$th that of the cylinder from $\frac{7}{8}$ in. to 2 in. diameter; $\frac{1}{20}$th that of the cylinder above 2 in. diameter.

In real practice the vacuum produced in the smokebox by the ejector action of the exhaust rises as high as 6 in. of water (.22 lb. per square inch), and it is this action that makes the locomotive boiler responsive in its rate of evaporation to the needs of the train. While the engine is stationary the boiler, although containing the full working pressure, may be doing no work at all except in making up for the small losses by radiation; a minute or so later, due to the fierce action of the exhaust on the fire, it may be developing a thousand horse-power or more, according to the weight of the train and the desire of the engine-driver.

With the short funnels common to modern locomotives it is usual to extend the same inside the smokebox. To help steam raising the use of the petticoat pipe is often adopted. This allows smoke to leave the upper part of the smokebox easily.

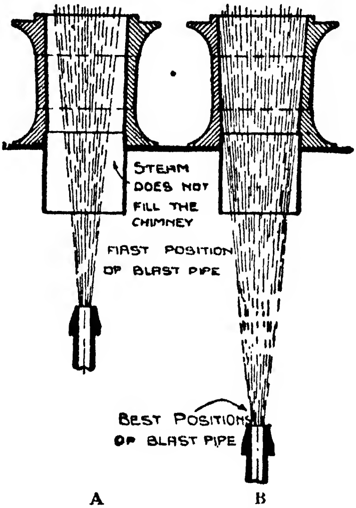


Fig. 57.—Proportions of Blast-pipe and Chimney. A, Inefficient; B, Efficient.

In locomotives where a very high smokebox vacuum is not required the efficiency of the blast may be reduced by placing the nozzle higher up in the smokebox than otherwise necessary. This condition is shown at A (Fig. 57).

Strength of Boilers. – For a given thickness of material and diameter a plain cylindrical boiler made from solid drawn tube is, of course, the strongest of any

—omitting reference to the flash boiler—and it is in this respect that the water-tube boiler is so satisfactory. This boiler also has very few joints, and even these can be hard soldered or brazed. A table of suitable steam pressures is given below.

TABLE OF SUITABLE STEAM PRESSURES

Scale	*Boiler Pressure*	*Temperature of Steam*
10 m/m and $\frac{7}{16}$ in.	25 to 40 lb.	267 to 287 deg. Fahr.
Half-inch	35 to 50 lb.	280 to 298 „ „
$\frac{11}{16}$ in. and $\frac{3}{4}$ in. ...	40 to 60 lb.	287 to 307 „ „
1 in. and $1\frac{1}{2}$ in. ...	60 to 80 lb.	307 to 324 „ „
2 in. to 3 in. ...	90 to 120 lb.	330 to 350 „ „

When a cylindrical shell is made from sheet material, rolled into shape with a longitudinal joint, the strength of the boiler will depend on the efficiency of this joint. A single-riveted lap joint works out under the best conditions at only 50% of the strength of the solid material, and a double-riveted joint at 75%. Flat ends should be made of material $1\frac{1}{4}$ times the thickness of the shell plates, and all flat surfaces not made of stiffer plates or castings should be stayed. In using non-ferrous metals it should be noted that copper has diminished strength at high temperatures. The same applies to brass with the additional uncertainty as to the stability of the particular alloy one may be dealing with.

The following formulæ may be used for estimating the strength of boilers:

$$WP = \frac{S \times P \times 2 \times R \times C \times T}{D \times F}$$

Where

S = Strength of material taken as 25,000 lb. copper, 20,000 lb. brass, 40,000 lb. steel

P = Plate thickness in inches
WP = Working pressure in lbs. per square inch
F = Factor of safety 5 to 8
R = Riveting allowance .5 for single riveting, .75 for double riveting
.8 welded, brazed or silver-soldered joint
D = Diameter of boiler barrel
C = Corrosion allowance, steel below ¼ in. = .5 to .8
T = Temperature allowance, copper = .85.
brass = .65.

For a given diameter of boiler the plate thickness would be—

$$P = \frac{D \times WP \times F}{S \times 2 \times R \times C}$$

For staying flat surfaces steel stays should not be loaded to more than from 5,000 lb. in small boilers to 7,000 lb. per square inch in large boilers. Brass stays should not be loaded above 2,000 lb. and copper 3,500 lb. per square inch safe load. The following stay spacings may be considered as accepted practice:

Up to ¾-in. scale, copper boilers ¾ in. to 1 in. apart.
1-in. to 1½-in. scale, copper boilers 1 in. to 1½ in. apart.
1½-in. scale, steel boilers 1½ in. to 1⅝ in. apart.
2-in. scale, copper boilers 1¾ in. to 2 in. apart.
2-in. scale, steel boilers 2¼ in. to 3 in. apart.
3-in. scale, steel boilers 3½ in. to 4 in. apart.

Stays should be threaded with fine threads, B A or model pipe threads in small sizes and gas threads in larger models being used.

In small copper boilers rivets should be at least 1½ times the plate thickness in diameter. The pitch should not be more than 3½ to 4 times the diameter.

Silver-soldered joints need only be riveted sufficiently to hold the work together while soldering. With soft-soldered joints the joint must be sufficiently strong to resist the working stresses without reference to the solder, which has no value at high temperatures. Any joint which is soft soldered must be close fitting. The plastic stage of ordinary soft solder is very near to the temperature of steam at 100 lb. per square inch. The soft solder is only a caulking material, and is the most satisfactory method of caulking in copper boilers. Minor crevices in steel boilers "take up" automatically owing to corrosion. This is not the case with copper boilers.

CHAPTER V

Constructional Details: Frames, Axle-boxes and Springs

THE construction of a model locomotive is a task often lightly entered upon and just as often laid aside uncompleted. This being the case, amateurs working in spare time should consider the design they have chosen with a view to the amount of leisure they have at their disposal, as well as to the resources of their workshop. Where both are limited the best policy is to adopt a small type of locomotive in a comparatively large gauge rather than a smaller model of a large one. A design following no prototype will also be found less difficult. Strict adherence to every feature of a given prototype often causes a lot of extra work, although some may consider it well worth the trouble. Where the model engineer desires a reliable working model with the least possible labour he must be prepared to modify all details which are not visible or very noticeable from a normal point of view. The necessary alterations to the internal arrangement of boilers have already been discussed. Similarly cylinders and motion must be modified. In the matter of frames, so long as the external shape is preserved, the components may be simplified in many ways.

Framing.—While sheet brass may be used for framing, mild steel sheet is stiffer and generally a more satisfactory material. The thickness of the sheet used should be approximately a scale equivalent of 1¼ in. or 1½ in., i.e. $\frac{5}{64}$ in. or $\frac{3}{32}$ in. for ¾ in. scale, and $\frac{3}{32}$ in. or ⅛ in. for

1 in. scale models. American locomotives have forged bar frames measuring approximately 3 in. thick, and therefore if the bar type of frame is modelled out of sheet material then double the normal thickness will be required.

As far as possible the builder should avoid the use of tapped holes in the frames. Holes should be plain clearing holes for the bolts and screws attaching the stretchers, brackets and other parts. Except in the smallest models there is no need to solder parts to the frames, and therefore steel is quite as good as brass from this point of view.

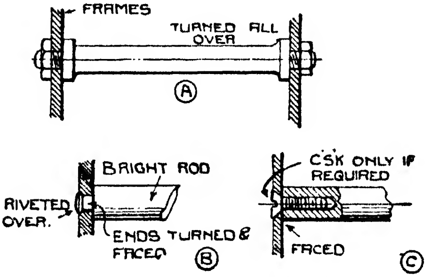


Fig. 58.—Round frame Stretcher Bars.

Where stretchers or distance pieces have no great duty other than to keep the frames at the correct distance apart, then the round-bar frame stretcher, varieties of which are shown in Fig. 58, is recommended. If the holes necessary for these stretchers are drilled in the frame-plates while they are together, then the use of turned stretchers will ensure the frames being reasonably square when they are erected.

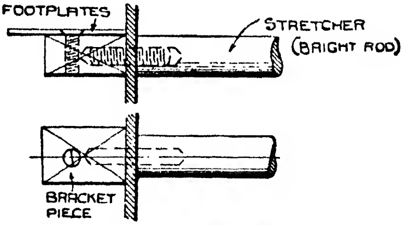


Fig. 59.—Round Stretcher Bars with Screwed-on Footplate Brackets.

For small engines the fitting of angles, etc., to attach the footplates is somewhat troublesome, and therefore the arrangement shown in Fig. 59 may be found useful. Small pieces of rectangular stuff are parted off in the lathe and drilled for a screw matching that used in round stretchers. When the use of a round stretcher is not convenient these rectangular brackets can be used alone, attached by a screw driven from inside the frames. The system is recommended for No. 1 and No. 2 gauge models. Other forms of stretchers are shown in Figs. 60 and 61.

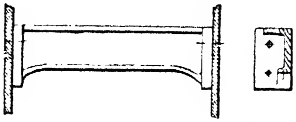


Fig. 60.—Cast Plate Stretcher.

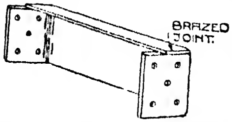


Fig. 61.—Built-up Stretcher.

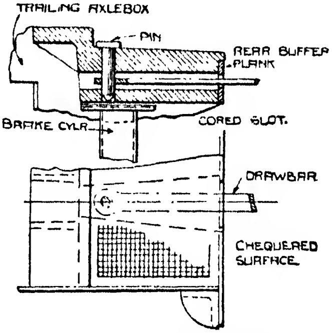


Fig. 62.—Cast Drag-plate.

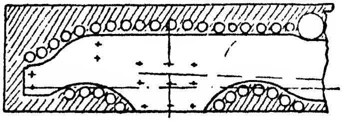


Fig. 63.—Method of Cutting Out Frame-plates.

Four-coupled (4—4—0) engines are notoriously heavy at the front end. To move the centre of gravity farther back than it would otherwise fall heavy cast footplates are often fitted behind the firebox. A suitable design is shown in Fig. 62. This casting is provided with a slot for the tender drawbar, facings for fitting a steam brake cylinder, and was designed for a L.N.W.R. model.

Cast frames were tried for many early models, but in spite of a saving in one direction, i.e. in the fixing of hornplates, angles, and brackets, no advantage accrued when all things were considered.

In choosing steel for frames a "planished" plate or piece of strip should be favoured, and in cutting it care should be taken not to distort the plate by chiselling out the waste portions. Centre and edge lines should be carefully marked out on one piece of plate, first chalking the surface and then "popping" the marks to prevent their total obliteration. The marked plate should then be riveted with copper rivets to the second plate and the two drilled, sawn and filed out to shape. The chisel should be used sparingly, and only in places where a preliminary close-drilling (see Fig. 63) has been made. The drawings should indicate all the holes that are likely to be required in the frames, and the plates should be completely drilled before

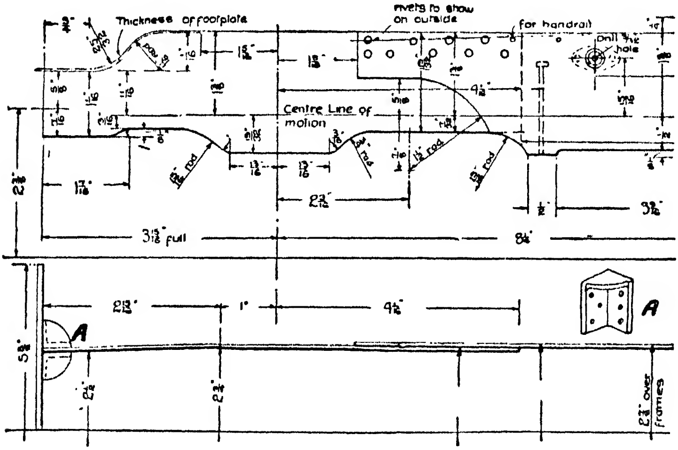


Fig. 64.—Main Frames for a 3½-in. Gauge L.N.W.R. Model 4—4—0 Locomotive.

they are parted; great care should be taken in making them identical in length and in the positions of the slots for the axle-boxes. The holes for the service rivets should be chosen with due regard to their future use, if any.

Auxiliary Framings.—Auxiliary framings for inside cylinders are often recommended for inside cylinder locomotives. They are, however, more useful in cases where cylinders are of the old-fashioned "valves between" type. The modern "valves on top" cylinders are not so difficult to manipulate in setting the valves or repacking pistons. For outside cylinder locomotives the separate auxiliary frame scheme is hardly worth the trouble unless, of course, cylinders of the stationary model-engine type have to be adapted to locomotive purposes. In that case it is conceivable that the building up of a pair of cylinders on separate frames as a complete unit, with all pipes fixed, will be found convenient from all points of view.

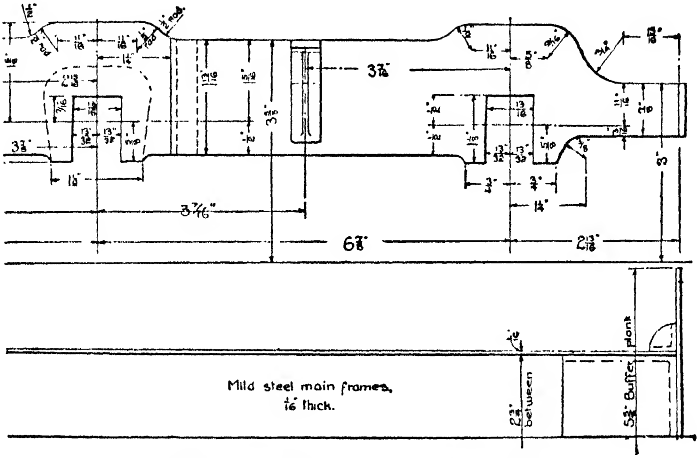


Fig. 64a.—See illustration on preceding page.

A typical frame arrangement for a 4—4—0 type locomotive is shown in Figs. 64 and 64A. In this, the bogie wheels are of large diameter, and therefore their lateral movement is limited by main frames. The frames are, however, set in at the front, still further clearance being provided by piecing them. The front portion is lap-riveted to the rear

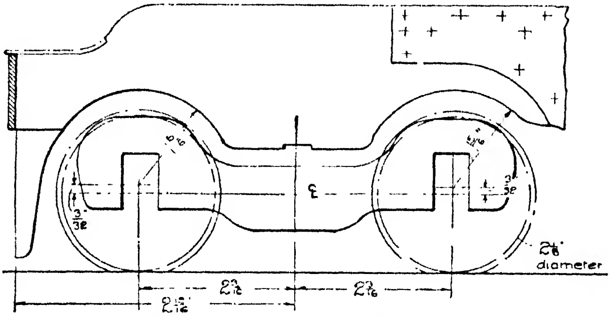


Fig. 65.—Front End of Frames in "George V" Locomotive Showing Clearance for Bogie Wheels.

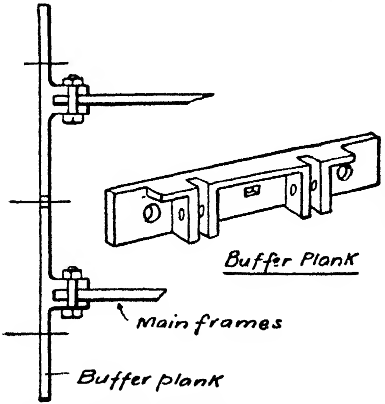


Fig. 66.—Method of Fixing a Cast Buffer Plank to Main Frames.

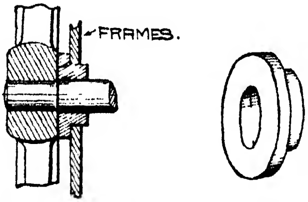


Fig. 67.—Axle Bushes for Small Unsprung Models.

part. On the G.C.R. and other lines, frames are often cranked at the critical point. Fig. 185 shows this scheme, the motion plate stiffening the frames just where they are cranked. The use of smaller bogie wheels has recently become common practice, and the sketch (Fig. 65) shows how the frames have been modified in the later L.N.W.R. 4—4—0's of the "George V" class.

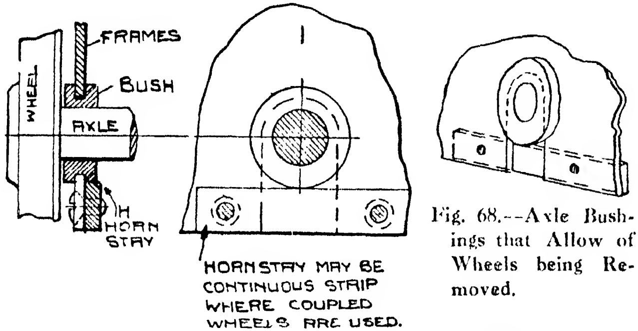


Fig. 68.—Axle Bushings that Allow of Wheels being Removed.

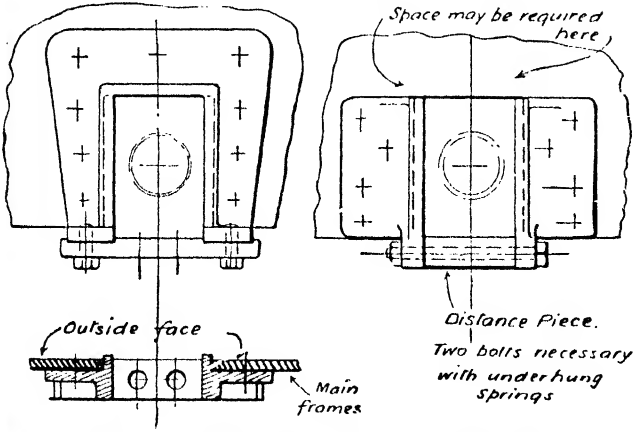
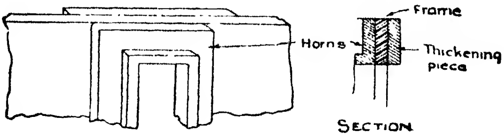


Fig. 69.—Types of Horn-blocks for Axle-boxes.

As a rule, the buffer planks are fixed to the main frames by angles. Sometimes castings, as shown at A (Fig. 64), are employed. The top table of these castings is useful for fixing footplates and other superstructures. Another method largely employed in smaller models is shown in the sketch (Fig. 66). Here the buffer planks are cast with an upper flange and with lugs for the main framing. These lugs are milled out to suit the thickness of the frame



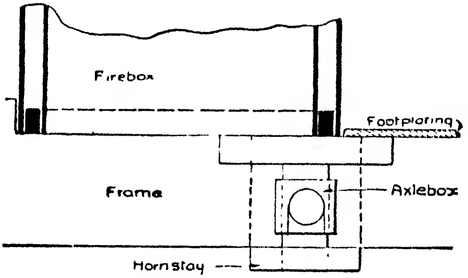


Fig. 70.—Method of Reducing Frame Depth at Firebox.

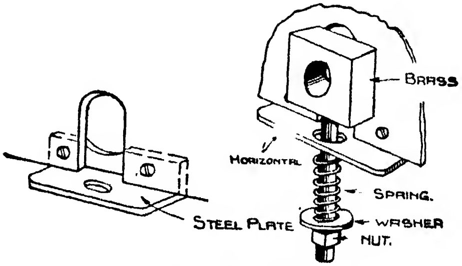


Fig. 71.—Simple Driving Axle-box.

plating, and one or two bolts or screws in each lug serve to secure the whole structure.

Axle Bearings.—In small models (viz., ½-in. scale) frames are much more simply arranged. Horn-blocks are dispensed with, and in gauge No. 1 engines the practice is to cut out springs and bush the frames with turned bushes (see Fig. 67). These may be of the single-flange type, but where such bushes are used care must be taken with

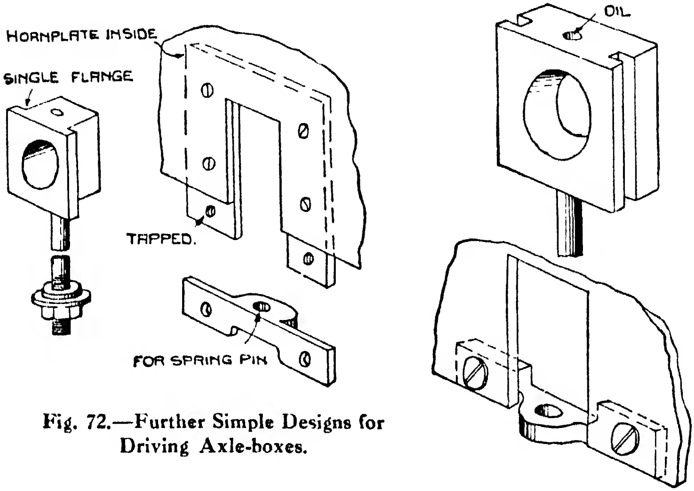


Fig. 72.—Further Simple Designs for Driving Axle-boxes.

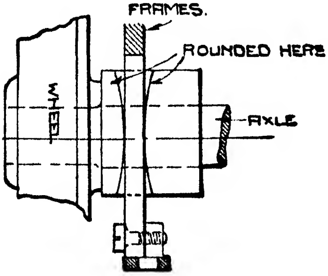


Fig. 73.—Showing Rounding of Axle-box Flange to Allow Wheels to Cant Under the Action of the Springs.

reference to the sequence of assembly operations, otherwise wheels may not be able to be put into place. A new form of bush designed for amateur-built engines is shown in Fig. 68. The double-flanged bush is fitted into a slot, the top circular portion of which should be accurately placed and formed by drilling a plain hole through both frame plates before slotting. The keep plate is a strip of metal about the same thickness as the frames, which is screwed to the main frames below the bushes. The wheels and axles can therefore be finally fitted together independently of the assembly of the frames and footplating, as in the case of a locomotive built on the orthodox plan with separate axle-boxes. Some types of horn-blocks are shown in Fig. 69.

The necessity for the "last inch" in firebox dimensions and the close proximity of axle-box openings in the frames often renders such expedients as shown in Fig. 70 necessary. The thickening piece should be long and the parts not unduly weakened by rivet holes.

Figs. 71 and 72 show simple axle-boxes. In the first the frames are slotted and the axles are restrained from moving in a fore-and-aft direction by the slot. The axle-box governs the vertical movement. The scheme is more useful for bogies and similar cases where the distance between the frames is not very important. To give more room for firebox and motion the second type of axle-box may be employed. The axle-boxes in Fig. 72 are very suitable for 2½-in. and 3¼-in. gauge locomotives and really need no horn-plates. The bearing area of the edge of the frames is sufficiently large for all practical purposes. Where horn-plates are desired then such may be made from a piece of the same material as the frames, as indicated in the sketches. In fitting any spring-borne axle-box the box should not be too rigid a fit laterally. It is always better to have some side play to allow the axle-box to tip slightly as it rises and falls. No play, however, must be allowed in a fore-and-aft direction other than that absolutely necessary to easy working. As a rule, the author rounds the surfaces of the flange, as shown in Fig. 73. This should be done whether horns are fitted or not.

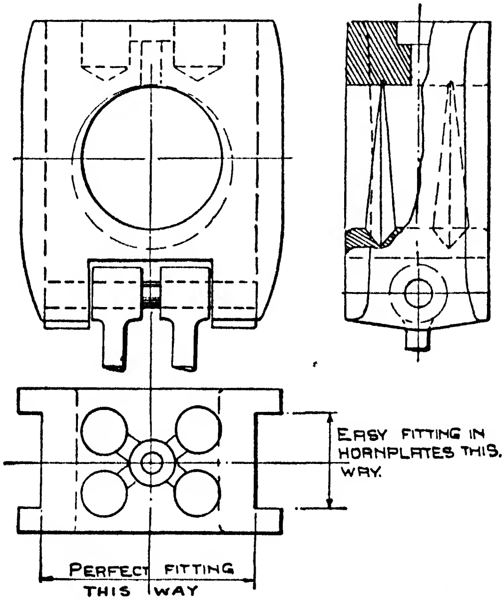


Fig. 74.—Solid Axle-box for Large Model.

Other Forms of Axle boxes.—For larger locomotives axle-boxes made as shown in Fig. 74 are used, and, if possible, the length of such a bearing should be equal to the diameter. This type of axle-box may be made from a casting or a block of brass, the eccentric groove being formed by a pointed boring tool in the lathe. Unless a separate keep is provided, as in the case of the axle-box shown in Figs. 75 and 75A, the box must be placed on the

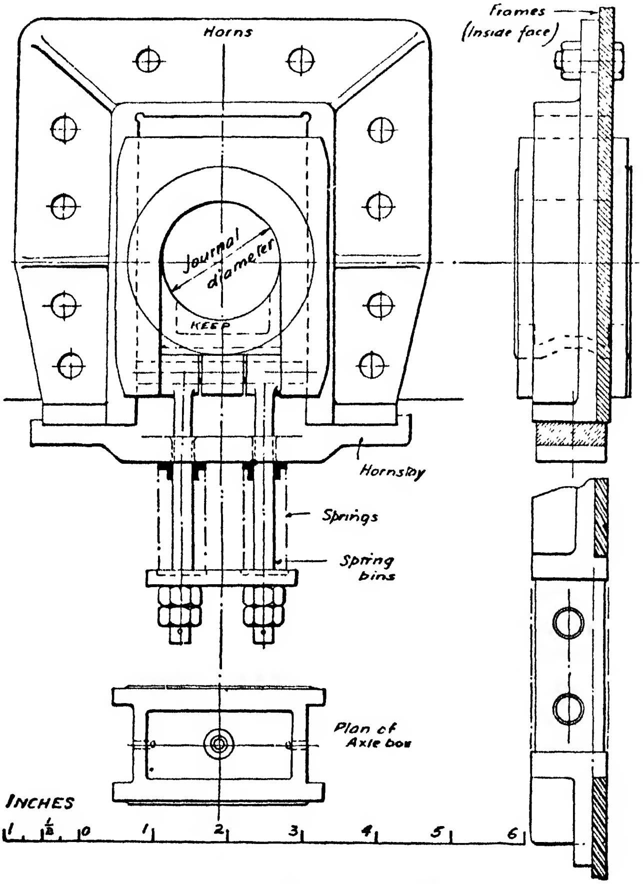


Fig. 75.—Large Model Axle-box.

axles before the wheels, and when once in place cannot be removed. The design shown in the last illustration is practically the same as that used in a real locomotive and would be employed only in the largest models.

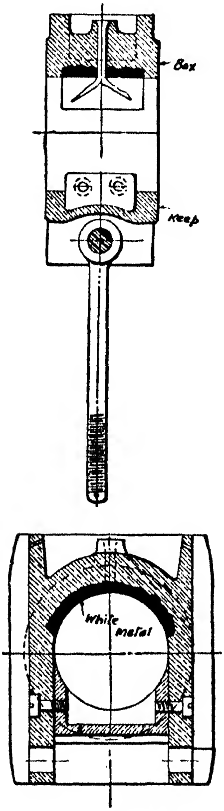


Fig. 75a.—See illustration on preceding page.

Spiral Springs.—Spiral springs are largely used in working model locomotives, and to determine the correct size of spring required for a given load the diagrams (Figs. 76 and 77) may be employed. If the load be 5 lb., and a suitable deflection $\frac{1}{8}$ in. with a 10-coil spring, one with a mean diameter (D) of .6 in. with 18 S.W.G. wire will provide this deflection as shown on the deflection diagram (Fig. 77). Referring to the safe-load diagram, it will be found that for 5 lb. an 18 S.W.G. spring .6 in. diameter is quite safe. It is obvious that a finer gauge wire, say 20G., would not be, as in .6 in diameter it is only safe up to 2 lb. load. By using the two diagrams in this way all complicated calculations will be eliminated. The number of coils does not affect the safe load, only the deflection. The diagrams suit both compression and tension springs.

Laminated Springs.—It may be taken as an axiom that laminated springs, if made to scale, will have little or no deflection, certainly not sufficient for the purposes of a working model. Where, for the sake of external appearance, they must be employed, then one of two methods must be adopted. As shown in Fig. 78, spring-steel

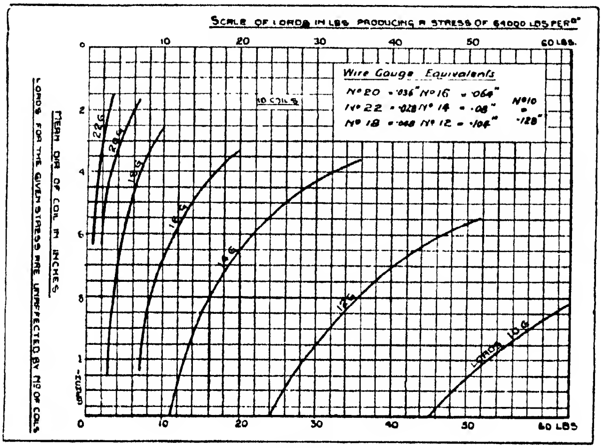


Fig. 76

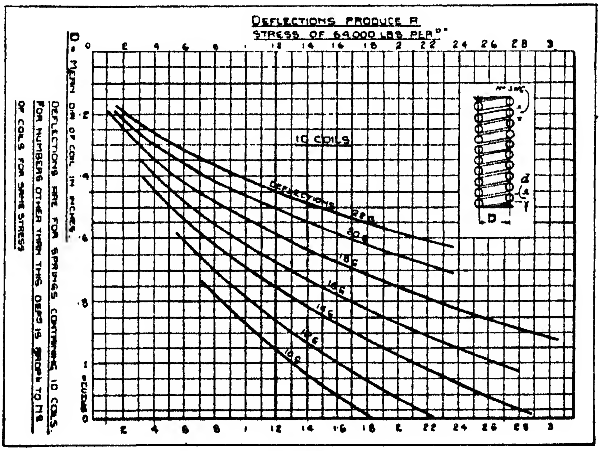


Fig. 77

Figs. 76 and 77.—Load Diagrams for Spiral Springs.

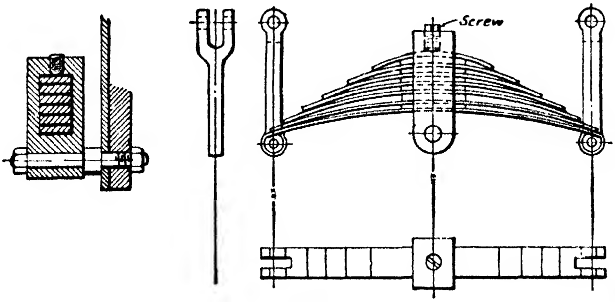


Fig. 78

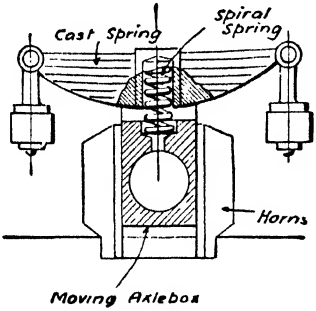


Fig. 79

Fig. 78.—Packed-out Laminated Model Bearing Springs.

Fig. 79.—Spiral Spring Concealed in Buckle.

Fig. 80.—Examples of Laminated Spring Suspension.

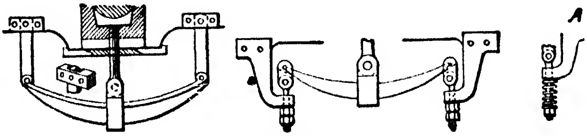


Fig. 80

plates are used (clock or watch springs make excellent laminations), and to reduce the stiffness the plates are packed out with strips of brass or steel placed in the centre. This gives the required "bulk" to the spring and at the same time provides sufficient resiliency. The other method is to cast the springs in the solid and to use spiral springs concealed in the buckle (Fig. 79) or in the suspension links as indicated at A (Fig. 80), and in the arrangement of bogie shown on page 95. The only difficulty in using plate springs is the eye end of the largest or back plate. Usually this is chosen out of thicker stuff than the remainder, and the eye is a piece of tube or drilled steel rod brazed on. Some skill (and luck) is required to temper the plate at the same time. The drawings in Fig. 80 show various suspensions for laminated springs.

CHAPTER VI

Wheels, Axles, Crank Axles, and Crank Pins

Types of Wheels. — Locomotive wheels are of three types: (a) driving wheels, (b) coupled wheels, and (c) carrying wheels, and except for the disposition of balance weights there is little difference between the first two classes. In actual practice wheels are made in two parts, the centres being of wrought or cast steel, or sometimes cast iron, and the tyres of a good quality hard steel, such as Bessemer steel. The tyres are shrunk on and fastened by studs or by retaining rings. Only in the largest models carrying passengers are separate tyres employed. Wheels are for the most part flanged; in eight- or ten-coupled engines one pair of wheels may have flangeless tyres to assist in negotiating sharp curves. Wheels are fixed to the axles by shrinking or forcing and securing by keys.

In model practice one-piece cast-iron wheels are usual, and a good range of castings made in suitable iron is available. The ordinary ironfoundry cannot be relied on to produce small wheels without chilling to such a degree that the amateur would find them impossible to machine.

The Number of Spokes.—The following table gives particulars of the number of spokes usual in real and in model wheels of various scales. It will readily be understood that it would be difficult to mould a wheel casting to, say, ½ in. to the foot or smaller exactly to scale.

	Real	*1 in. scale and larger*	*2½ in. gauge*	*1¾ in. gauge*
Bogie Wheels				
3 ft. to 3 ft. 6 in. ...	10	10	10	8 to 10
Carrying and Tender Wheels				
3 ft. 6 in. to 4 ft. 6 in.	12 to 14	12 to 14	12	10 to 12
Shunting Engine Coupled				
4 ft. to 4 ft. 9 in. ...	13 to 14	14	12 or 13	12
Tank Engine Coupled				
5 ft. to 5 ft. 6 in. ...	16 to 18	16 to 18	14 to 16	13 to 15
Passenger Engine Coupled				
6 ft. to 6 ft. 9 in. ...	18 to 22	18 to 22	17 to 20	16 to 18
7 ft. to 7 ft. 9 in. ...	22 to 24	22 to 24	20 to 22	18 to 20

In a small working model there is no objection to an odd number of spokes if it will improve the appearance of the wheel by making it nearly to scale and at the same time practical from the point of view of the foundry.

The modern cast-steel wheel has spokes of oval section. This is not followed in small models, as moulding is rendered more difficult, and therefore a section such as is shown in Fig. 81 is employed. The taper should be adequate and regular.

Balance Weights.—The balance weights of the prototype may be copied exactly, and a balance equal to the original will be obtained if the same number of cylinders and cranks are employed. As the mathematics of balancing would be out of place here a diagram showing the usual types of wheels employed is included in Fig. 82, where C = coupled, ID = inside cylinder driving, SD = single driving (outside cylinder), T = tender and trailer, OD = outside cylinder driving wheels, ISD = inside cylinder driving, and SB = small bogie wheels. The cross sections of the wheels (Fig. 83) exemplify the two

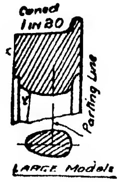


Fig. 81.—Tyre and Spoke Profiles.

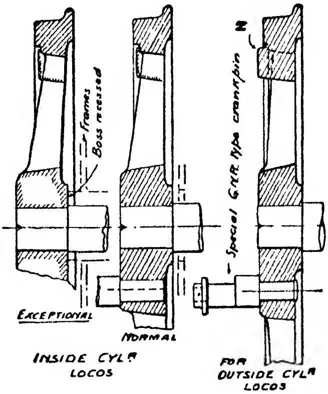


Fig. 83.—Sections of Driving Wheels.

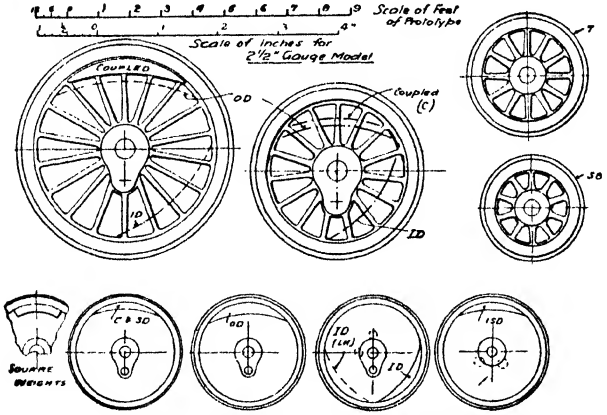


Fig. 82.—Types of Locomotive Wheels.

types employed. For an inside-cylinder engine the face of the wheel is often coned outwards, so that the maximum length of axle-box journal can be obtained. This coning is accentuated in the case of the driving axle of many engines, notably in the Caledonian and G.C.R. 4—6—0 types.

In modern outside-cylinder engines the face of the wheel spokes are usually quite flat, as the available width for the outside motion is limited. Balance weights, however, are arranged to project beyond the face of the tyre, as at Z, so that the plane of these weights more nearly coincides with the parts they are counterbalancing.

Making Patterns for Wheels.—In making patterns the tyre and flange and the back of the wheel boss should be left much thicker than required; other parts may be finished sizes, allowance being made for shrinkage. One master wood pattern, with double shrinkage allowance, may be made for a set of coupled wheels, brass castings obtained, cleaned up, and balance weights added in their respective positions and sizes. Wheels can always be repeated, and the character of the whole set is much easier to preserve than if separate patterns are attempted. The widths of tyres for various scales are given in Table II. The average width in real practice is from 5¼ in. to 5⅝ in. with a depth of flange of about 1⅛ in. The angle of coning of the treads should not exceed 1 in 20, and the outer sharp arris should be turned off at an angle of 45°. The face of the wheel marked Y in the section (Fig. 81) should not be turned but, to give a good result, should be quite true and neat in the original pattern. Then the face X (Fig. 81) only will need machining.

Turning Wheels.— In turning wheels the casting should be fettled up, so that on chucking it by the tread, back outwards, it runs reasonably true. The edge of the flange may then be turned nearly to size (but square), the back of the wheel and boss being faced and the hole of the axle bored. Never drill small wheels from the face side. Gauges should be made so that all similar wheels have the same bore, at least within half to a quarter thousandth of an inch. The wheel may then be reversed in the chuck and finished off.

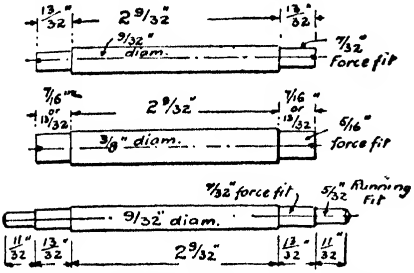


Fig. 84.—Axles for 2½-in. Gauge Models.

Axles.—The axles of full-size locomotives are made from a high grade of mild-steel of a character which will stand shocks. They have collars next to the wheels and journals. These may be copied in the model, but reliance in larger working models should not be placed on such collars for taking lateral loads. The wheel-boss faces provide much better surfaces. The ordinary model axle

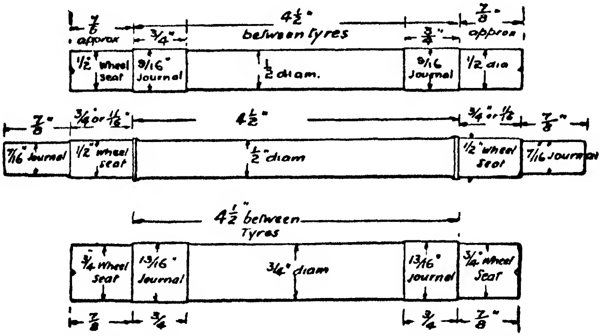


Fig. 85.—Axles for Larger Gauges (1-in. Scale).

is not subjected to such heavy stresses as in a real locomotive, but wear and tear is greater on outdoor lines, due to the presence of grit.

Fig. 84 shows typical axles for a model 2½-in. gauge engine, while Fig. 85 represents the author's practice for engines of 1 in. scale and larger. Axles should be forced into the wheels, the axles being from ½ to 1½ thousandth larger than the hole according to the size of the axle (see Fig. 86). The increase in size should be slightly greater

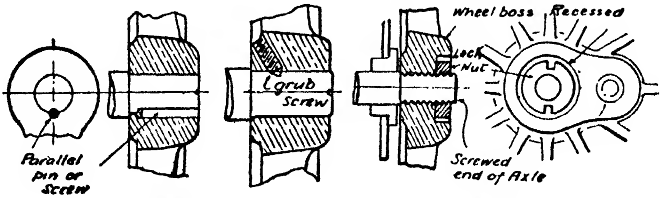


Fig. 86 Fig. 87

Figs. 86 and 87.—Methods of Fixing Wheels to Axles.

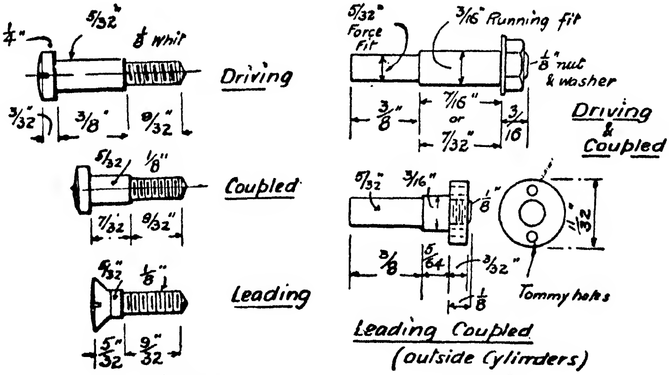


Fig. 88 Fig. 89

Figs. 88 and 89.—Crank Pins.

at the back than at the front, but this does not mean that the fitting at the latter point should in any way be loose. Centres should always be left in the axles so that wheels may be skimmed true. The distance between tyres is so important that accuracy must be observed in all lateral dimensions of wheels and axles.

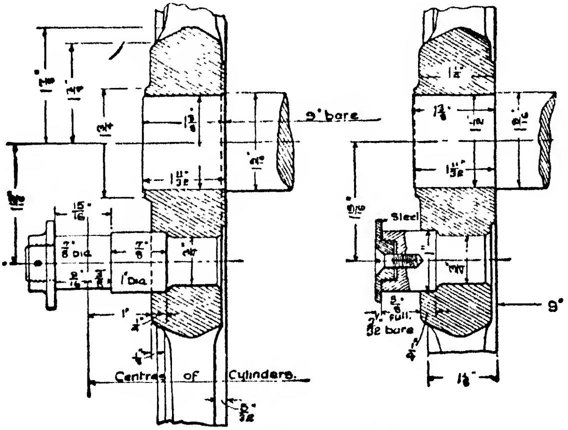


Fig. 90.—Large Model Crank Pins.

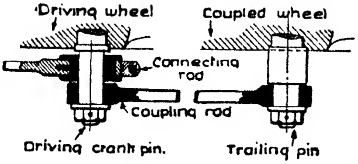


Fig. 91.—Crank Pins for Outside Cylinder 4—4—0 Locomotive.

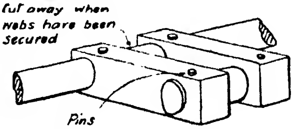


Fig. 92.—Built-up Crank Axle.

Bogie and carrying wheels require no fixing other than that provided by the force fitting, but driving and coupled wheels must be secured by pins or keys. The most satisfactory method is a screw or parallel pin driven axially half in the wheel and half in the shaft. Screwing wheels on to the axle is only adopted in small commercially made models, and a locking device must be provided to adjust and maintain the crank pins of coupled wheels at the correct angle. Fig. 87 shows a type of fixing adopted in best "toy" models.

The following sizes are recommended for axles in the various gauges, the exact dimensions of wheel seats, etc., being determined by the design of the axle. In any case, regular dimensions should be adopted, so that standard reamers may be obtained where their use is necessary.

Type	*Gauge*			*Scale*		
	1¾ in.	*2½ in.*	*3¼ in.*	*1 in.*	*1½ in.*	*2 in.*
	Diameter in Inches			Diameter in Inches		
Driving and Coupled	¼	⅜	9/16	13/16	1⅛	1 9/16
Bogie and Tender	3/16	9/32	⅜	9/16	13/16	1⅛

The maximum length of journal possible should be obtained. This will vary from ¼-in. long in small engines to 1¼ times the diameter in larger models. Crank-pin journals of crank axles should never be less than two-thirds the diameter of the axle in length.

Crank Pins.—Crank pins are an item in model locomotive construction which depend for design on the size of the engine.

For small (1¾-in. gauge) engines shouldered screws (see Fig. 88) are quite satisfactory. Fig. 89 shows the standard practice for 2½-in. gauge models, while for larger engines Fig. 90 is representative. Modern outside-cylinder locomotives of the "Atlantic" and 4—6—0 types often have very small clearances between the connecting rods and leading coupling rod crank pins. This leads to special arrangements for retaining the rods. Figs. 88 to 91 include a few designs. In any case, the retaining caps should fit the cranks tightly, so that the screw has little work to do in holding it in place. For model work the three-screw method is the least satisfactory.

Where screwed-on retaining nuts or collars, such as are shown in Fig. 90, are used the addition of a pin appears to be essential. Changes in diameter of crank pins (and axles) should be protected from failure by corners of ample radii, this being very important in large working models.

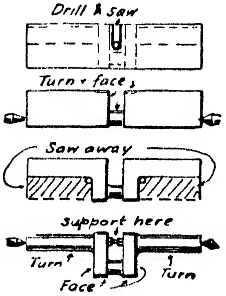


Fig. 93.—Method of Making Single-throw Crank from Bar.

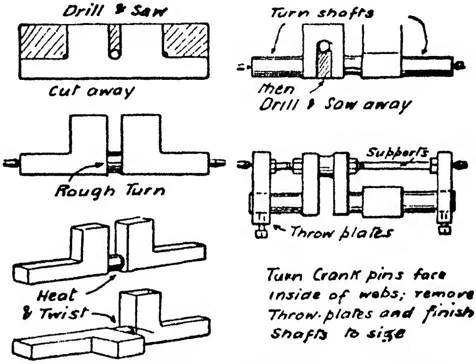


Fig. 94.—Operations Necessary for a Solid Two-throw Crank Axle.

Special crank pins are used on the G.N.R. "Atlantics" (see Fig. 83), which provide different throws for the connecting rod and coupling rod respectively.

Crank Axles.—Cranked axles are indigenous to this country. In America and abroad generally outside-cylinder locomotives are the rule, although France, with its four-cylinder compounds, uses quite a large number of cranked axles. The making of a model crank no doubt deters many amateurs from adopting an inside-cylinder prototype. Those who intend building a simple model with, say, a single inside cylinder should not be afraid of a built-up crank axle even if a lathe is not available. A workable degree of accuracy may be obtained by the construction shown in Fig. 92, use being made of bright drawn-steel rod. The parts are secured by pins and brazing. When joined the shaft between the web is cut. The author has seen double-throw crank axles made in the same way with success. Soft solder may be used instead of brazing, but the job will not be quite so sound.

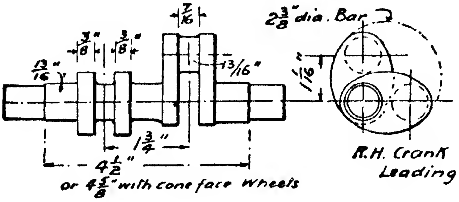


Fig. 95.—Method of Turning an Oval-web Crank Axle Out of a Round Bar.

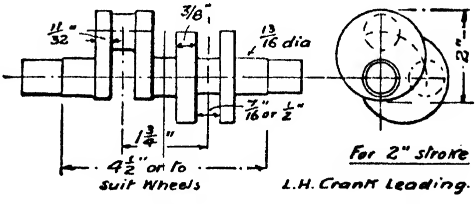


Fig. 96.—The "Worsdell" Type of Crank Axle.

Both single- and double-throw crank axles may be turned with the least possible amount of labour from mild-steel bar of a section the same size as the webs. The diagram (Fig. 93) shows the method of dealing with a single-throw shaft, and Fig. 94 with a double-throw. The centre portion of the latter should be bent hot after rough turning. Throw plates for the ends are required to get the best results. A good turner on a power lathe can produce such a crank under 2½ hours each if several are operated on at a time.

Cranks may be cast in mild steel, but those made from such castings are not quite so sound as cranks from wrought mild steel. Oval crank webs are often adopted for locomotive work, and Fig. 95 shows an economical method of turning such a crank out of the round bar.

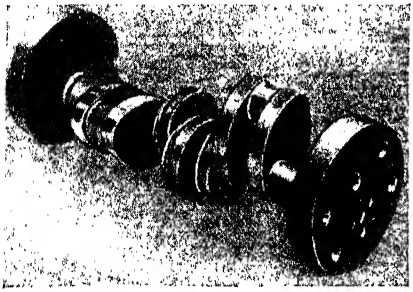


Fig. 97.—An Oval-web Crank Axle with Eccentrics out of Solid Bar.

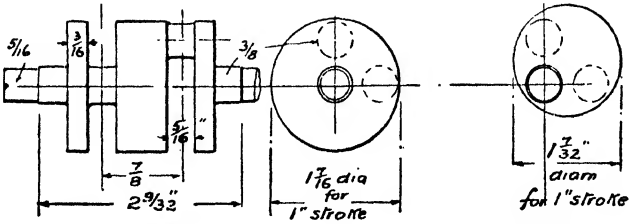


Fig. 98

Fig. 99

Figs. 98 and 99.—Alternative Forms of Crank Axle.

Two sides of the webs coincide in outline with the section of the round bar. The eccentrics (where used) may be formed out of the solid by increasing the number of centres on the ends of the original bar (see Figs. 96 and 97).

No advantage would appear to accrue by making a large model crank on the built-up method, but where balance webs are required—because of their use in the particular prototype being modelled—these are best made separately and applied to the webs of the crank axle.

Position of Cylinders.—The position of the cylinders and the type of valve gear used will largely determine the proportions of a crank axle. Where space is very much limited, then the use of round webs—the thickness of which may be half that of the crank diameter—will be found quite satisfactory. Fig. 98 shows a type of axle with a single central web which can be machined with the least trouble. More metal must be removed than is necessary where the webs are twisted to 90°, but where the tools are available

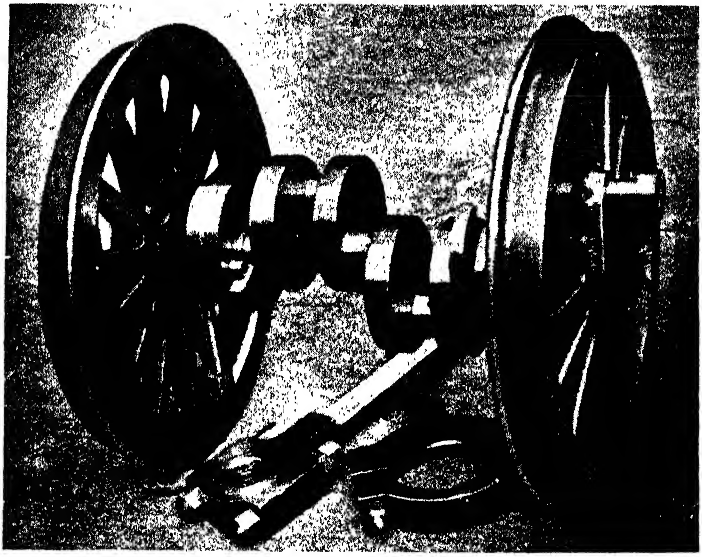


Fig. 100.—Crank Axle with Outside Slip Eccentrics.

this part of the work may be relegated to a heavy roughing lathe. The setting out shown in Fig. 99 represents another solution of the problem. In models having slip eccentrics the crank webs can very often be utilised as stops for the shifting eccentric sheaves in their two positions. This device is shown in the photographic reproduction (Fig. 100). Nearly all engines with outside cylinders and link motion designed by the writer during the last ten years have had the eccentrics solid with the driving axle. On the whole much labour is saved, a sound job results, and much smaller sheaves than otherwise possible can be obtained. Fig. 97 is a typical example of this practice, whilst Fig. 102 shows a set of link-motion eccentrics solid with a plain axle as used for outside cylinder locomotives.

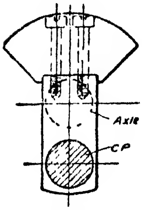


Fig. 101.—Crank-web Counter-balances.

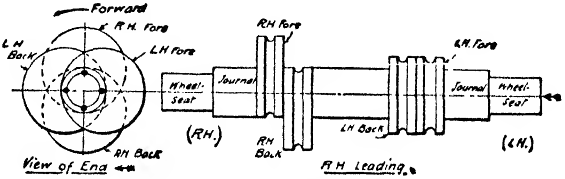


Fig. 102.—Link-motion Eccentrics Solid with Axle.

The diagram Fig. 101 shows a method of applying counterweights to the rectangular webs of a crank axle, which could be used in modelling some types of L.S.W.R. inside-cylinder locomotives

CHAPTER VII

Bogies, Pony Trucks and Radial Axle-boxes

Bogies.—A bogie is a separate carriage or truck attached to and supporting the main frame of the locomotive by a central pivot or "bogie pin." In a steam locomotive a bogie is usually carried on four wheels of relatively small diameter. It provides the necessary support for the front or rear end of the engine in a manner which renders the whole wheel base of the locomotive much more flexible on curves than if the frames were carried on rigid axles. As a rule, a four-wheeled bogie is much to be preferred to a two-wheeled truck or any other form of radial axle at the leading end of an express locomotive. A bogie also fits very naturally under the cylinders.

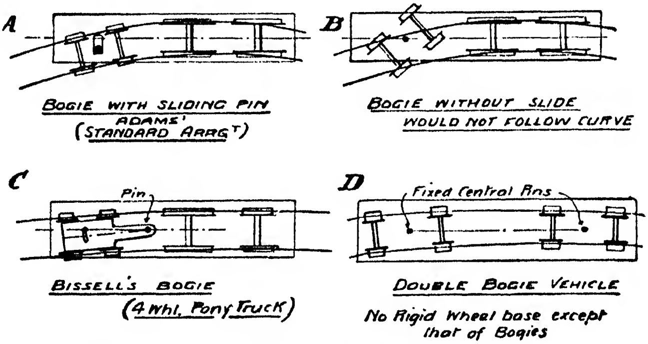


Fig. 103.—The Principle of the Railway Bogie.

The placing of a four-wheeled bogie truck on a plain central pivot does not entirely fulfil all the functions of a bogie forming part of a locomotive which has any portion of its wheel base rigid and parallel to its main frames This will perhaps be better understood by a reference to diagram B, Fig. 103. The bogie in such a locomotive must slide laterally as well as turn on its pivot, as shown at A. It is also desirable that the sliding box or pad piece into which the bogie pin fits should be controlled by springs or some equivalent device which will tend to keep the truck central. This is most important in larger models carrying passengers to prevent the bogie end of the locomotive "nosing" from side to side when travelling on a straight track.

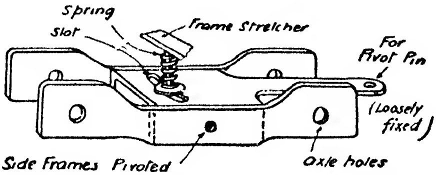


Fig. 104.—The "Bissell" Type of Bogie.

A form of bogie not often used, now known as the "Bissell" bogie, is illustrated at C in Fig. 103 and in Fig. 104.

In this truck the pivot is placed behind the rear bogie wheel, so that the centre of the truck virtually slides and turns. Its action is only truly correct for one particular radius of curve, and therefore is considered objectionable in full-size work. It is, however, for a model a very simple form of construction, easily controlled, and works quite well in practice. As illustrated, it is suitable for small gauge models. The frames act as equalisers, being pivoted to the cross plate. A central post with a spring should be fitted to a convenient frame stretcher to limit its movement and provide for vertical springing.

Two forms of "Adams," or sliding pivot bogies, common to British locomotives are illustrated in Figs. 105 and 114, the first being the predominant type. Some of the springing details shown are employed indiscriminately in both types. The bogie (Figs. 106 to 109) has frames set at a narrower distance apart than those of the locomotive, so that an equaliser and spring may be applied to both axleboxes on each side. The bogie frames are connected by a strong "stretcher casting" in the centre. This stretcher has a slot formed in it in which a pad piece is arranged. The circular top flange of this block supports the weight of the locomotive. The block is also bored to take the pin. This pin is fixed to or is part of another strong cross stretcher secured to the main frames of the locomotive. The sliding block is fitted with spiral or laminated side-controlling springs which tend to keep it central. No control of the swivelling movement of the bogie on the pin is usual or necessary.

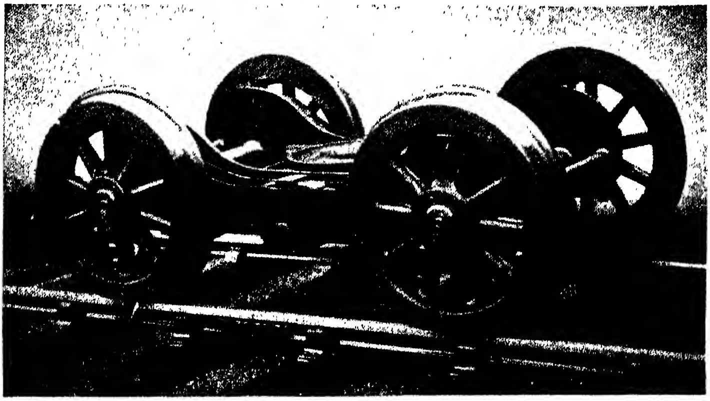


Fig. 105.—"Adams" Type of Bogie Fitted to 7¼-in. Gauge Model G.C.R. Locomotive.

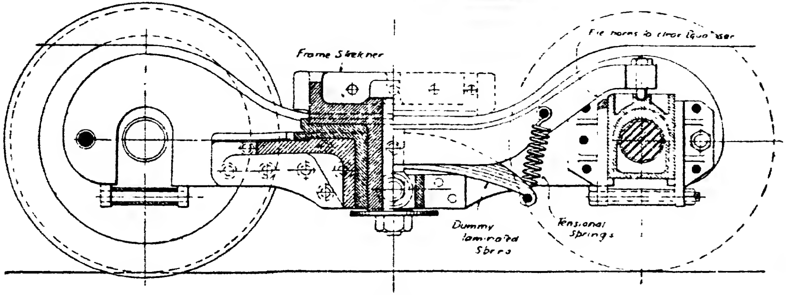


Fig. 106

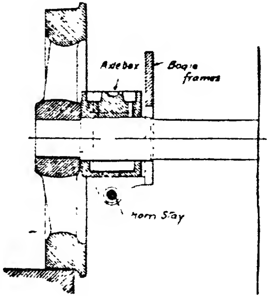


Fig 108

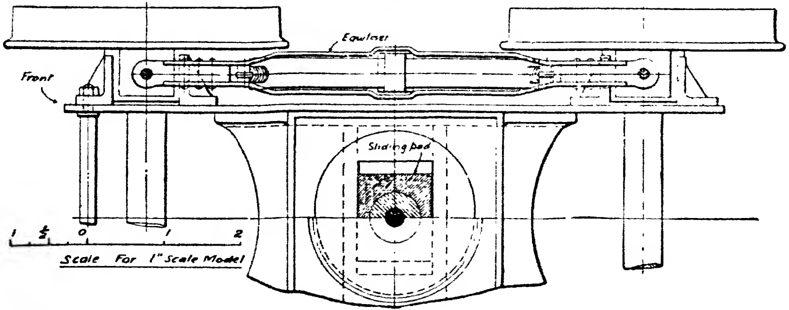


Fig 107

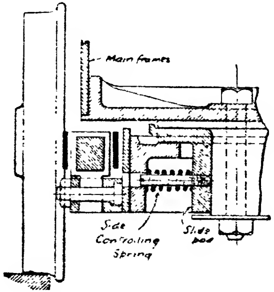


Fig. 109

Figs. 106 to 109.—Bogie of the "Adams" Type made for a Large Scale Model.

The Adams type of bogie is very simply modelled in small sizes by slotting the cross stretcher to take the pin, as illustrated in Fig. 110, the sliding block being omitted. Fig. 111 shows the standard arrangement for 2½-in. gauge locomotives. A side control is only essential in any engine of this or smaller gauge in which the centre of the rigid wheel base is some distance from the bogie centre, as, for instance, in a 0—4—4 or 2—6—4 type model. The usual axle-box guides are dispensed with in favour of an adaptation of the scheme illustrated in Fig. 71 (Chapter V). The slot in small models should be as wide as possible, as curves are proportionately much sharper than in large examples.

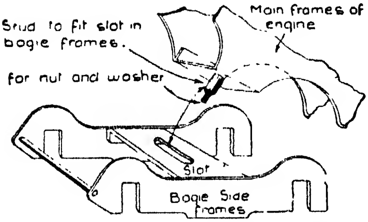


Fig. 110.—Simple Model Bogie.

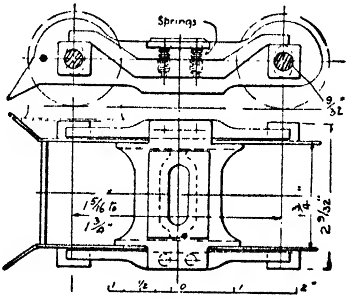


Fig. 111.—"Adams" Bogie for 2½-in. Gauge Models.

A further modification of the sliding type of bogie suitable for 1¾-in. and 2-in. gauge is shown in Fig. 112. The sliding block is fitted to two round rods riveted to the main frames. The bogie pin is a shouldered screw, while the springing of the whole truck is effected by a single central spring. The frames of the bogie act as an equaliser, so that the whole of the functions of the orthodox type of locomotive bogie (as in Fig. 106) are preserved. It is important to note that equalising the side frames on a pivot alone is not sufficient. The central spring allows for a complete rise and fall of one side or the other of the bogie

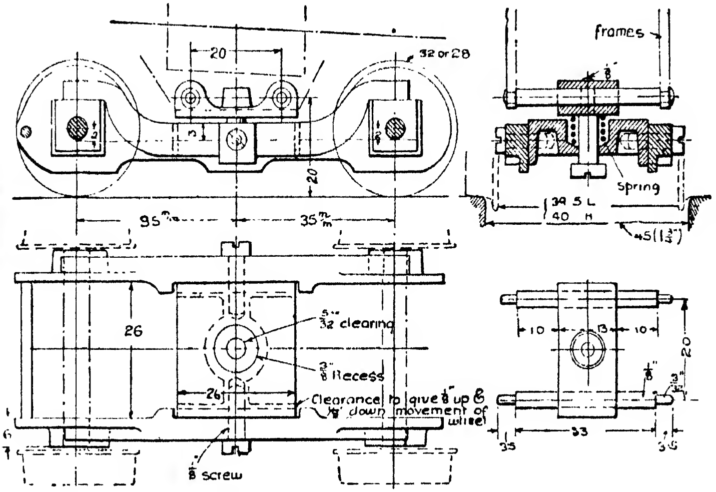


Fig. 112.—Bogie with Equalising Frames and Central Spring for 1¾-in. Gauge Models.

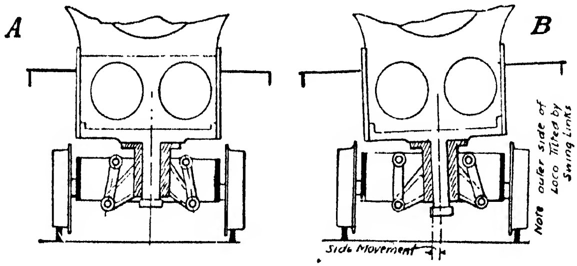


Fig. 113.—Diagram Showing the Action of Swing Links.

truck, a feature which an uneven road surface demands. The round rods with shouldered ends make a very simple frame stretcher.

The swing-link bogie (the second common form) is used to some extent in this country, but is more popular in America. The usual sliding block is employed, but this block does not bear directly on the cross stretcher of the bogie. The block, and therefore the weight of the part of the engine the bogie supports, is connected to the bogie stretcher by a set of links placed at a slight inclination on each side as shown in the diagram, Fig. 113, at A. These links, due to the weight upon them, tend to maintain the bogie in the central position, as will be seen from the sketch B. Further, the outer rail of the curve tends to lift the engine and therefore increases pressure on the outer wheels. This assists in preventing the flange from mounting the rail.

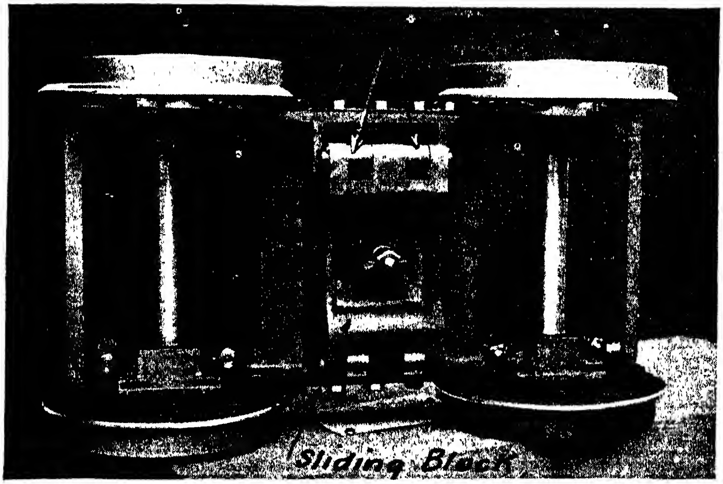


Fig. 114.—Underside of Bogie shown by Figs. 113 and 115.

The photograph and drawings (Figs. 114 to 115A) show a typical example of the swing-link bogie as applied to an English locomotive. In most of them it is accompanied with an absence of the equaliser, the axle boxes being separately sprung as on the L.Y.R., G.N.R. and L.B.S.C.R. locomotives. The G.W.R. uses the swing-link bogie extensively, but in conjunction with the equaliser.

Concealed Springs.—As laminated springs are not of much use in a small model, and as they are fitted to equalisers to the exclusion of other types of springs in actual practice, it is usual to devise some method of concealing a spiral spring in the buckle of the dummy model laminated spring or on the ends of the equaliser. Fig. 106 shows one method, while the various schemes for bearing springs illustrated in Chapter V will suggest others. Where the imitation of the laminated spring is not attempted, then spiral springs may be used either underhung as shown in Fig. 116 at A or overhung as at B. The first method has the disadvantage that should the engine become derailed the spring pins are bound to be bent or otherwise damaged. By placing the springs on top of the equaliser no such damage is possible. Moreover, the arrangement looks very neat and is quite effective.

Pony Trucks.—The use of the pony truck or bogie with a single pair of wheels has increased considerably during recent years to the exclusion of the sliding radial axle-box. The pony truck is at all times to be preferred in model practice, although sometimes it cannot be easily applied. The action on a curve is the same as that of the "Bissell" four-wheeled truck, Figs. 103 and 104; and similarly a truck of a given radius is only suitable for one particular curve. As only one pair of wheels is employed, this fault is of no great importance in practice. The radius of the truck should be proportioned so that the axle is truly radial to the centre of the average curve.

Some form of side control is advisable, but is not essential in small models. Fig. 117 shows the standard arrangement employed for 2½-in. gauge engines. The

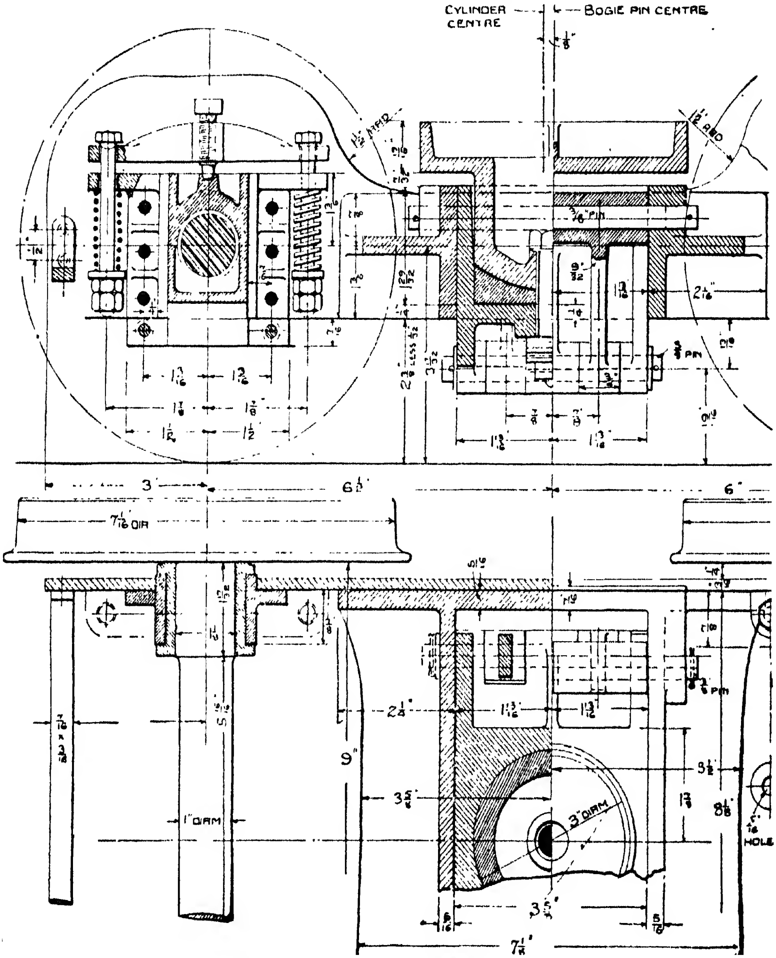


Fig. 115.—Model G.N.R. Swing-link Bogie for 9½-in. Gauge Locomotive.

pivot is more or less of a universal joint, and the bearing springs are integral with the truck and stretcher casting.

Fig. 118 shows an adaptation to the leading end of a model locomotive with outside cylinders, the frame stretcher

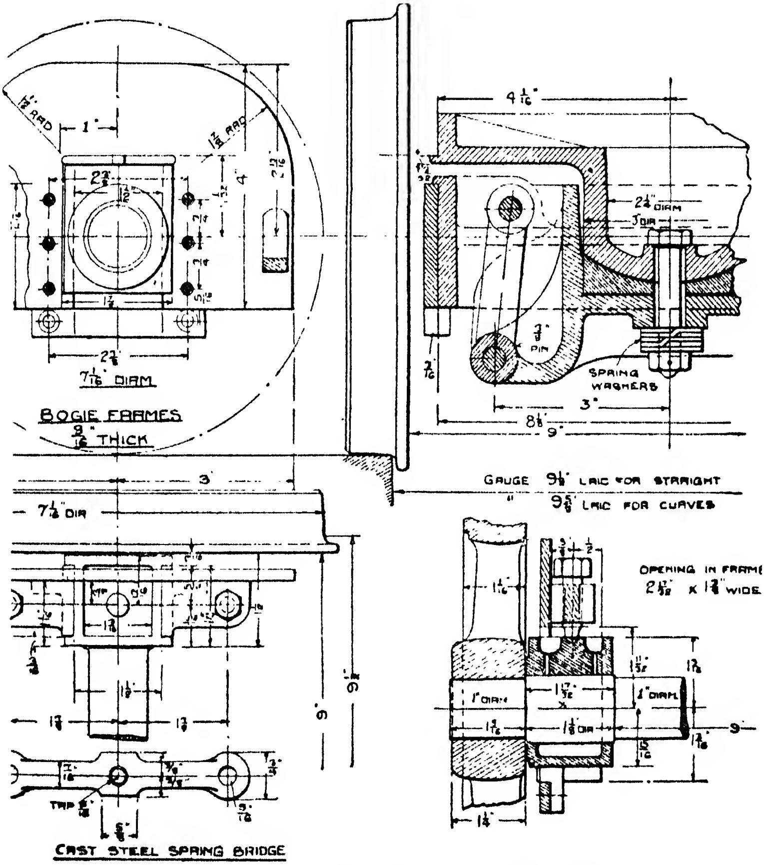


Fig. 115A.—See illustration on preceding page.

being a piece of square rod shouldered down at the ends to fit holes in the main frames. The arrangement shown by Fig. 119 is more applicable to a large model. Here the frames are more or less rigid vertically and have a limited lateral sliding movement only. The axle-boxes are fitted in the usual guides and are provided with a lever-spring gear. Side controlling springs may be fitted close to the pivot, as in Fig. 120.

It is important that main frames which are adjacent to bogie wheels or pony trucks should be reduced in width to provide for the required side play. In modern engines bogie and pony truck wheels are often made of relatively small diameter so that they can swing clear under the main frames. This is not always possible, and the limits prescribed by the presence of main frames bears to an important extent on the general design of the engine with respect to the minimum radius of curves that can be negotiated.

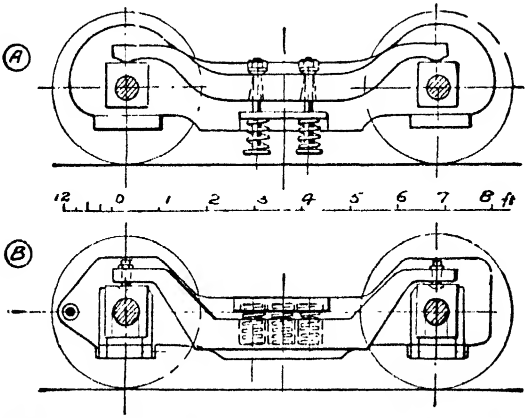


Fig. 116.—Equalising-spring Gear for Bogie Trucks.

Radial Axle-boxes.—The action of the radial axle-box is identical with that of the pony truck such as just described. The axle-boxes are usually inside the frames, are tied together and guided by inclined or curved horns. The form illustrated in Fig. 121 is rather complicated. Here the sliding movement of the axle-box is entirely separate from the vertical motion of the wheels on the bearing springs. The radial axle-box (Fig. 122) was designed for a large model in which the fitment came directly under the firebox. The main guide casting is an inverted **U** section, closed against ashes and the heat of the fire at the top. Fig. 123 is an illustration of a simple arrangement very successfully applied to a large model. The horns are machined to an angle tangential to the desired radius, and the two axle-boxes are tied together at the top by a crossbar with a lipped palm-piece at each end. The bearing springs are attached to a bridge resting on the crossbar.

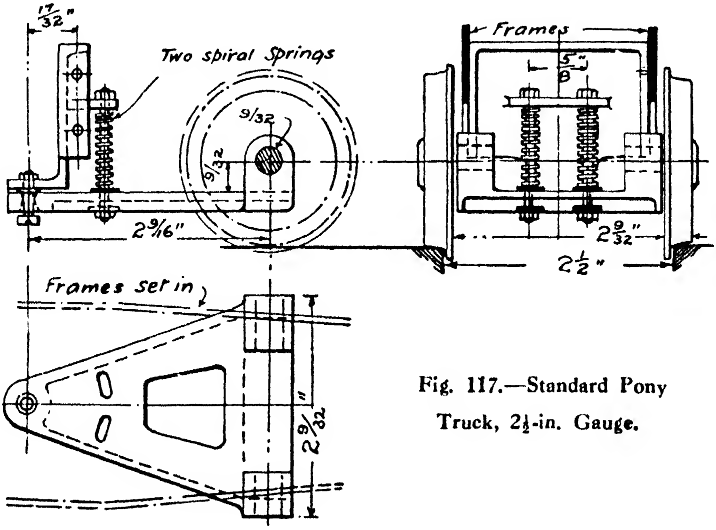


Fig. 117.—Standard Pony Truck, 2½-in. Gauge.

In all radial axle-boxes in which the axle-box moves up and down on the springs, as well as slides, the fitting of the boxes in the guides must be very slack, otherwise the axle-box will jam when the axle is tilted. The radius chosen for the truck from the pivot to the axle, or for the

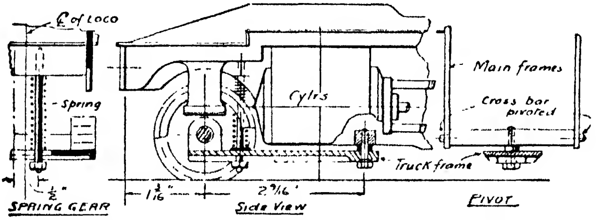


Fig. 118.—Pony Truck at Leading-end of Locomotive.

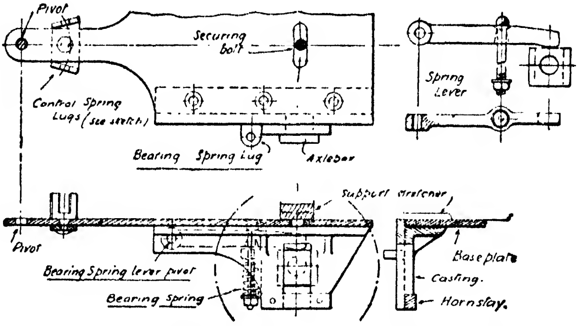


Fig. 119.—Pony Truck at Trailing-end of Tank Locomotive.

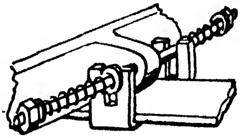


Fig. 120.—Side Control Spring for Pony Truck.

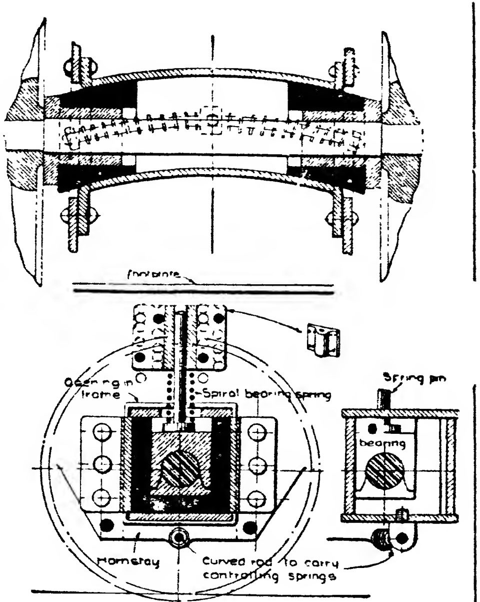


Fig. 121.—Radial Axle-box for Pair of Carrying-wheels of a Large Model.

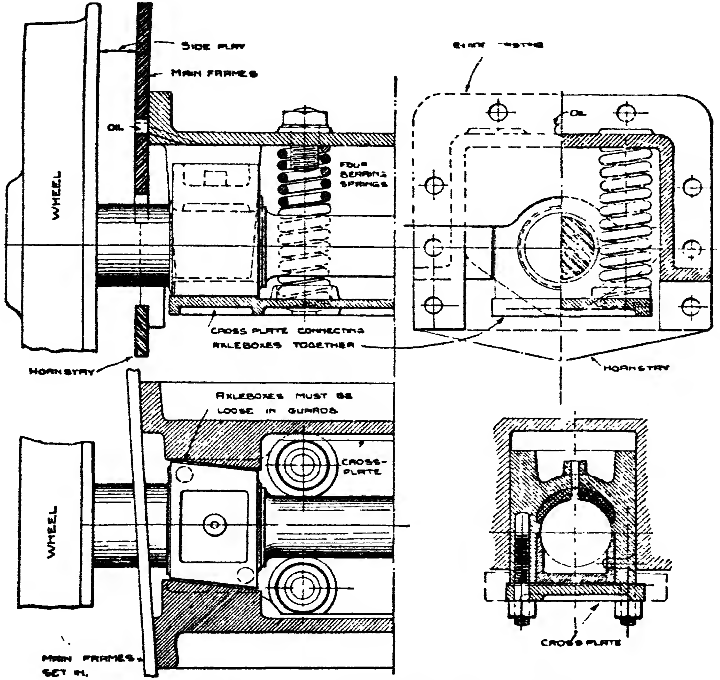


Fig. 122—Another Form of Radial Axle-box used in 15 in. Gauge Models.

horn-plates, as the case may be, should be larger rather than smaller than that nominally required.

To estimate the amount of clearance required between frames and bogie wheels (including pony trucks) a template of the proposed minimum curve should be laid alongside the elevation drawing of the engine. The centre of the curve should be placed against the centre of the rigid portion of the wheel base, as indicated in Fig. 124.

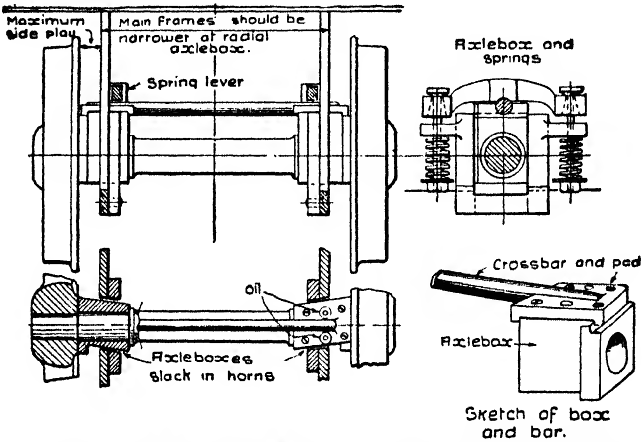


Fig. 123.—Simple Arrangement for Imparting a Radial Movement to Carrying Axle-boxes.

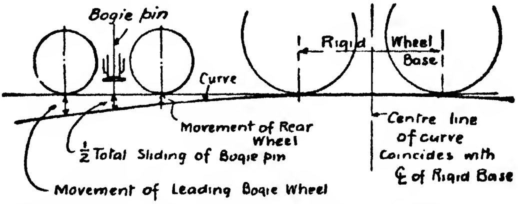


Fig. 124.—Method of Estimating the Side Play of the Bogie Wheels of a 4—4—0 Type Locomotive.

This method was referred to in the notes on selecting a design of locomotive, and is shown applied to a model 4—4—0 type engine.

Trailing Frames.—Locomotives having wide "Wootten" fireboxes, such as fitted to the G.N.R. Atlantics and to most American designs, require special treatment at the trailing end. The frames are doubled under the firebox in the G.N.R. engines, but the trailing wheels are supported by the outer plates only, as illustrated in the photograph of the 9½-in. gauge 4—4—2 type engine (Fig. 124A).

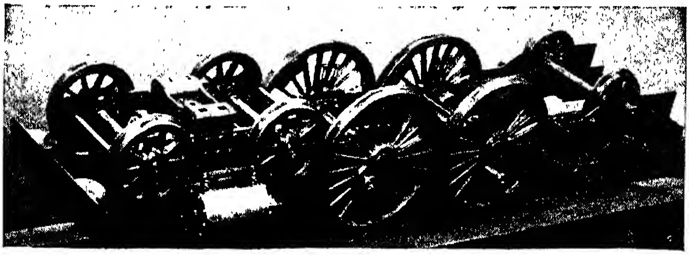


Fig. 124A.—Chassis of a Large Model G.N.R. Atlantic Locomotive.

In America it is common practice to fit an outside framed pony truck under the firebox.

CHAPTER VIII

Cylinders

Types of Cylinders. — Cylinders in model-locomotive practice may be classified into four main groups:

(a) Inside cylinders with valves between, embodying most of the features of real practice up to the last decade.

(b) Inside cylinders with valves either on top or below the piston. This is the modern and most convenient form.

(c) Outside cylinders with steam chests inside the frames.

(d) Outside cylinders with valves above the pistons.

Before a satisfactory design for the arrangement of cylinders classed under the heading (b) was evolved by the author several arrangements were suggested to obtain the very desirable features of accessibility to the valves and port faces. Two arrangements are illustrated by diagram Fig. 125 showing the valves outside the cylinders, the ports being visible through a hole in the main frames. The second scheme (Fig. 126) is adapted from the early L.N.W.R. engines of Mr. Ramsbottom's design.

The standard British practice up to the advent of the superheater is shown in the diagram Fig. 127 and photograph Fig. 128. As will be seen, from the point of view of construction, subsequent repair, and packing of the spindles the scheme has little to recommend itself to the model engineer. Furthermore, the cylinders are restricted

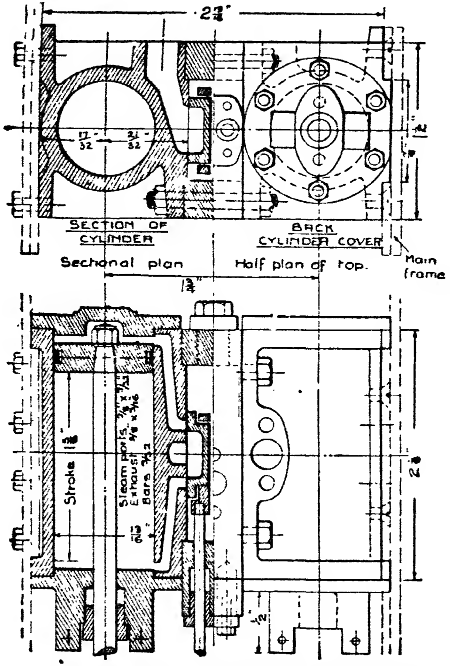


Fig. 127.—Standard British Inside-cylinder Arrangement, for ¾-in. Scale Model.

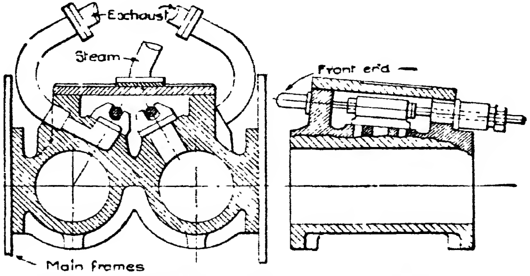


Fig. 126.—Inside Cylinders with Inclined Valves.

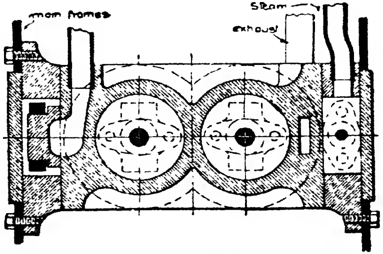


Fig. 125.—Model Inside Cylinders with Outside Valve Gear.

in bore by the distance between the frames and the large amount of space taken up by the steam chest. In one well-known model in which this type of cylinder was employed the cylinders, slide bars, motion plate and spindles were erected on auxiliary frames, fitting between the main frames. In view of their inaccessibility this was not at all a bad idea. The whole unit could be withdrawn by removing a few screws.

Cylinders with Valves Below the Piston.—Cylinders with valves below the pistons were used on British locomotives contemporary with those with valves between, and were considered superior in that the valves did not rest on the port faces when the engine was running with steam shut off. In addition, better draining of the cylinders was claimed for the design. Both these considerations have no great weight in model practice. The chief advantage is that the valve can easily be inspected and set by turning the loco upside down and removing the steam chest cover. Further, the cylinders and valve chest are less cramped. A photograph of the arrangement is given by Fig. 129.

The author's standard design, evolved in 1902, is shown in Fig. 130. The steam passages are very simply arranged by drilling, the opening for the horizontal passage being stopped by a screw plug. As valves rusting or otherwise sticking on the spindle off the port faces is a source of trouble rather than an advantage in model practice the use of a spring to obviate the effects of gravity is essential and is included in the design. The valve chest may be placed parallel to the axes of the cylinders, as indicated on the drawing, or if the ordinary arrangement of Stephenson's link motion (see Chapter X) is employed, then the surfaces must be inclined to suit the motion. As fitted by

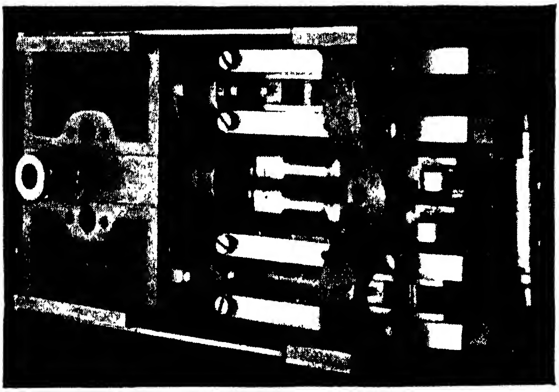


Fig. 128.—Cylinders (*see* Fig. 127) Built into Auxiliary Frames.

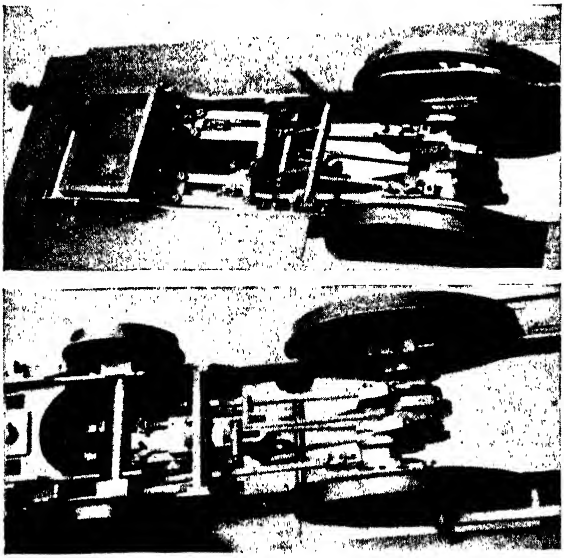


Fig. 129.—Two Views of a Model Locomotive Chassis with "Valves-below" Cylinders and Stephenson's Link Motion. (*Made by Mr. H. P. Jackson.*)

the author the valves were operated by a slip-eccentric valve gear (with sheaves outside the crank webs, see Fig. 100, Chapter VI) through a rocking shaft.

Radial Valve Gears.—The application of radial valve gears like Joy's, Hackworth's and Greenly's to model locomotives led to the adoption of cylinders with the valves on top. The arrangement of the passages was therefore modified by the author as shown in Fig. 131. The exhaust, which had been the difficulty with such cylinders, was led through the steam chest as indicated. This pipe has a taper thread at the bottom, so that by coating the screw with a little red lead and oil a perfectly steam-tight joint is easily obtained, and the top joint is similarly made sound by a stuffing-box. By unscrewing the latter the steam chest cover can readily be removed for the inspection of the slide valves.

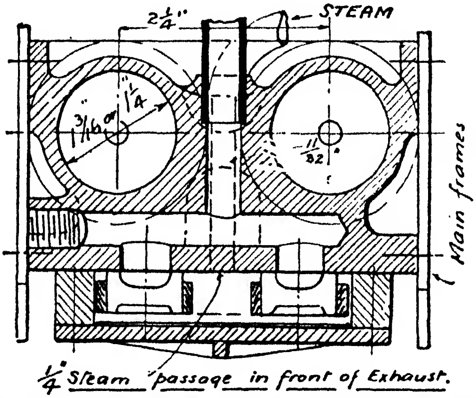


Fig. 130.—Model Inside Cylinders with Valves Below.

Considerable freedom in the matter of dimensions is obtained by adopting this design. In addition, the steam connections are of the simplest character. The exhaust leaves the cylinders in the centre, and is therefore in normal designs directly under the chimney.

The centres of the cylinders should not be placed at more than a scale equivalent of 2 ft. between, except in

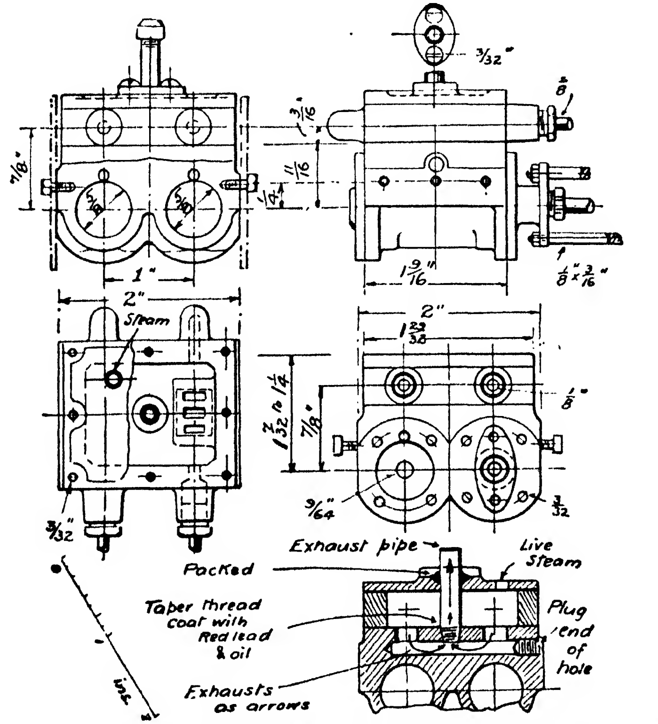


Fig. 131.—Valves-above Cylinders for Standard 2½-in. Gauge Models.

2½-in. gauge engines the usual standard is 1¾ S where S is the scale of the model. The valve spindles may be in any convenient position so long as the valve can clear the exhaust pipe. Generally, to suit Joy's or other radial valve gear, which moves in the same plane as that of the connecting rod, the spindles are placed directly above the piston rods. Fig. 132 is a cross section of a "valves on top" set of inside cylinders designed for a model 1-in. scale locomotive fitted with indirect Stephenson's link motion or Walschaert's single eccentric valve gear. In both these reversing gears the valve spindle is much more conveniently connected up if it is placed on one side or the other of the vertical line of the cylinders.

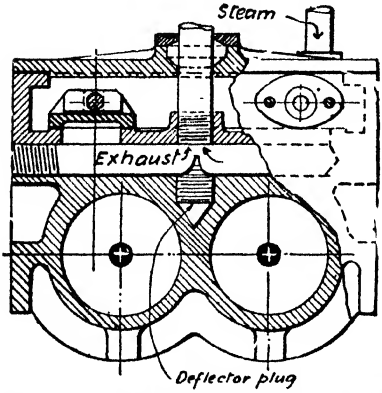


Fig. 132.—Inside Cylinders with Valve Centre Arranged for Walschaert's Gear.

It is advisable to arrange inside cylinders (Fig. 133) of this design with the lower fixing-flanges as high up as possible, so that the maximum clearance is obtained at points adjacent to bogie wheels and frames. In the 2½-in. gauge standard cylinders it will be noticed that the fixings to the frames are above the centre of the cylinders for this reason. In many modern engines the cylinders are not placed directly over the centre of the bogie, which renders some such precautions necessary.

Fig. 133.—Cylinders with Valves on Top.

Ports.—With the valve chest inside the frames, outside cylinders are in the larger model engines entirely separate components on each side. Fig. 134 illustrates the author's standard design. The exhaust pipes are made up in the form of an inverted **Y**—often termed "breeches pipes" because of their shape—and to get at the joint with the cylinder the opening in the main frames for the steam chest is scalloped out on the top. The design given by Fig. 134 is arranged for 2½-in. gauge locomotives. In larger engines the ports are usually cast in, and the general scheme is similar to the cylinders applied to the 15-in. gauge model shown in Fig. 135. In casting-in ports it is advisable to increase the thickness of the port bars slightly above the normal to ensure sound castings. For engines of medium size, say 1-in. to 1½-in. scale, the exhaust ports only are cast in. The steam ports are then end-milled down, and passages consisting of two or more holes, according to the size of the model, are drilled to meet these milled recesses. In coring the cylinder bore plenty of metal

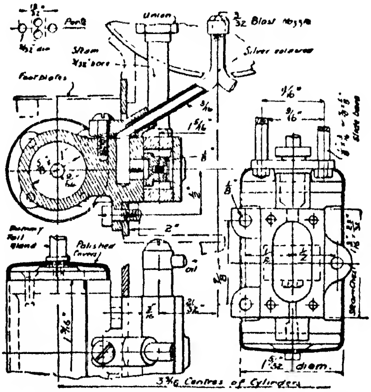


Fig. 134.—Separate Outside Cylinders for 2½-in. Gauge.

should always be provided in the walls to be machined out. In the case of cylinders for 2½-in. gauge locomotives and smaller the castings are best cast quite solid and then roughly drilled to slightly less than the size of the bore. From this hole the cylinders can be machined where necessary, the bore being finished and lapped as a last operation. Emery should never be used for lapping gunmetal cylinders.

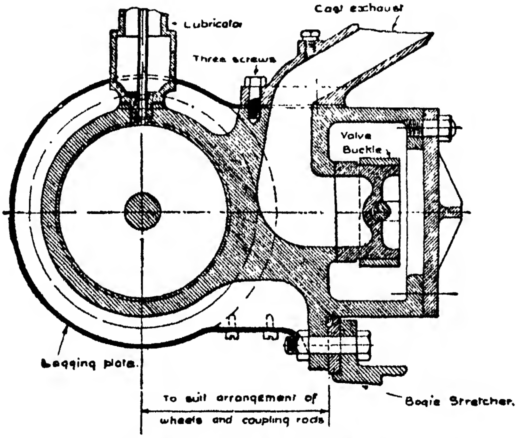


Fig. 135 and 135A (opposite).—Separate Cylinders for Large Models.

Cross-connected Cylinders with All-circular Forms.—In view of the difficulties in aligning, supporting and arranging the pipes to and from separate outside cylinders the author designed a system, more particularly intended for locomotives of small gauge, in which a cross-connected steam chest is employed. The exhaust passages (see Figs. 140 and 141, page 119) are arranged within the walls of the steam chest, and the advantage is obtained that the chest itself forms a very stiff cross-stretcher for the main frame. Valve setting can be accomplished either by sight or by means of a plug jig with the ports cut in it (see Fig. 141).

The latest development of the design is interesting in that it eliminates fitting and machining rectangular forms. The whole of the work to the frames and cylinders may be done in the lathe and drilling machine. The design shown by Figs. 136 to 139 is intended for 1¾-in. gauge models (or 2-in. gauge engines with addition of ¼ in. to the transverse measurements marked A, B and C), and, it will be noticed, the "all-circular" feature of the scheme is obtained by making the opening in the main frames $\frac{3}{32}$ in. out of centre. The spigot which fits this opening provides a surface for the joint of the exhaust passage. The horizontal passage for the exhaust is drilled right through the top of the steam chest casting as shown in the sections Figs. 138 and 140. The latter drawing also indicates an arrangement of two plates, with notched edges to allow the steam to pass and with a spring between them, to ensure the valves always remaining on their faces.

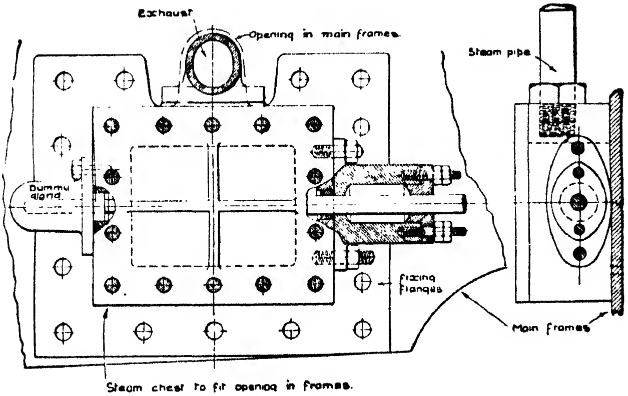


Fig. 135A.—(See illustration on preceding page.)

2½-in. Gauge Cylinders.—To suit 2½-in. gauge engines cylinders of dimensions illustrated in Fig. 142 are used.

Here the offset of the cylinder and steam chest spigots is ⅛ in., and the hole in the main frames 1⅜ in. The bogie pin may be fitted to the steam chest, a square facing being cast on the underside as indicated. There is no reason why the system should not be applied to larger models than 2½-in. gauge, although the use of separate cylinders

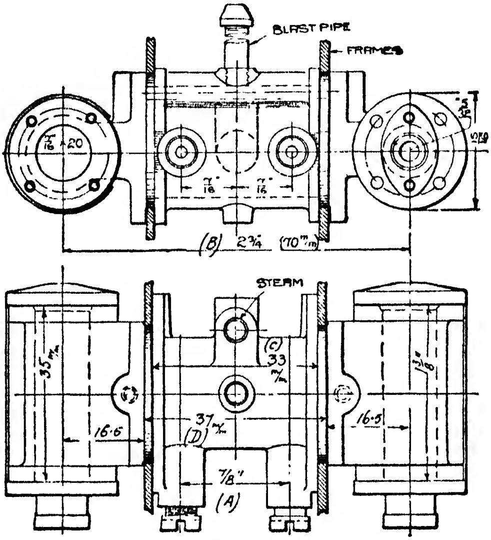


Fig. 136.—Standard Model Outside Cylinders with Cross-connected Steam Chests; No. 1 Gauge Size.

and exhaust pipes has less against it than in the smallest sizes.

Outside Cylinders with Valves on Top. — Many modern engines, especially superheater locomotives, have outside cylinders with valves on the top. This is an outcome of American practice, and its development has been encouraged by the adoption of outside valve gears. The earlier examples had plain slide valves which were operated by link motion inside the frames, a rocking shaft

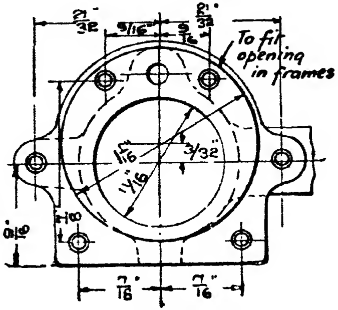


Fig. 137

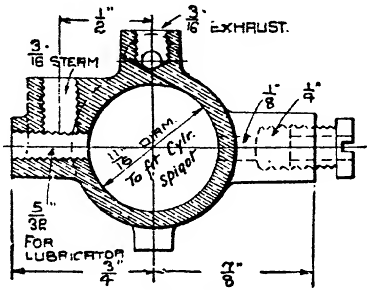


Fig. 138

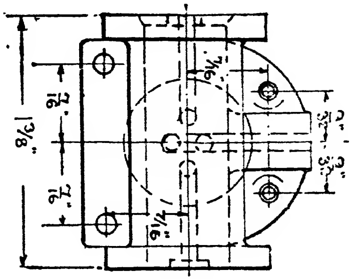


Fig. 139

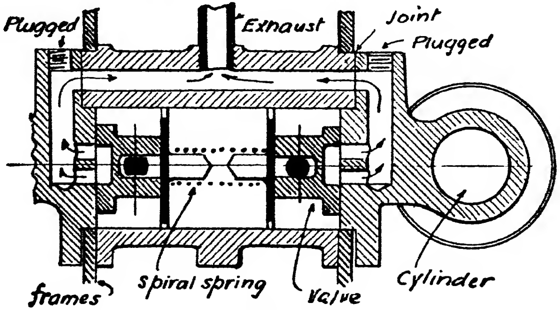


Fig. 140

Fig. 137 to 139.—Details of Cylinders Shown by Fig. 136.

Figs. 140 and 141.—Method of Drilling Exhaust Passages for Cross-connected Cylinders by Means of Jig.

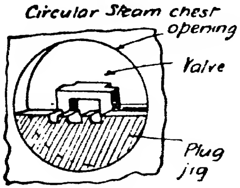


Fig 141.

transmitting the motion to the outside. The author has recently adopted this scheme in some 15-in. gauge engines he has designed, the advantage claimed being ready access to the valves, port faces and glands. The superheater locomotive is usually fitted with piston valves, but, as a general thing, piston valves are not likely to be adopted in amateur-made models. Designs are shown (Figs. 143 and 144) in which the external appearance of the piston-valve prototype is retained, in conjunction with ordinary slide valves. The steam chest and cylinder body are separate castings screwed together, their end flanges being of such a profile that when connected up and covered by a sheet-steel lagging plate the illusion is complete. With both Walschaert's and the author's corrected valve gear it is

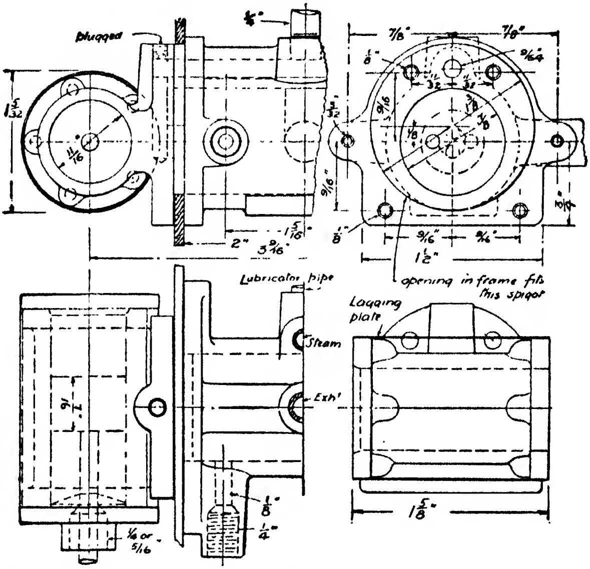


Fig. 142.—Cross-connected Outside Cylinders for 2½-in. Gauge Models

usual to offset the valve spindle in line with the gear. This tends to cramp the steam chest, but by placing the fixing screws judiciously in the four corners of the steam chest a satisfactory fastening can be obtained.

As shown for both the American and British models, the use of the ordinary gasfitters' running joints is a feature in the attachment of the steam piping. The live steam pipe is secured by a running nipple and back nut. The nipple is threaded both inside and outside to the same pitch. It is screwed well up the pipe at the outset and runs off the pipe at the same rate as it is being screwed into the steam chest. The joints of both the nipple and the back nut will require grummeting with thread dipped in a red-lead and oil paste.

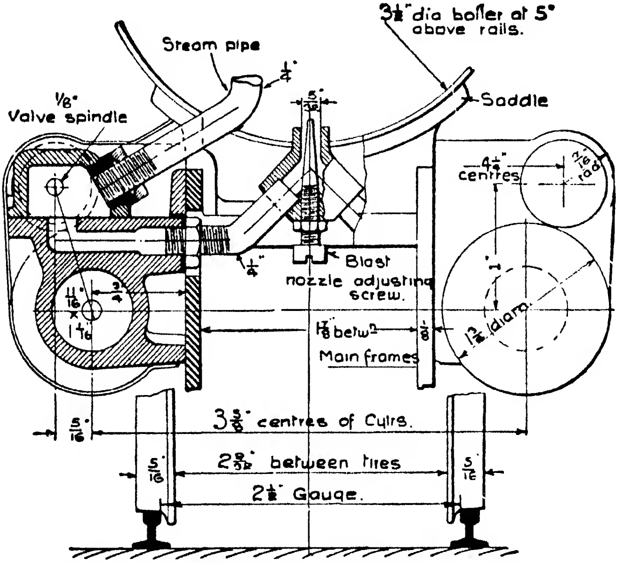


Fig. 143.—American Model Standard Outside Cylinders for 2½-in. Gauge.

The design for British models (note the smaller overall dimensions) shows a spigot fitting into a hole in frames. This spigot is formed in machining the face next the frames in the lathe. The spigot takes all shearing stress off the fixing screws.

The two-cylinder compound system, while it offers some advantages in a working model, is more or less quite obsolete. In this country the Smith three-cylinder system (Midland Railway), with one H.P. cylinder between the frames and two L.P. cylinders with cranks at 90° outside, apparently still gives satisfaction. The receivers on each side of the central H.P. cylinder form the valve chests for the outside L.P. cylinders. The diagrams A and B (Fig. 145) show two methods of arranging the passages from the H.P. exhaust. The H.P. cylinder itself is a liner fitted in and soldered to the central casting. A further idea (C) would be to conduct the H.P. exhaust to a smokebox superheater before transferring it to the L.P. steam chests.

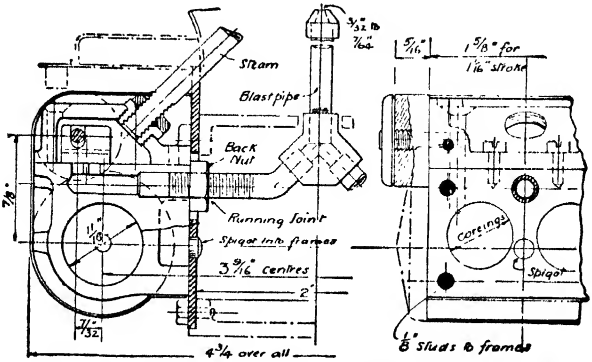


Fig. 144.—Cylinders for 2½-in. Gauge L.S.W.R. Model.

A four-cylinder compound arrangement is illustrated in Fig. 146. Where four cylinders of the same size are employed it would be quite simple to rearrange the passages to use high pressure steam in all of them. In either case the inside and outside cranks would be placed at 180° to each other, and one set of valve gear employed on each side. Some form of rocking-shaft gear would then be necessary to transmit the motion in a diametrically opposite direction from one spindle to the other.

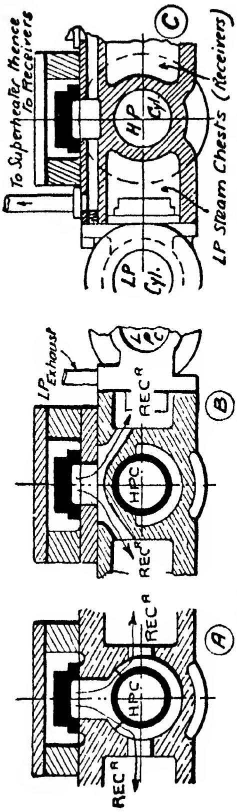


Fig. 145.—Model Cylinders for Three-cylinder Compound Locomotive.

Pistons. — In all model-locomotive work, owing to the low piston speed, pistons should be accurate in diameter and fit (within $\frac{1}{1000}$th of an inch in diameter in smaller sizes not equipped with efficient spring rings), and should be comparatively long. The writer uses for the approximate minimum thickness the rule $.3\,S + \frac{1}{16}$, where S is the stroke of the piston in inches. Further, the piston should never have less than $\frac{1}{16}$ in. plain portion at each end, and of necessity should be truly concentric and in alignment with the piston rod. The piston is the heart of the model, and most models fail to give the best results because of pistons which are faulty either in design or workmanship, or in both. No amount of hemp or other soft packing makes up for bad fitting in this important feature of the model. Many a boiler or system of firing has been condemned when the real trouble has been waste of steam.

Piston Construction.—Where the lathe available is insufficiently delicate and the skill of the worker not particularly high, the small model is best fitted with a piston packed with hemp or asbestos yarn. Three typical arrangements are given in Fig. 147. Piston rings have been successfully made for cylinders as small as ½-in bore. In all models with pistons less than 2 in. diameter the author recommends built-up pistons. This is absolutely essential in 2½-in. gauge models. The design A, Fig. 148, shows a piston for a ⅝-in. gunmetal or cast-iron cylinder. The ring is of steel, and should be machined about $\frac{2}{1000}$ths of an inch bigger than the bore. The slot should be filed at an angle with a fine three-cornered file from the inside, so that the width of the slot is such that it almost closes when the piston is inserted in the cylinder. Great care must be taken not to distort the ring. The ring should fit the slot freely, but without shake longitudinally. If there is any suspicion of an opening in the slot a little glut of asbestos yarn may be tucked into it before assembling the piston. Diagram B shows a built-up piston with multiple rings.

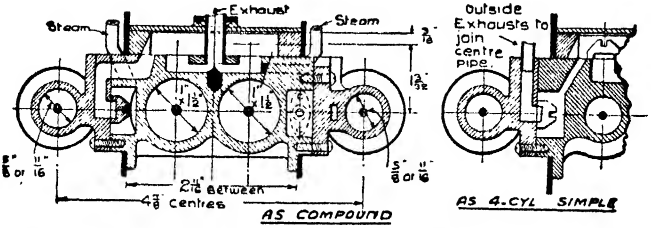


Fig. 146.—A Model Four-cylinder Arrangement, Compound or Simple.

Steam Ports.—Two systems may be observed in model locomotive practice. In all cases it is desirable to maintain a slightly higher pressure in the boiler than that used in the cylinders at the higher working speeds. This may be done (as in the toy models) by restricting the port areas. The other scheme is to make the ports large and "wire-draw" the steam by providing regulator ports of relatively small dimensions. The author on several occasions has improved the working of an over-cylindered, unboilered model by one or the other or by a combination of both ideas. The average maximum proportions of steam and exhaust ports may be determined by the following rules, i.e. for engines of 1 in. scale and smaller. For larger engines than those of 4¾-in. gauge (1 in. scale) eliminate the factor S.

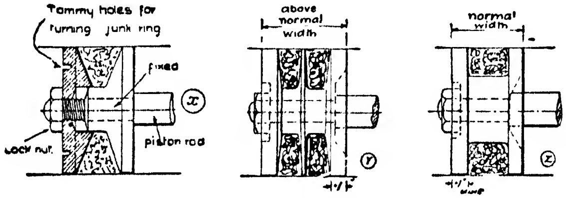


Fig. 147.—Piston Packings.

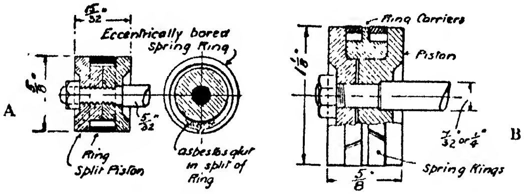


Fig. 148.—Piston Rings.

$$W = (\tfrac{1}{2} D \times S) + \tfrac{1}{16} \text{ in.}$$

$$WS = \tfrac{1}{16} L$$

$PB = \frac{5}{64} L$
$WE = \frac{1}{8} L$

Where S = Scale of model in inches to foot
D = Diameter of cylinder
L = Length of stroke.

Glands. — From the home-worker's point of view the studded gland is easier to make and also in entire accordance with actual practice. Where screwed-in glands are accurately made they are quite satisfactory and easily adjusted.

Materials for Cylinders.—In no case should soft yellow brass be used as cylinder material. If non-ferrous metals are employed a hard gunmetal is essential. Bronze pistons and valves are also advisable. German silver (nickel and bronze) is a material only recommended for piston rods and valve spindles of small models because it is less likely to rust when the engine is not in service, although with care—i.e. first draining and then oiling the cylinders thoroughly when the loco is finished with—steel rods give no trouble. Steel valves and steel piston rings wear very well in conjunction with well lubricated gunmetal or cast-iron cylinders. Gunmetal cylinders require liberal lubrication when supplied with dry steam. In all cases superheated steam should be used only in conjunction with a mechanical or other efficient system of lubrication. Gunmetal or bronze slide valves work very well on cast-iron cylinders. In cylinders for large

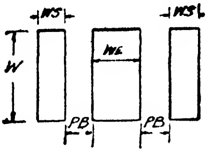


Fig. 149.—**Steam Port Proportions.**

Fig. 150.—Valve Construction and Spindle Attachments.

Fig. 151.—Oscillating Cylinder Fitted to Outside - fired Gear - drive Tank Locomotive.

Fig. 152.— Method of Reversing an Oscillating Cylinder.

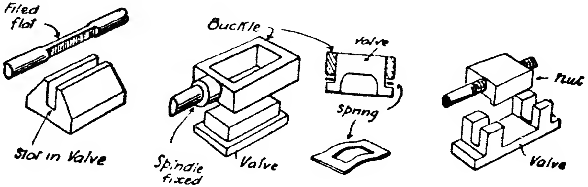


Fig 150

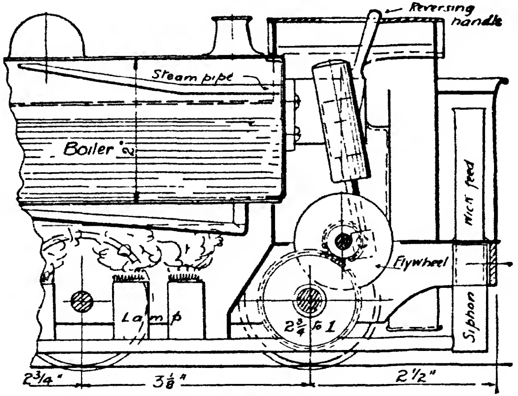


Fig. 151

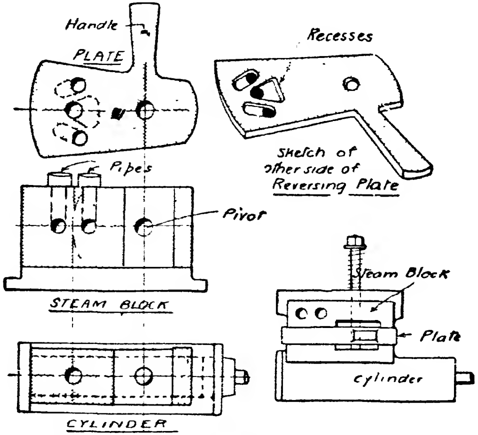


Fig. 152

models cast-iron pistons and rings working in hard cast-iron cylinders is common practice.

Slide - valve Fixings.—The diagrams (Fig. 150) show various methods of attaching slide valves to valve spindles. The scheme (Fig. 158) is very good, but only applicable where the stuffing-box is separated from the valve chest. Otherwise the spindle and valve could not be assembled. It has the merit of allowing the spindle to be rotated for use with some form of screw adjustment.

Oscillating Cylinders. — Oscillating cylinders are not very often used in scale model locomotive work, being employed mostly for toys of small dimensions. Some success will, however, be obtained in No. 1 and No. 0 (1¼ in.) gauge engines by gearing the crank shaft by spur wheels with a ratio of 2½ to 3 to 1, a single oscillating cylinder being employed. To steady the motion the crank shaft should be fitted with a heavy flywheel.

As a rule, the cylinder is placed in the cab with the reversing lever, which in its central position forms a stopcock, projecting through the roof. This arrangement leaves the whole of the underside of the boiler free for the flame of the spirit lamp. A suitable design for a No. 1 gauge four- or six-coupled tank engine is illustrated in Fig. 151. The design of oscillating cylinders is fully treated in the author's book "Model Engineering," and except for sketches showing how the reversing may be effected (Fig. 152) by changing over the steam and exhaust passages, readers are referred to that work.

The better class of toy model, such as is made in large quantities by experienced and well-equipped manufacturers, is usually fitted with fixed cylinders. The most successful of these have piston-valve cylinders made with great precision. These cylinders are suitable only for use with low steam pressures of 15 lb. to 25 lb. per square inch, and even with only a moderate degree of superheat (steam drying, in actual fact) require a careful selection in the material used for cylinders, pistons and valves and ample lubrication. The perfectness of the fit of the piston valve and piston is obtained by grinding, no packing being used in any part. In a cylinder the writer measured the clearance between the piston (which was comparatively long) and the walls of the bore was under $\frac{1}{1000}$th of an inch.

With low pressures (and the small ports) these cylinders remain quite tight for a considerable time due to the water condensing and filling up the small spaces between the moving parts, and therefore where the steam is quite dry the spaces require to be filled with a liberal supply of suitable high-temperature oil. Such cylinders have no advance in the valves, and may be reversed by changing over the steam and exhaust pipes; this is accomplished by the well-known device of a four-way valve. The diagram (Fig. 153) shows the principle on which such cylinders are constructed; it is suited to lightly built models having boilers working at pressures not exceeding 30 lb. per square inch. These cylinders are not sufficiently powerful to support the combustion of a solid fuel fire in an ordinary loco-type boiler.

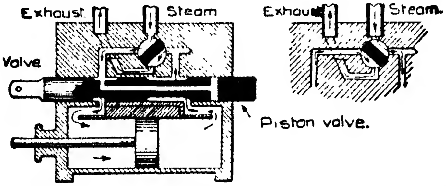


Fig. 153.—Piston-valve Cylinders and Reversing Gear Used on the High-grade Commercial Models.

CHAPTER IX

Valve Gearing: General Principles and Simple Reversing Motions

In view of the information available in explanation of the action of the simple slide valve (see also the author's book "Model Engineering") it is proposed in this chapter to deal more exclusively with the subject of reversing gears.

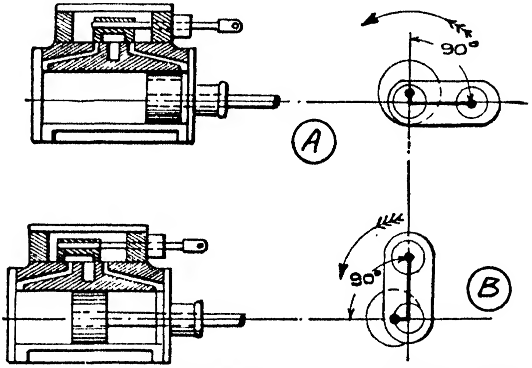


Fig. 154.—Two Relative Positions of Valve and Crank Pin with 90° Advance.

A model locomotive without some means of reversing would be unacceptable even to the beginner, and while many valve gears are very complicated in their action and rather delicate in their parts a locomotive may be made to reverse by very simple contrivances, chief among which is the "slip eccentric."

Valve Gearing

Before describing the construction of this and other gears there are two fundamental differences in model reversing gears which need to be thoroughly understood. The normal valve, i.e. the valve without "lap," is timed exactly 90° in advance (or in retard) of the crank pin, and as shown in Fig. 154 at A the valve is fully opened when the piston is in the centre of its stroke, and as at B covers the ports when the crank is on dead centre. As the port should of necessity be commencing to open, or just have opened at the beginning of a stroke, then, with

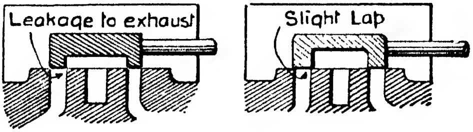


Fig. 155

Fig. 155. — Simple Slide Valve without Lap, Except that Required to Prevent Cross-leakage.

Fig. 156. — Imaginary Indicator Diagram with Simple Valve.

Fig. 157.—Obsolete Link-reversing Gear with Single Eccentric.

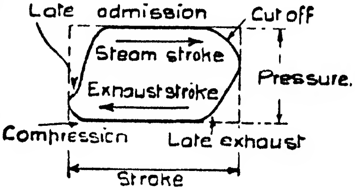


Fig. 156

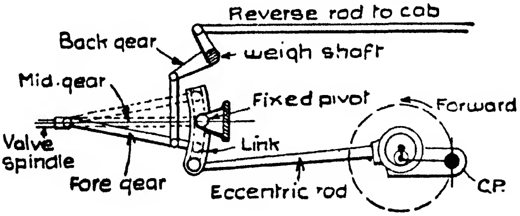


Fig. 157

this timing, lap is impossible. As a small amount of lap is necessary to prevent steam passing through to the exhaust cavity (see Fig. 155) the indicator diagram such an arrangement produces is not ideal (Fig. 156). All ordinary oscillating cylinders which have identically the same timing (i.e. 90°) as that shown in Fig. 154, and most of the commercially produced models with fixed cylinders, reversed by a four-way cock, give the same diagram. In small models the scheme is sufficiently satisfactory owing to the low piston speed involved, and to the fact that due to the excessive cylinder condensation present in tiny cylinders no great saving is observed by introducing an expansion stage.

The chief advantage of the 90° timing arrangement is that the reversing can be very simply effected from the cab of the model by changing over the steam to exhaust and vice versa, as shown in Fig. 153 in the last chapter. Of course, a piston or a spring-loaded slide valve is essential in this case. The other alternative is to introduce some link or slide arrangement which will diametrically reverse the valve movement and thereby change the direction of rotation of the shaft.

This can very simply be done in two ways. The motion of the eccentric can be reversed by means of a curved link (Fig. 157) or (where the motion is taken from a point in the connecting rod) by a pivoted slide arrangement, the angle of which can be tilted either side of a central mid-gear position. The two methods are respectively the genesis of the well-known Walschaert's and Joy's radial valve gears. Of course, they can be modified in detail, but hardly in principle.

It will be observed that the motion (Fig. 158) derived from the up and down vibrations of the connecting rod

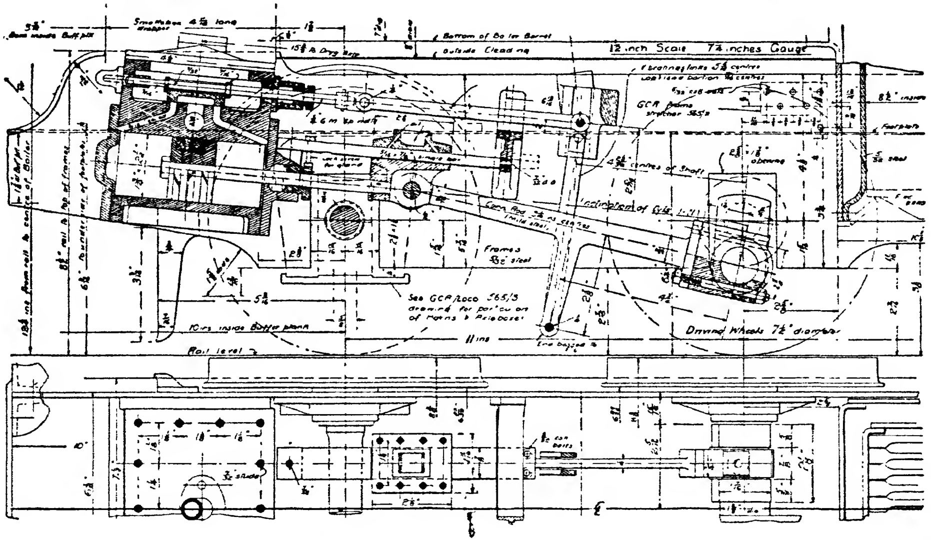


Fig. 158.—Author's Uncorrected Modification of Joy's Valve Gear.

or crank pin has exactly the same timing as an eccentric placed at 90° to the crank. This circumstance is a fundamental one. Errors are, however, introduced due to the angularity of the rods or links connecting up the moving parts. These are much in excess of those experienced in an ordinary 90° eccentric gear, and upset either the timing (point of steam admission and cut-off) or the magnitude of the port opening, as is apparent from the point-path diagram (Fig. 159). One or the other may be almost entirely eliminated in a lapless valve by making the vibrating lever from the joint in the lug to the slide-block pin equal to x with the gear on the dead centre position. As will be seen from the arcs CD the travel of the valve is then unequal, and this error can only be reduced by a long lug on the connecting rod, a short piston stroke, and the greatest possible vertical distance between the piston rod and valve spindle. The fault is, however,

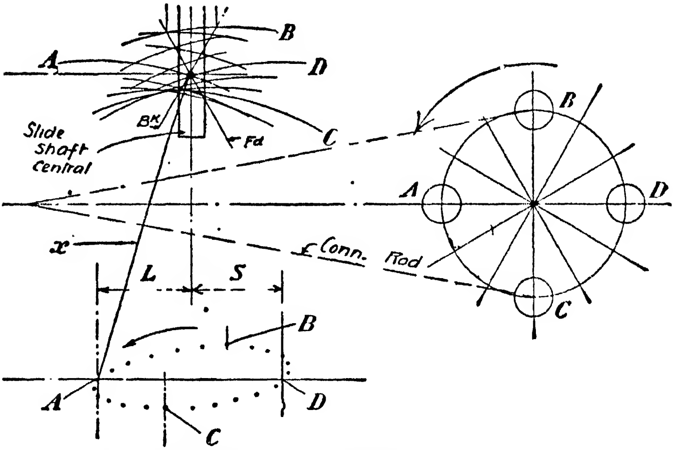


Fig. 159.—Point-path Diagram of "Greenly-Joy" Motion (uncorrected).

not important in a small model. The dimensions L S are together equal to the stroke, and it is this component of the movement that is responsible for the error. Another point is that the port bars—between the steam and exhaust ports—should be ample to provide for the unequal valve travel and to prevent leakage from steam to exhaust.

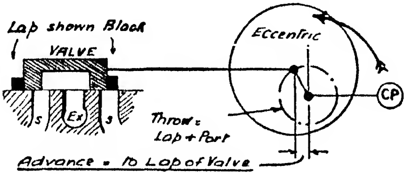
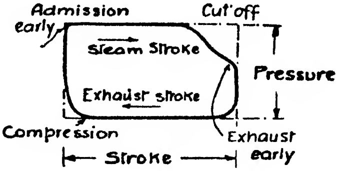


Fig. 160.—Addition of Lap and Advance to Slide Valve.

In the example illustrated in Fig. 158 a small amount of lap was given to the valve. With the very long vibrating lever there was no difficulty in making this small. The steam distribution is fairly good in full gear, but bad when any attempt is made to "link up."

Valve Adjustments.—The skilled and experienced experimenter will, however, desire a greater degree of perfection than such gears that have been described provide. The introduction of quite a small amount of lap over and above that necessary to prevent cross leakage (see Fig. 155) into the proportions of the slide valve improves the theoretical indicator diagram immensely, and in actual working a much sweeter running motion will be produced at the higher speeds.

Fig. 161.—Diagram Showing How the Indicator Diagram is Improved by Use of Valve with Lap and Advance.



It is essential that the valve should be on the point of opening at the dead centre of the crank, i.e. when the piston is commencing its stroke, therefore when a valve with an appreciable amount of lap is employed the eccentric must be advanced as shown, in exaggerated degree for a model, in Fig. 160. The advantage of this is shown in the diagram Fig. 161. A definite amount of port opening at the dead centre position, known as "the lead" of a valve, is not necessary in any average model locomotive. Now as this relative position of the valve must be observed in the opposite direction of rotation, the eccentric in the reverse position is not diametrically opposite its forward position, as will be seen by a reference to Fig. 162. This is another fundamental fact and entirely excludes most of the simple reversing devices such as already described. If a gear like that shown in Fig. 157 were used the valve would be timed just as much late on the reverse as it was advanced on the forward stroke. The virtual position of the valve in the reverse gear would be that corresponding to an eccentric position shown by dotted lines x (Fig. 162), i.e. at less than 90° advance and with all functions occurring "late."

The only extremely-simple reversing valve gear which allows the valve with lap to function properly is that known as the slip-eccentric valve gear. In link motions it is usual to provide two eccentrics, one for forward gear and one backward, and by a slotted link to engage either one or other eccentrics with the valve spindle. The Stephenson gear is chief among these motions, and its action in reversing is clearly shown in the sketches given by Fig. 163.

The radial gears (Walschaert's and Joy's respectively) require the addition of a second motion which, acting harmoniously with either the slotted link or angular-slide reversing device, as the case may be, produces at the valve spindle a timing of the valve which is almost identical

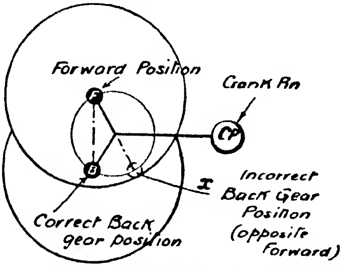


Fig. 162.—Diagram Showing Relative Positions of Forward and Reverse Eccentrics when Valve is Advanced.

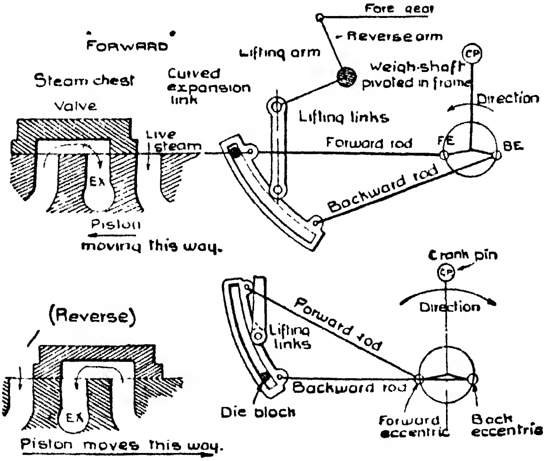


Fig. 163.—Action of Stephenson Link in Reversing.

with that produced from an eccentric which is "advanced" beyond the normal 90°. The "angle of advance" of an eccentric is the angle it is moved in advance of the normal

90°, not the total angle it is advanced in front of the crank pin. This second motion is almost always taken from the horizontal movement of the crosshead or connecting rod. It is apparent, therefore, that when the valve gear is in mid-gear the only motion the valve spindle obtains is that from the movement of the crosshead. When the crosshead is at one end the valve is then on the point of the steam admission at that end. At the other extremity of the stroke the same thing happens in the reverse direction. This latter function exemplifies the difference between the incidence of the valve movements of a slide

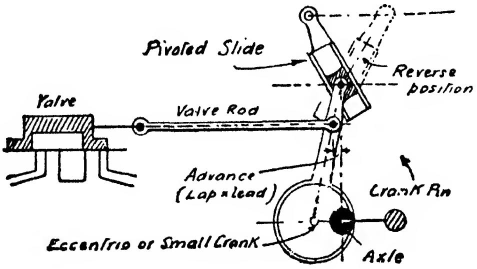


Fig. 164. — Diagram Showing Principle of Hackworth's Radial Valve Gear.

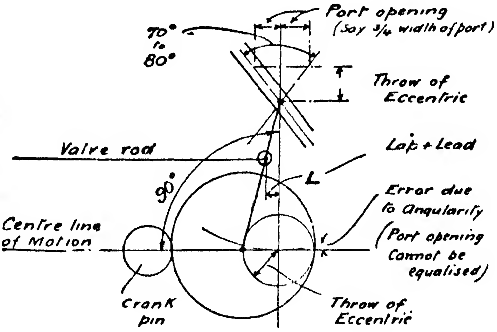


Fig. 165. — Diagram Showing Method of Setting Out Hackworth's Radial Valve Gear.

valve with lap and one which is without lap. The simple valve (Fig. 154) does not move with the reversing lever in mid-gear. The improved valve (i.e. valve with lap) moves to the extent of the lap when the driver's lever is in a central position. In Hackworth's gear, which, by the way, is the father of most slide-block reversing motions, an eccentric or short crank on the same centre line as the crank pin is used. The vertical movement of the slide block when the slide is tilted governs the main opening and the reversing, and the horizontal motion performs the opening to advance (see Figs. 164 and 165).

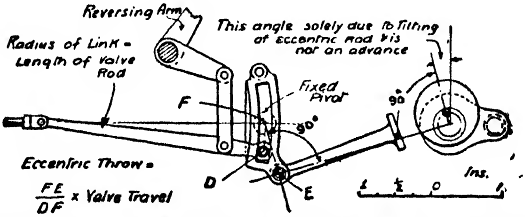


Fig. 166.—Method of Setting Out a Single-eccentric Link Motion.

Single - eccentric Link - reversing Gear. — Referring back to the single-eccentric link-reversing gear illustrated in Fig. 157, a simple valve with only sufficient lap to prevent cross leakage is required, and as soon as the position of the valve spindle is known the setting out can proceed. The length of the working portion of the slotted link should not be less than 3½ to 4 times the *valve* travel. Where the valve spindle is on the same centre line as the rest of the driving motion (Fig. 166) then the eccentric will not be actually placed at 90° to the crank, as in the case of Fig. 157, where the valve spindle is raised, although wherever it is its relative movement as transmitted to the link must be the same. The design of the link will also have some influence. With a link as shown the eccentric travel is greater than valve travel, as owing to the arrangement of pivots the link acts as a reducing lever. With a box link, where the connections of the eccentric rod and valve rod coincide, the throw of the sheave will be equal to the valve travel, plus a trifle to make up for the inevitable lost motion. The setting out shows the proportions necessary for a $\frac{3}{16}$ valve travel. There is no rule as to the respective lengths of valve rod and eccentric rod. It is better if the latter is the shorter of the two. The most common construction for the pivoted link is to attach the slotted curved link to a plate which fits in a suitable bearing in the frames.

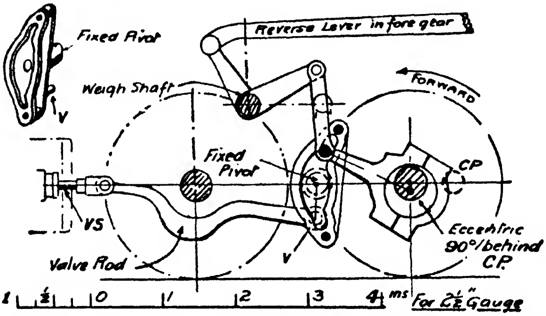


Fig. 167.—Unusual Form of Single-eccentric Link Gear Suitable for Small Models.

Fig. 167 shows a single-eccentric motion in which it is impossible to arrange for any valve movement near to a central mid-gear position. It is suitable for small engines, and although from the position of the eccentric a simple valve would seem imperative in connection with this gear, owing to the use of a long link and a short eccentric rod, and to the advancing effect of the angularity of this rod, a small amount of lap may be provided. The gear is not perfect in this respect in each port opening, but the function is worth taking advantage of. The crank axle should be fitted with a stiff spring (if any) to reduce up and down movement to the minimum. The slotted link is, as shown in the sketch, fixed to a plate pivoted to the frame. The eccentric rod lies between the plate and the link, and has a projecting die-pin on the end which also engages the end of the lifting links, so that a reversal of the motion may be obtained by the levers. The gear is a relic of the ancient "gab" motion.

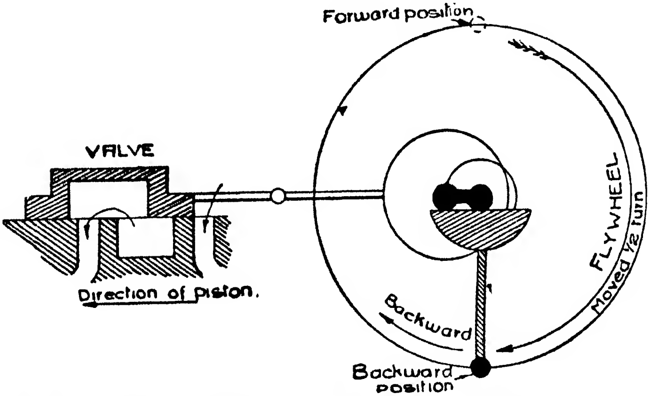


Fig. 168.—Diagram Explaining the Principle of the Slip-eccentric Reversing Gear.

The Slip-eccentric Valve Gear.—The slip- or loose-eccentric valve gear is the simplest and most efficient model locomotive reversing motion. It is, of course, useless in engines on which the driver rides because it cannot be operated in a sufficiently simple manner from the cab, but for small engines running uncontrolled it gives the best steam distribution of any gear. There are cases, however, such as in small engines with two inside cylinders, where a perhaps less efficient gear like that illustrated in Fig. 158 may be more conveniently applied, and has the added attraction of a reversing lever in the cab.

As shown in Fig. 162, with the slight advance that is desirable to make a model run sweetly, an eccentric should take up positions approximating to F and B. To accomplish this the single eccentric is made loose on the shaft or axle, and is operated by a stud, stop or other driving pin either in one position or the other. The effect is to make the engine continue to run in the direction it is started. If the relative position of the crank pin is moved something less than half a turn, then the loco-

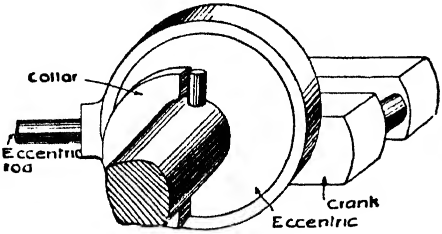


Fig. 169

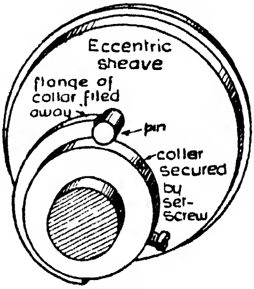


Fig. 170

Figs. 169 and 170.—Methods of Driving a Slip-eccentric.

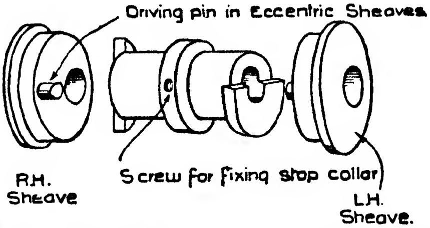


Fig. 171.—Double-stop Collar for Two Cylinders.

motive will travel in the opposite direction. Fig. 168 illustrates the principle and Fig. 169 shows one method of driving the eccentric with a pin fixed in the axle. As the accuracy of the valve setting is dependent to a large extent on that of drilling the axle, a method (Fig. 170) which provides for the correction of any errors in workmanship is strongly recommended. Here a pin is placed anywhere in the side face of the eccentric sheave, preferably exactly on what may be termed its major axis. A flanged collar, with half its flange cut away, is fitted to the axle as illustrated. This collar is fixed on to the axle by a set screw, and if two collars are used adjustment of position may be made separately for each side. For the usual two-cylinder outside locomotive a double collar (Fig. 171) is often employed with the stop flanges machined at 90°. Here the eccentric must be accurately drilled, as the only adjustment that can be applied is that of altering the amount of lap and advance. The marking out and drilling is, however, less likely to be accompanied by inaccuracies than in the "drilling the axle" method sketched in Fig. 169. A setting-out diagram (Fig. 172) is included.

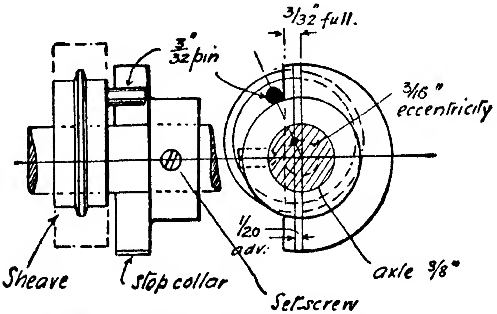


Fig. 172.—Diagram Showing Method of Setting-out Stop Collar and Slip-eccentric.

A single-cylinder locomotive is more efficient, and the uneven turning moment rendered less apparent if the slip-eccentric motion is used. It is necessary tc move the engine a few inches one way or the other to effect reversing.

The loose-eccentric gear was used on the earliest steam locomotive (e.g. the "Rocket") for reversing in conjunction with a hand gear for starting. It was also employed on the famous L.N.W.R. "Webb" three-cylinder compounds to control the valve of the single low-pressure cylinder.

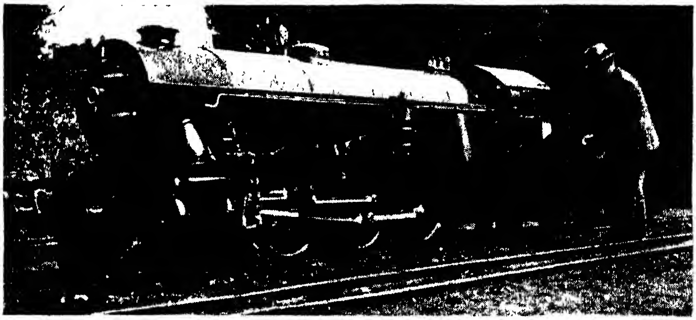


Photo: Miss Mary Fair.

Fig. 172a.—"Green Goddess" Locomotive, 15 in. gauge. Designed by the Author for the Romney, Hythe and Dymchurch Railway.

The "Green Goddess," a 15 in. gauge locomotive designed by the author for the Romney, Hythe, and Dymchurch Railway, is shown by Fig. 172a, and illustrates an example of the model Walschaert valve gear. Dimensions are: Cylinders, 5¼ in. x 8½ in.; driving wheels, 25½ in. diameter; length, 24 ft. 9 in.; weight in working order, 8 tons. The photograph is by Miss Mary Fair.

CHAPTER X

Valve Gearing: Link and Radial Valve Motions

Stephenson's Link Motion. — As explained in the previous chapter, Stephenson's link-reversing gear has two eccentrics, one for each direction of motion and each with the necessary advance. The eccentric rods are connected at their ends by a curved and slotted link which, besides providing a convenient method of reversing the motion, maintains the angle of advance necessary where a valve with a lap is employed in all positions of the reversing lever. This important function gives the driver the opportunity of altering the point of cut-off and availing himself of the expansive force of steam. This not only provides perfect control over the power developed in the cylinders, independently of the main steam supply (i.e the position of the regulator), but results in economy in steam and

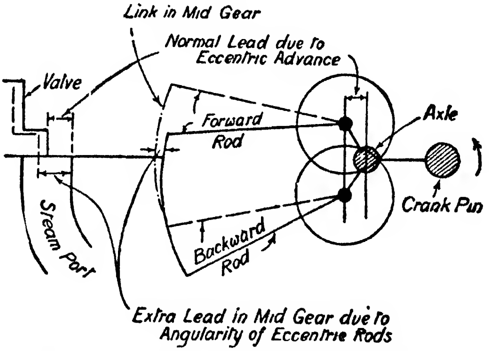


Fig. 173.—Effects of Angularity of Eccentric Rods in Link Motion.

fuel and much sweeter running of the engine at high speeds. While the variable cut-off is not of paramount importance in a small model, a valve with some lap and an advance equal to that lap is very desirable. In larger engines it is an essential.

As a matter of fact, with the Stephenson motion the advance increases as the lever is brought nearer to mid-gear, and this function is in small models made use of to eliminate the necessity for advancing the eccentrics. Even in larger models the author always makes advance of the eccentric slightly less than the lap because of this characteristic, which, by the way, is peculiar to the Stephenson gear when open rods are used. With crossed rods the effect is negative. The angularity of the rods—which, of course, is greater with short than long rods—is responsible for this, and is illustrated by the sketch (Fig. 173). The test for the amount of this increased "lead" is to place the big end on dead centre and to operate the reversing lever. The valve spindle will move slightly in the direction of opening the port as the lever gets to mid-gear.

The Launch-engine Link.— The effect is more noticeable with the form of link illustrated in Fig. 174 than with the launch-engine type of link usually employed where short rods and small-throw eccentrics are essential. Fig. 175 shows this type of link, which should, if possible, be avoided in small models owing to the difficulty of getting the eccentric-rod pins sufficiently close to the curved slot to prevent excessive slip on the die. Where the launch link is used the slot should be much longer than apparently necessary to allow for this objectionable up and down movement of the die.

Where the launch link is employed the eccentric travel may be made equal to the valve travel. With the loco-type of link (Fig. 174) there is a reducing effect due to the link acting as a lever, and the eccentric throw must be increased (with a given valve travel) in proportion. A paper or wooden model several times full size may be made to investigate this, as shown by Fig. 176, V equalling half the valve travel and E the eccentricity of the sheaves. In this model the link is set out quite straight and the diagram pinned on to a rotating block of wood. The pivot on the end of a *long* valve rod representing the die should be movable along the slot between the limits Q, and attaching the valve rod to a cardboard model of the slide valve, the effect of reversing and linking up may be observed with reasonable accuracy. The required eccentricity of the sheave may also be settled arithmetically. With a link as shown by Fig. 177, the eccentricity of the sheave will equal $\frac{P}{Q}$ × half valve travel.

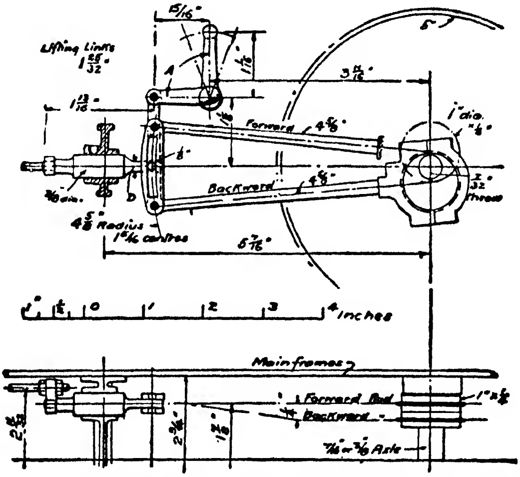


Fig. 174.—Stephenson's Link Motion with Locomotive-type Link.

As a rule, if Q is divided into three equal parts P will measure five of these parts, therefore eccentricity of sheave must be 5/3 times the valve travel.

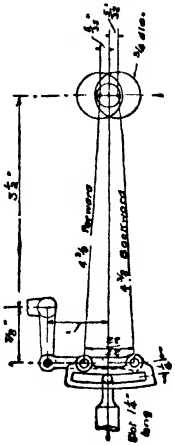


Fig. 175

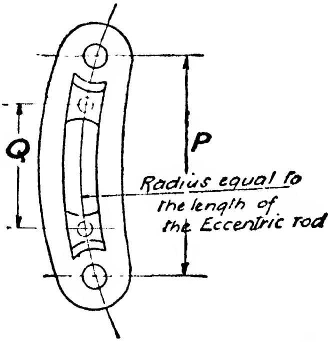


Fig. 177

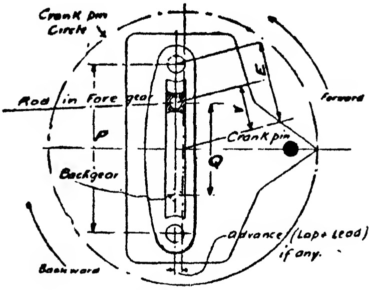


Fig. 176

Fig. 175.—Stephenson's Link Motion with Launch-type Link.

Fig. 176.—Method of Setting-out for Model Valve-gear.

Fig. 177.—Curved Link as Used in Locomotives.

Simple Link Motion.—The illustration (Fig. 174) shows a straightforward arrangement of link motion as applied, say, to a 4—4—0 type outside-cylinder model. The gear is said to have "open rods." The crank pin would be at R.H. dead centre. If the forward eccentric were connected to the bottom of the link the arrangement would be termed a "crossed-rod" gear, and there would be less advance in mid-gear—exactly the opposite result to that obtained in the "open rod" motion.

The lifting arm of the weigh shaft supports the curved link and eccentric rods by means of the lifting links, and in large work is counterbalanced. The lifting links are connected, for simplicity, to the bottom joint of the curved link. The die-block is solid with the intermediate spindle, a practice recommended by the author in small engines. This arrangement, coupled with the use of duplicate curved links (as sketched in Fig. 178), cuts out the forking of the eccentric rod ends. As in this case the valve spindle is close to the frames (a common happening), the guided intermediate spindle has a lug on its forward end to receive the spindle and two adjusting and securing nuts. The backward eccentric rod, being the least used, is set over, the forward one being straight and in line with the rest of the motion. The angle (A) between the lifting arm and reversing arm of the weigh shaft will depend on the position of the reverse lever or wheel in

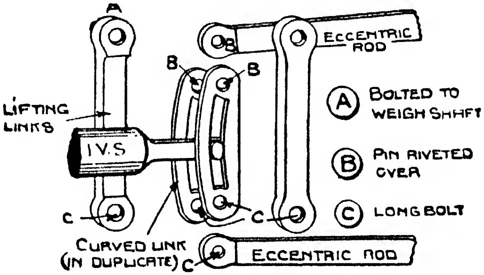


Fig. 178.—Link Motion Components with Duplex Links.

the cab. It is usually an angle less than 90°. As the close proximity of the boiler may require the weigh shaft to be as close or closer to the horizontal centre line of motion, it may be necessary to cut away the underside of the shaft to clear the forward rod when in back gear.

The die on the intermediate valve spindle should be machined out of the solid. It is essential that the vertical dimension D (Fig. 174) in all link motions should be reduced to the minimum, otherwise a permanently "linked-up" state will obtain and much of the valve travel will be lost. This can be done with a hollow end mill, one side at a time, as indicated in Fig. 179, and the superfluous metal filed away. Pattern X is required for the valve gear (Fig. 174) and Y for the link motion (Fig. 175). In the latter case curved links in duplicate and this form of intermediate spindle die-block are strongly recommended, so that the slot can be placed more closely than otherwise possible to the eccentric-rod joints.

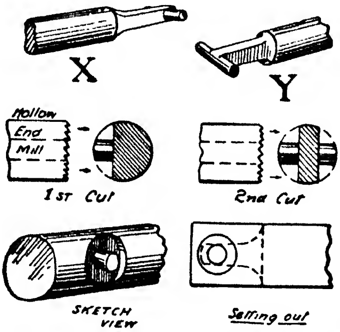


Fig 179.—Method of Making Intermediate Valve Spindle with Solid Die Pin.

Both motions were designed for 3¼-in. gauge, but would, with modification, suit a 2½-in. gauge locomotive.

Alternative Stephenson's Link Motion. — Another arrangement of Stephenson's motion is illustrated in Figs. 180 and 181. Here the valve gear actuates the slide valves through a rocking shaft. As this rocking shaft and levers reverses the movement of the die the eccentrics have to be placed exactly opposite to their usual position which crosses the rods. The negative effect on the advance is not, however, observed, as the rocking shaft changes it into a positive one. Although the model to which this gear is fitted is a large one (7¼-in. gauge) no advance of eccentrics is provided, but the valve has a considerable lap. It has proved quite successful, and has burnt no more fuel nor consumed no more water than a smaller model of 5-in. gauge.

This arrangement shows how difficulties arising from the close proximity of the coupled axles (always present in 2—6—0- and 2—8—0-type outside-cylinder engines have been overcome.

Fig. 182 illustrates the Stephenson's link motion for a 2-in. scale model G.N.R. "Atlantic" locomotive. A slung valve rod, holding the die, takes the place of the usual sliding intermediate valve spindle. The illustration, with dimensions reduced one-half, will suit a 1-in. scale model. The boiler of this engine is very large, and therefore there is little clearance between the top of the forward rod and this shaft when the gear is in back gear. This rod must therefore be cast or forged to eliminate the need for any large boss at the root of the lifting arms.

Although now almost obsolete for express engines the front-coupled wheel arrangement is very common practice for tank engines. The valve gear (Fig. 184) is representative of this, and was designed to suit a 1-in. scale model of the L.B.S.C.R. "Gladstone" type. The valves

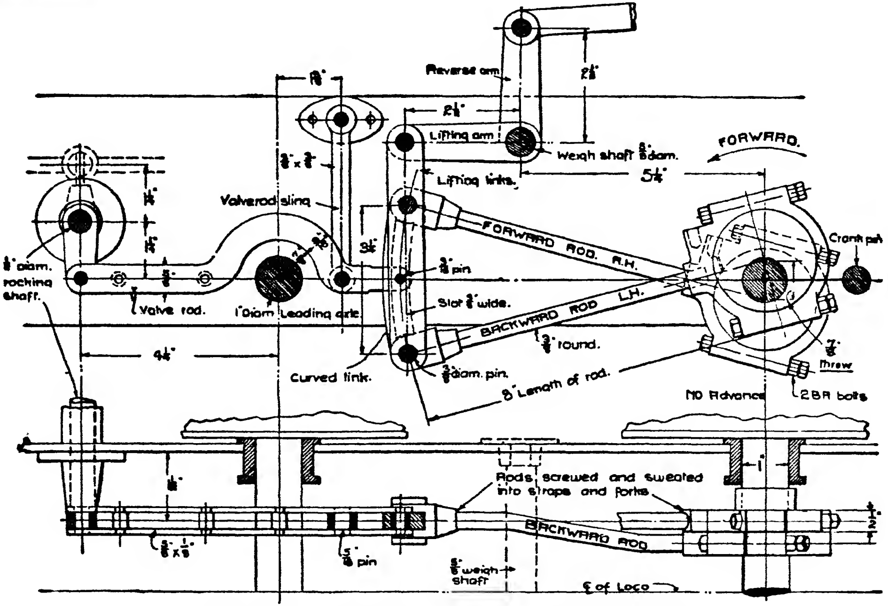


Fig. 180.—Link Motion for 2—6—0 Goods Engine.

are below the cylinders and the motion is inclined. In setting out the eccentrics, they must be dealt with as in a case where the crank-pin dead centre coincides with the line of the valve motion. Actually the crank and eccentrics are respectively displaced to the amount of the angle between the centre lines of the two motions.

Another interesting arrangement of valve gear designed for a G.C.R. 7¼-in. gauge model is illustrated in Fig. 185.

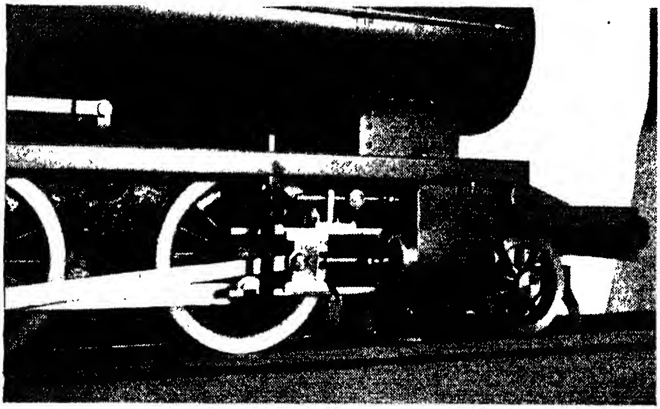


Fig. 181. Finished Goods Engine, Showing Rocker.

As in Fig. 183, the curved link is solid and is fitted with a hardened die, the eccentric rods being forked in the orthodox manner. As the rods are long and the angular effects small the eccentrics are advanced more than usual. The position of the valve is adjusted by turning the valve spindle, one end of which is screwed into the intermediate spindle, the other being of a bobbin shape and revolving in the slot in the back of the valve.

Link Motion with Rocking Shaft.—Fig. 183 shows an arrangement of link motion for an engine with valves on top of the cylinders (i.e. a rocking shaft is employed),

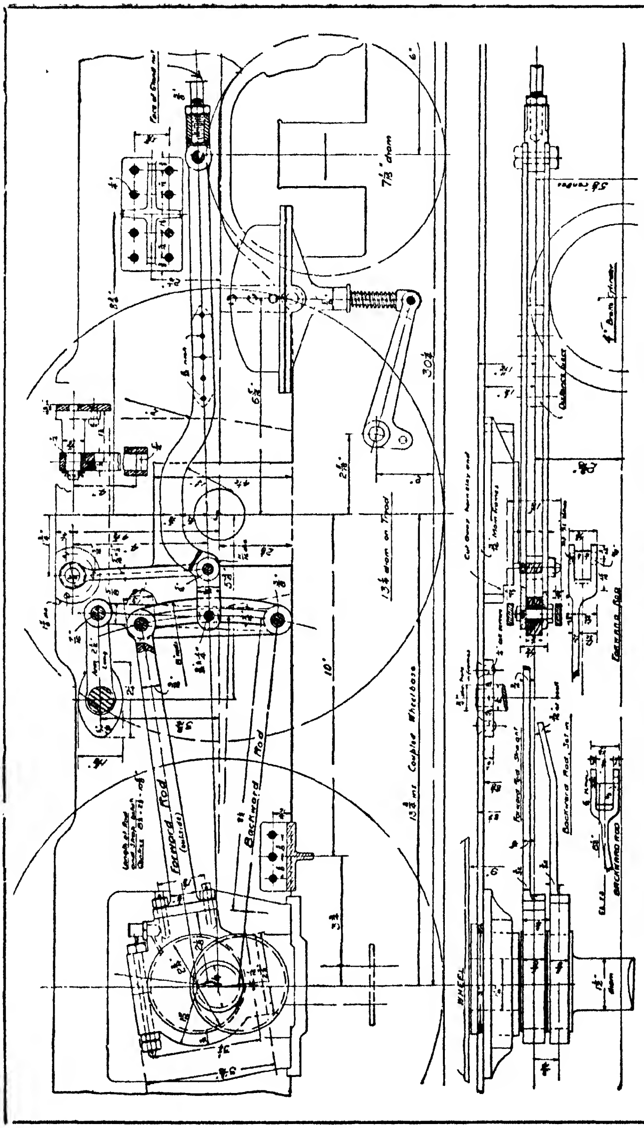


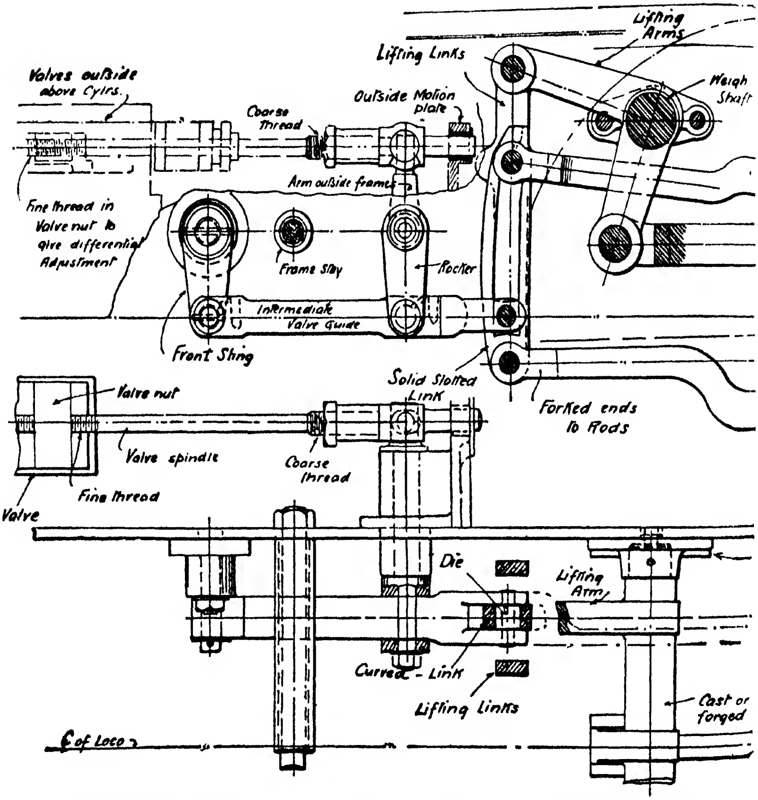
Fig. 182.—Link Motion for Large Model of G.N.R. "Atlantic" Locomotive.

in which the eccentric rods are long and embrace the leading coupled axle. The boiler and driving wheels are both of large diameter and the weigh shaft cannot be placed in a position that will allow the reversing arm to clear the wheels and boiler barrel satisfactorily. The weigh shaft is therefore coupled to the countershaft midway between the axles. This has the usual outside arm and reversing rod to the cab. The particular example was applied to a 15-in. gauge model, but is representative of all similar cases in engines above 2½-in. gauge.

Gooch's Link Motion.—In this motion the curved link, driven by the usual two eccentrics, is slung from the centre and is not moved up and down in the act of reversing. The valve or radius rod is lifted or depressed by the reversing arm of the weigh shaft, as in Walschaert's gear.

Allan's Link Motion.—This motion is a combination of Stephenson's and Gooch's motion. Both the link and the valve rod are connected (by opposite arms) to the weigh shaft. The link therefore moves one way and the valve rod the other, and by proportioning the lengths of the arms the expansion link can be made quite straight. The advance in Allan's and Gooch's motion is not effected by the angularity of the eccentric rods.

Curved Links.—The working portion of the slot of Q (Fig. 177) should in all cases be not less than 3½ times the valve travel. The length overall will depend on the size of the pins and curved slot employed. The eccentric rods and straps should be made to dead length between centres. Especially where several engines are being built, they should be tested for length on a jig. The sheaves being correctly set in relation to the crank pin, all that is necessary to obtain a perfect setting is to adjust the position of the valve on its spindle so that it opens at the same point in the stroke in each direction and at each end of the cylinders. Several forms of adjustment are available. The amount of the port opening may vary slightly at full port opening, but so long as the "timing" of the admission is correct this does not matter very much.



Figs. 183 and 183a.—Link Motion for "Atlantic" Locomotive with Outside Valve Chests.

Walschaert's Valve Gear. — Walschaert's valve gear, although sometimes applied to ordinary inside-cylinder engines—the L.S.W.R. 4—4—0 locomotives, for example—

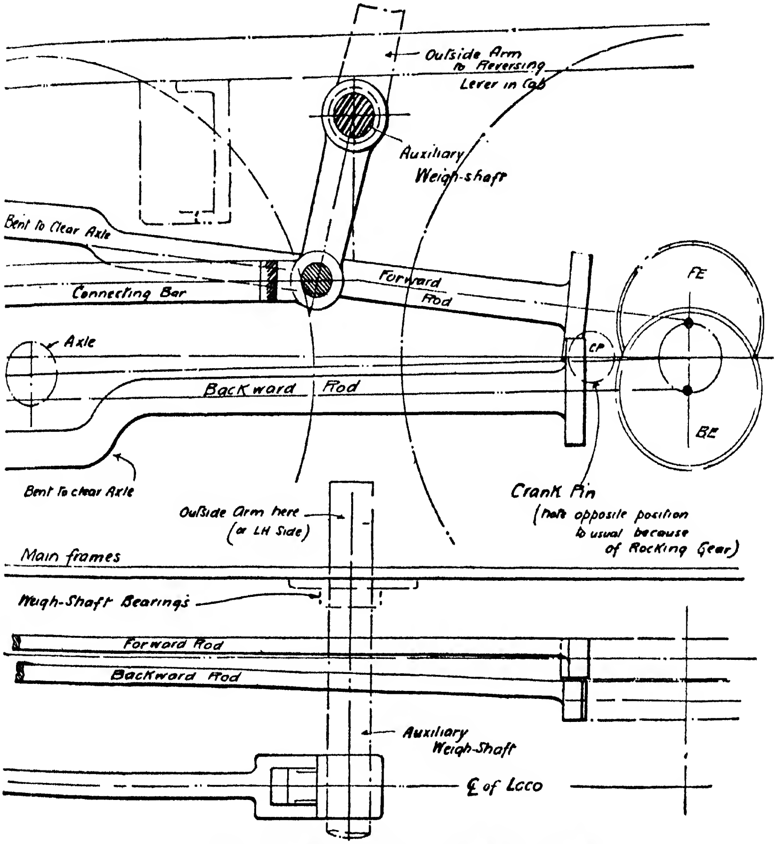


Fig. 183a.—(See illustration on preceding page.)

is more usual in a modern superheater loco having outside cylinders with valves on top. Besides being above the cylinders, the valve rod, because of its various attachments, is usually set to one side of the vertical centre line of the cylinders and connecting rods.

To exemplify the adaptation of the gear to a working model Fig. 186 illustrates a setting for a 1-in. scale engine. The only difficulty which, by the way, is one that presents itself in this, Joy's and other valve gears having the vibrating lever as a feature, is due to the fact that the lap employed in models is proportionately rather smaller than usual in full-size practice. "Lead"—pronounced *leed*—is also omitted. The lower end of the vibrating lever moving to the extent of the piston stroke, it is a somewhat troublesome thing to get a small enough reduction in movement at the top. The setting out is as shown in Fig. 187. The vibrating lever is attached to the crosshead, and the bottom has a movement s and s^1 on either side of the centre. The lap of the valve L must be equal to the movement L_1, and to obtain this the lengths of the vibrating lever $V_1 + V_2$ must be suitably proportioned. Now as the lap in a model is relatively small and the pins of the motion large this proportioning introduces mechanical difficulties. Means must therefore be devised to reduce V_2 to the minimum consistent with the strength of the parts. Figs. 188, 189 and 190 show three schemes, the last being the most satisfactory in small engines. These drawings are prepared to suit an engine with a 2-in. stroke. To provide for other sizes the author would recommend that the lap should not exceed half the width of the steam port, and by using the longest possible vibrating link a reasonable distance between the pivot pins may be obtained with a diameter of pin that will wear satisfactorily.

For the rest of the gear, i.e. the return crank (or eccentric), link and reversing rod, the method of setting out described in connection with the simple single-eccentric gear may be followed. In the diagrams (Figs. 157 and

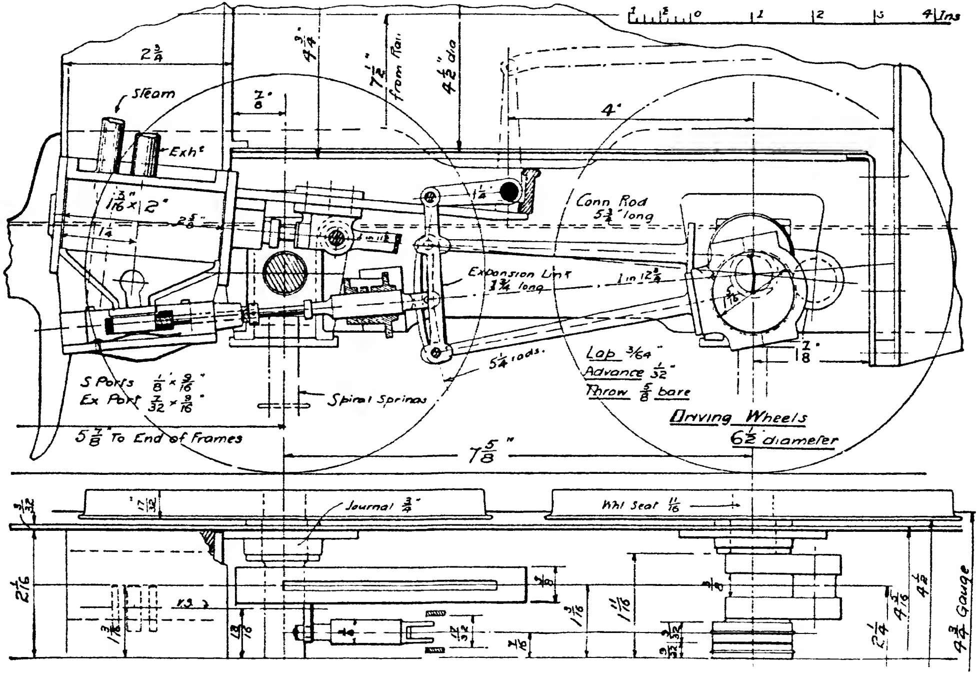


Fig. 184.—Link Motion for Front-coupled Engine with Inside Cylinders and Underneath Valves.

186) the end of the curved link coincides with the horizontal centre line of motion. The return crank is therefore exactly 90° from the crank pin. With an inclined connecting link (eccentric rod) the angle of inclination must be taken into consideration, as in Fig. 166. The throw of the eccentric must be proportioned without regard to the function of the vibrating link, and as in Stephenson's motion must move the valve an amount equal to the lap + the width of the port on each side of the centre. Of course, the leverage (P and Q, Fig. 177) of the curved link must be taken into account as in the case of the ordinary Stephenson link, as referred to in the description of Fig. 177.

Joy's Valve Gear.—This form of the original "Hackworth" radial valve motion became very popular in the late 'eighties, and some railways still use it to the exclusion of all others. The great advantage claimed in real practice was the fact that it cleared the already cramped crank shaft of the four eccentrics, and in model work this characteristic is the most valued one. With inside cylinders the valves must, in the smaller gauge models, be placed above or below the cylinders, and Joy's valve gear, or one of its modifications, therefore makes a convenient and simple reversing gear.

In employing the driving crank pin, or a point on the connecting rod, to actuate the valve, the function of the vertical movement is to open the port and, in the combination of this motion with the horizontal component of the crank-pin circle, an "advance" is obtained, as in the case of the combination of the eccentric (or return crank) and crosshead movements in Walschaert's valve gear. If the valve motion in Joy's gear were taken directly from a point in the connecting rod, the joint pin would make a

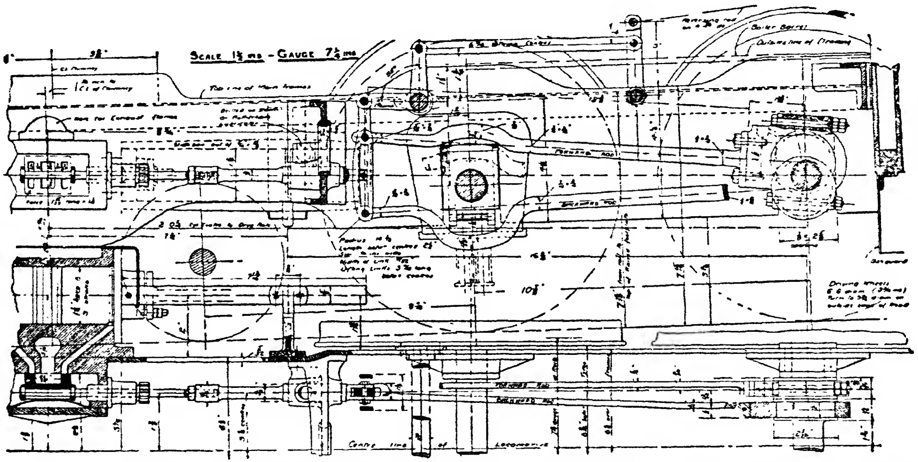


Fig. 185.—Directly-connected Link Motion as Used on G.C.R. Engines with Outside Cylinders

point path in the form of a more or less perfect ellipse, but while this would, as shown by the diagram (Fig. 191) at AB and CD, give an equal port opening, at the dead centres (see EF) there would be a serious error. The top joint E, which represents the die or slide block in the tilting slide shaft, would not occupy its proper central position owing to the loss in the length due to the angle at which the vibrating link stands when in the dead centre position.

In Joy's gear the system of links employed corrects this error. The vibrating link is attached to a lower link (called a jack link) slung from the connecting rod. The anchor link at the lower end of this can be of any length, and is simply a convenient attachment. The horizontal position of the weigh shaft is determined by the ellipse of the point on the connecting rod, the maximum angle of the weigh-shaft tilt being about 30° (see Figs. 192 and 193).

The length of the correcting or "jack" link will be determined more or less by the position of the connecting rod in respect to the rail level, but the length of the vibrating lever must be such that when an arc the length of the proposed vibrating lever is swung to the vertical centre line, as in Fig. 194, $A = A_1$. This can be found by a trial and error method on a scrap of paper in a few moments; both B, B_1 and C C_1 do not equal each other, and are attempts which do not realise the above condition obtaining in the length marked A.

In the design for a 3½-in. gauge model of Joy's motion the lap and lead function is derived from the horizontal motion of the vibrating lever through the medium of an eccentric top pin. As the extent of the vibration in Joy's gear is always less than in Walschaert's, it is possible in

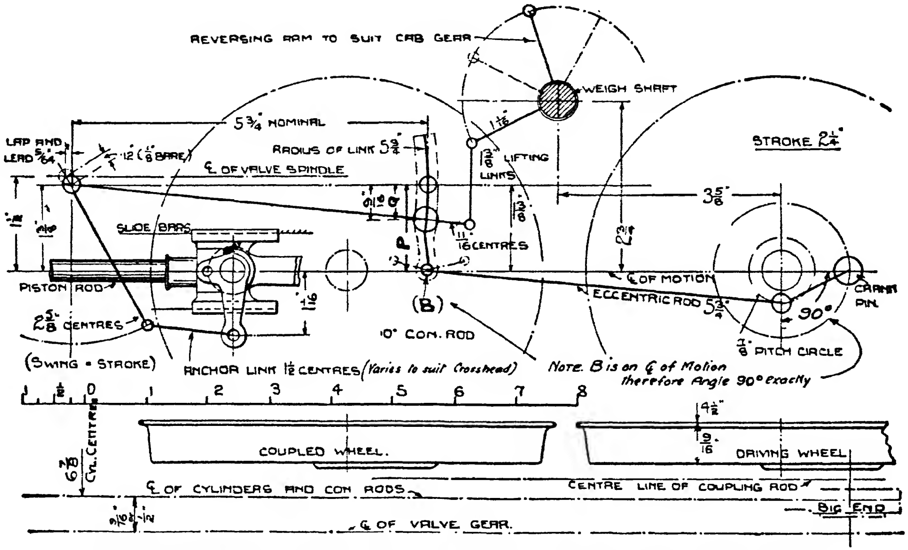


Fig. 186.—Method of Setting-out Walschaert's Gear for 1-in. Scale Model with Outside Cylinders.

most examples to employ two separate pins. The lower pin, which extends through on each side to the slide blocks, may be cut through to about half its diameter to reduce the V_2 dimension (see Fig. 187). This scheme is shown as an alternative at A, and if adopted the lap of the valve will be slightly larger than that used with the eccentric pin device. A curved slide should, if possible, be employed with this type of motion in large engines, especially in conjunction with an ample lap.

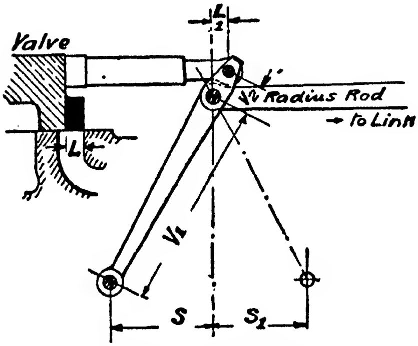


Fig. 187.—Method of Setting-out Lap and Lead Functions of Vibrating Lever.

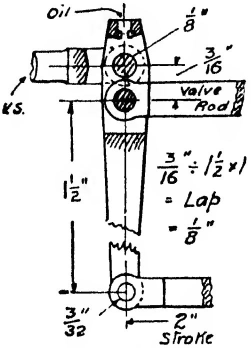


Fig. 188.—Arrangement of Vibrating-lever Lap and Lead Joints.

Greenly's Corrected Motion for Inside Cylinders.—A few years ago the author devised a form of correcting motion which has by repeated trial and error methods—clearing the slide bars is the chief difficulty—been arranged to suit all normal designs. It has the merit of giving a sufficiently accurate correction and provides for joint pins of almost any diameter. Joy's gear, when modelled on a small scale, is rather flimsy in this respect and therefore is not often used in the author's designs.

The motion is derived from a point in the connecting rod near the big end. At this point a swing link is jointed to a lug by a substantial pin. The other end of the swing link is supported by a correcting link, the point near the centre forming the connection to the vibrating lever. The function of the correcting link is not only to carry the swing link, but to lift it at each dead centre to the exact amount required to neutralise the loss in length of the vibrating link due to the latter's angularity when in this position. The setting out is best done graphically, as the various links at first may work out awkwardly regarding their relation with other parts of the engine. The pivot point on the connecting rod being fixed, a point on the swing link should be chosen that will lift the die block sufficiently to open the valve fully when the link is inclined at not more than 30°. With the big end on dead centre and the vibrating link swung to its utmost, as shown in Fig. 195, the line SL, representing the swing link, should be drawn in, cutting the lower point L

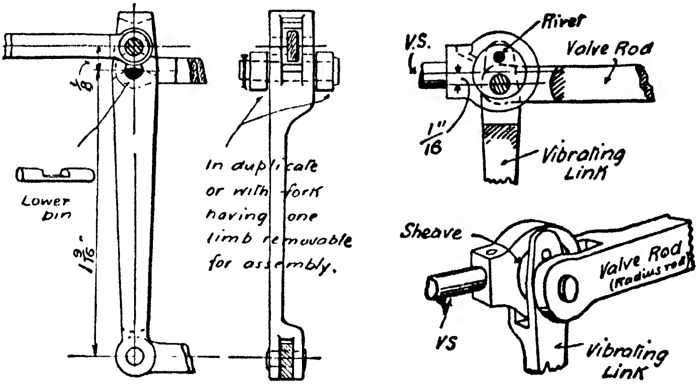


Fig. 189

Fig. 190

Figs. 189 and 190.—Other Arrangements of Vibrating-lever Lap and Lead Joints.

Farther along this link a point must be chosen for the correcting link. The length and pivot point of this is chosen, the necessary function being that, in swinging, the lower end shall lift to coincide with the point s.

One feature of the author's designs of this and Joy's valve gears is the use of straight slides in the shaft, the slides being formed by drilling the solid casting and afterwards sawing and filling (or milling) out the spaces between. The slides themselves are pieces of bright-drawn steel rod. With a long valve rod (radius rod) and small lap the straight slide has little effect on the steam distribution, and can safely be used in models up to 1½-in. scale. In small models the scheme is much to be preferred to the usual device of allowing the extension of the top pin of the vibrating lever to work in grooves in the slide shaft. An example of the gear is shown in Fig. 196.

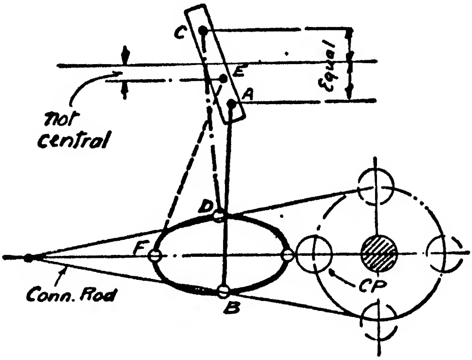


Fig. 191.—Principle of Joy's Valve Gear.

Greenly's Corrected Valve Gear for Outside Cylinders.—A combination of levers has been devised which provides a very sound and realistic valve gear for locomo-

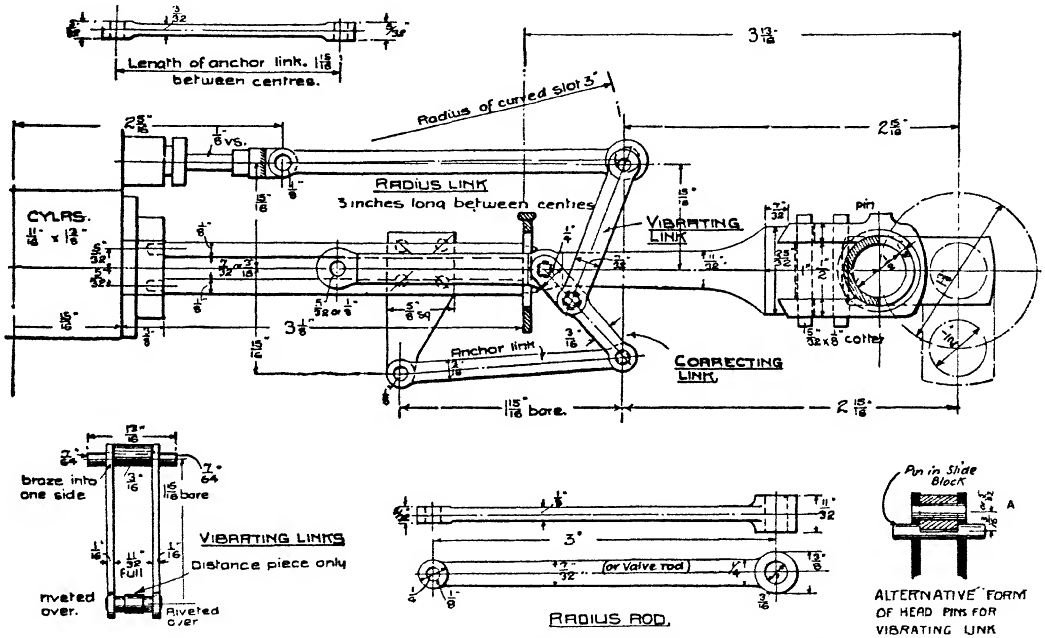


Fig. 192.—Joy's Valve Gear arranged for a 3¼-in. Gauge Model.

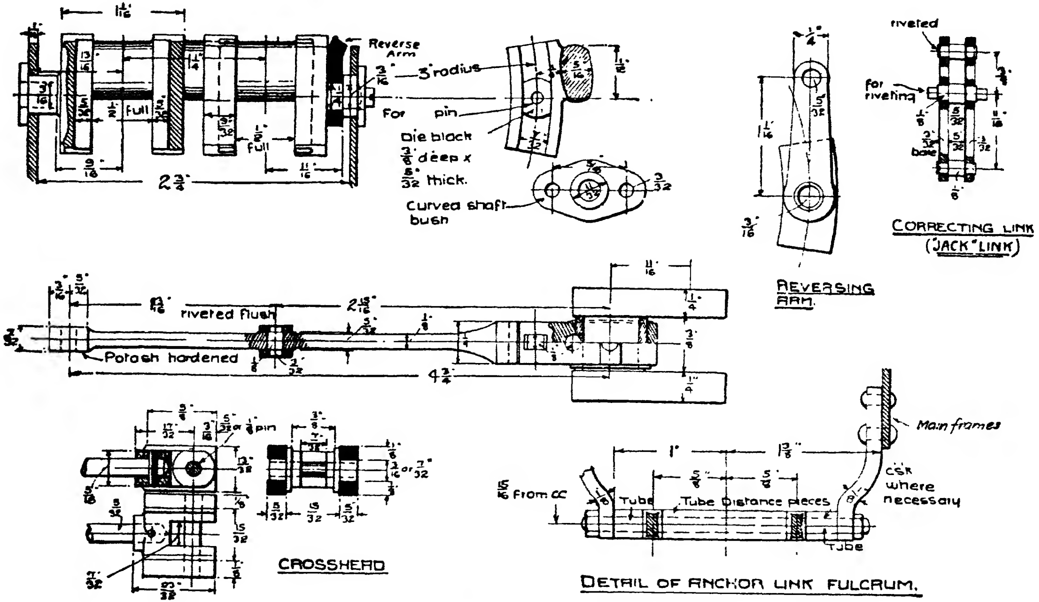


Fig. 193.—Details of Joy's Valve Gear.

tives with outside cylinders and valves on top. It is arranged to take its motion from the crank pin, and the weigh shaft and correcting link are supported from an outside girder-frame of exactly the same style as the girder

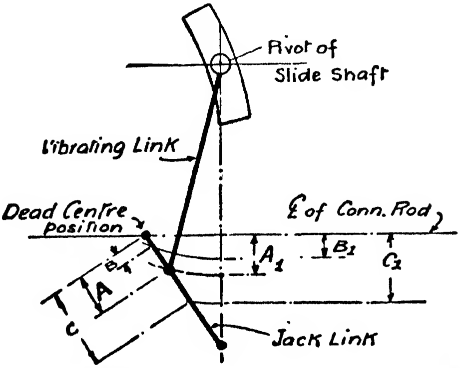


Fig. 194.—Method of Setting out Connecting Links of Joy's Valve Gear.

used for carrying the Walschaert's motion employed on modern engines of the "Atlantic," "Pacific" and 4—6—0 types, and more particularly those of American and Colonial design.

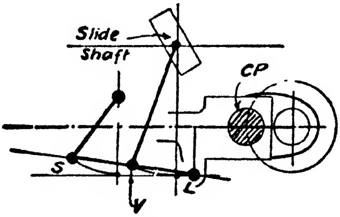


Fig. 195.—Method of Setting out Corrected Valve Gear.

The gear in a working model is much more robust than Walschaert's and, furthermore, involves fewer parts and joints. A two-cylinder Walschaert's gear has 25 pin joints and two die blocks, against 13 pins, two sets

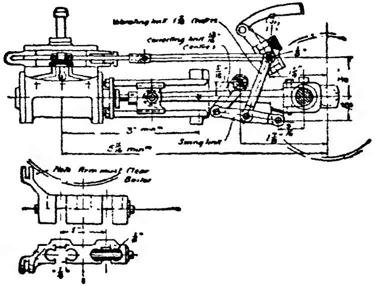


Fig. 196

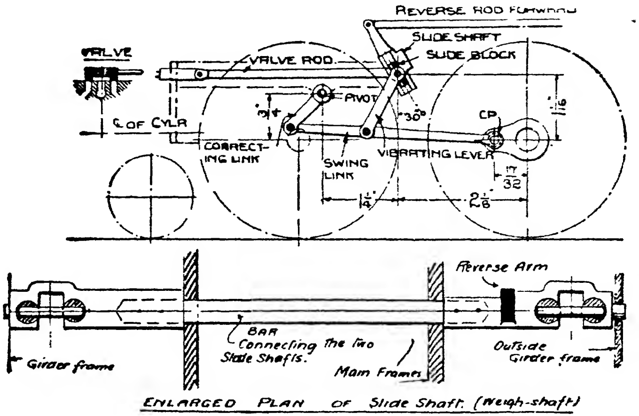


Fig. 197

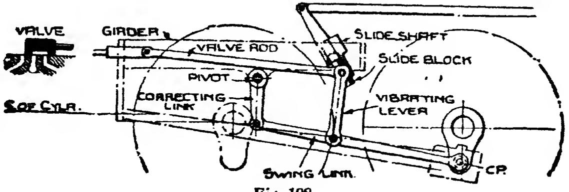
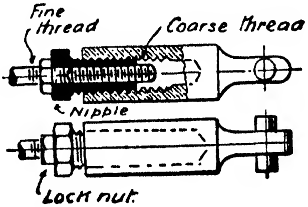


Fig. 198

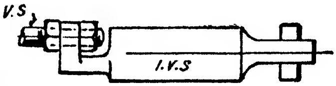
Fig. 196.—Greenly's Corrected Valve Gear arranged to suit Inside-cylinder Locomotives.

Figs. 197 and 198.—Corrected Valve Gear for Outside-cylinder Locomotives, in Two Positions.

of die blocks and no crosshead connection or return crank in the author's gear. The method of setting out is the same as for the inside-cylinder motion, but the swing link that it is found convenient to employ is very much longer. The diagrams (Figs. 197 and 198) show the gear standardised for a 2½-in gauge American type model. In large models the lap (advance) function is obtained with an eccentric or two-pin head to the vibrating lever as in other radial valve gears. The enlarged view of the slide shaft shows that it is made up of two blocks or castings cross-connected by a shaft running in bearings in the main frame.



A
Fig. 199



B
Fig. 199

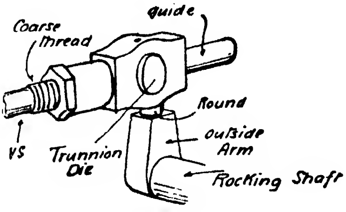


Fig. 200

Fig. 199.—Screw Adjustment for Valve Spindles: A, Differential Type; B, Lug and Double Links.

Fig. 200.—Rocking-shaft Joint for Gear shown by Figs. 180 and 181.

Tests for Joy and Similar Valve Gears.—In setting a radial gear the ultimate test for accuracy in setting the rods is (presuming the lengths of the links are reasonably correct to drawing) to place the connecting rod *exactly* on dead centre. The valve rod should not move either way on the reversing lever being shifted from one extreme to the other. If it moves with the reverse rod the die is too high, and an opposite movement shows that it is too low. With a sprung engine the axle boxes may be out of position vertically, and the spring nuts (a relatively strong spring is advisable on the driving axle) may be adjusted either up or down. A serious error in the writer's gear may be corrected by bending the swing link, or in Joy's gear by a similar operation on the connecting rod. When a sufficient accuracy is obtained the valve may then be adjusted on its spindle to give equal port opening and admission. Time of admission is more important than that of the cut-off or the precise amount of maximum port opening.

Valve Adjustments.—Means for a fine adjustment in the position of the valve on the spindle is a valuable asset, especially if such adjustment can be effected without taking any part adrift and under steam.

The differential screw system is perhaps the best, and is exemplified by the illustration A (Fig. 199) of the standard intermediate valve spindle used for ½-in. scale link-motion models. Here a nipple with a coarse thread (3/16-in. Whitworth) is screwed into the I.V.S., the valve spindle having a fine thread. A rotation of the nipple gives a fine adjustment because of the difference in the pitch of the two threads. Another scheme B (Fig. 199) involves the setting over of the valve gear to provide a lug on the intermediate spindle. The valve stem is nutted both sides of this lug. Where there is no room for this reliance must be placed on the screwing in of the stem into the valve buckle or nut. This, of course, means detaching the eccentric rod or valve rod at the fork on the outer end of the valve stem or by reversing the position of the intermediate valve spindle, where such is used.

An adjustment equal to that obtained by half a turn of the spindle is usually all that is possible in this case. Other variants are included in the valve-gear arrangements already illustrated. The differential screw adjustment illustrated in Fig. 200 is a part of the rocking-shaft gear necessary to transmit the movements of a link motion of the design shown by Figs. 180 or 183 to the cylinders outside the frames.

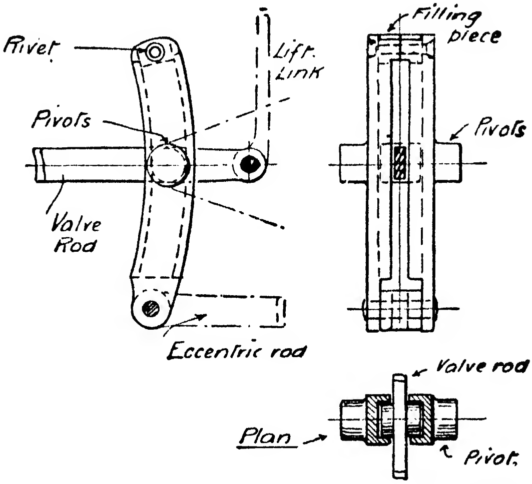


Fig. 201.—Box Link for Walschaert's Valve Gear.

Box Links.— In Walschaert's gear, more particularly where the curved link must be supported on central pivots, the box form of construction is to be recommended. The whole of the machining can be accomplished in the lathe by simple turning methods. The ordinary slotted link is generally a job involving skilled handwork.

In the box link the two separate but similar pieces are turned up first to form the pivot pin, and then on the faceplate the two (or more) pieces are machined with the groove for the die block or projecting pin on the valve rod. The links are then bolted or riveted together with distance pieces top and bottom. The scheme is illustrated in Fig. 201. The half-tone (Fig. 201A) is a view of a model fitted with the author's corrected valve gear.

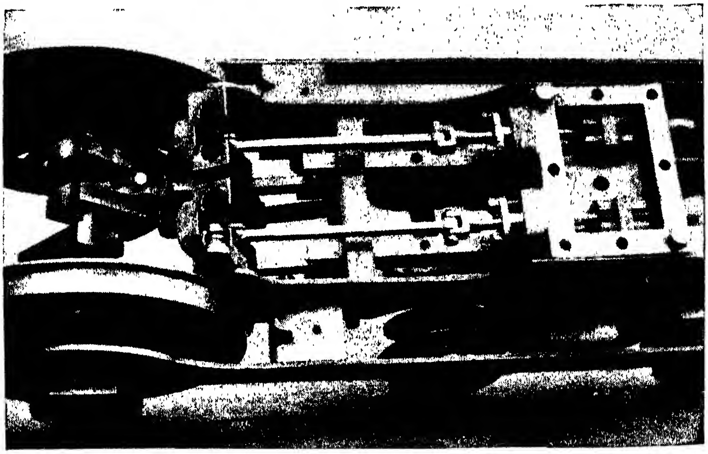


Fig. 201A.—Model 2½-in. Gauge Engine Fitted with Greenly's Corrected Valve Gear.

CHAPTER XI

Motion Details

Connecting Rods for Inside Cylinders.—The connecting rod in the simpler models generally resolves itself into modification of the marine type with a split big end. These are usually cast in gunmetal, the ends sawn, soldered up and bored for the journal and screws, and then unsoldered. A typical example is illustrated in Fig. 202.

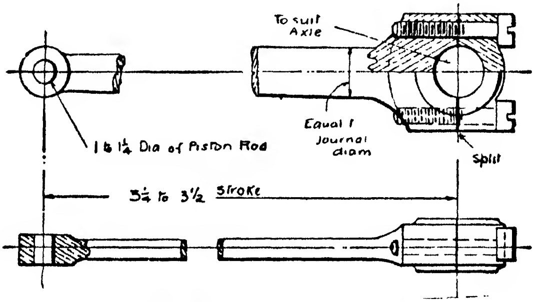


Fig. 202.—Simple Cast-brass Connecting Rod with Split End.

The length of the average inside-cylinder connecting rod varies from 3¼ to 3½ times the stroke. The little end pin should not be less than the diameter of the piston rod.

A type of rod which better imitates the orthodox strap-ended rod is illustrated in Fig. 203. This particular design is the standard for 2½-in. gauge engines, and is provided with a lug for the author's valve gear. The strap is fitted before boring the bearing, and the sides of the big end are faced on a mandrel. The rod portion is usually cleaned up and painted vermilion, the ends being bright.

An example of the strap-ended rod in a most elaborate form is shown in Fig. 204. Both ends are fitted with adjustable brasses and the straps are secured by two bolts in each case. A strapped little end is usually employed in conjunction with the four-bar crosshead.

Where the model is too small to fit safety-lock screws to the cotter the latter should have a very slow taper. On one or two British railways a species of marine big end is employed, as illustrated in Fig. 205. The steel forging for the rod has a forked end and the usual split brasses. The latter are secured in the fork by a lipped cap, in steel, and two substantial bolts.

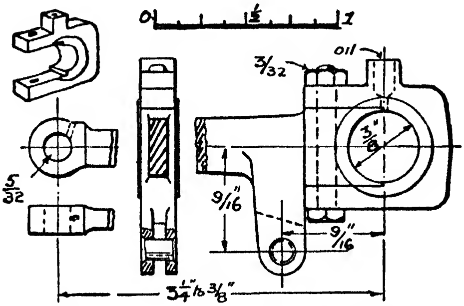


Fig. 203.—2½-in. Gauge Model Strap-ended Rod with Valve Gear Lug.

The little ends of inside-cylinder locomotives are usually of the eye-ended pattern, bushed with a plain brass bush. On the G.W.R. the forked little end is, however, a standard fitment on a large number of inside-cylinder locomotives.

Connecting Rods for Outside Cylinders.—Where the cylinders are outside the frames a connecting rod of good

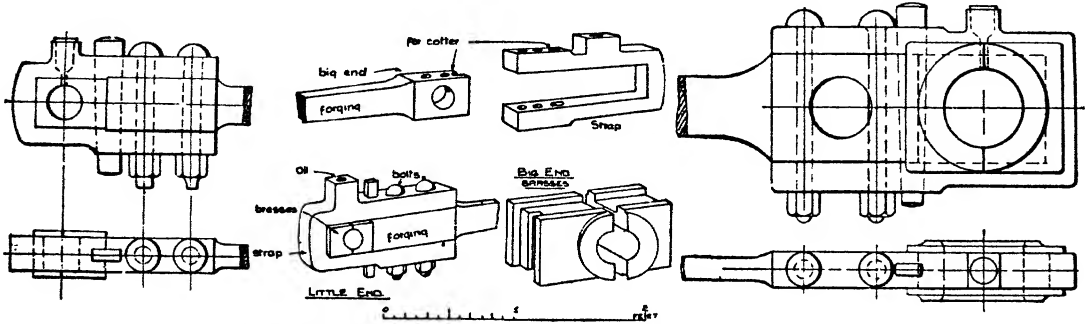


Fig. 204.—Standard British Strap-ended Connecting Rod for Inside-cylinder Locomotives.

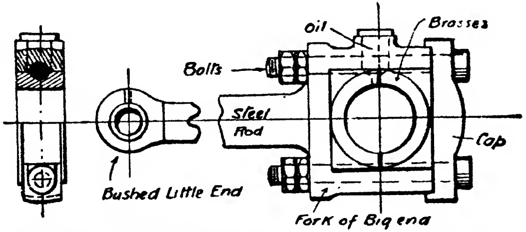


Fig. 205.—Connecting Rod with Marine-type Big End.

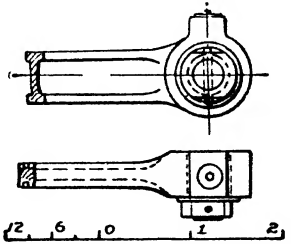


Fig. 206.—G.W.R. Outside-cylinder Big End.

appearance, finish and accuracy to scale is an essential. The smaller model has rods either of steel or cast or wrought nickel silver, the latter metal being chosen because it is white and does not rust. Drawn bar nickel silver is harder and stiffer than a casting, but it is easier to arrange for the fluting where a casting is used. In either case it is imperative to a good model that the big end, at least, should be bushed with brass. The little end of a steel rod may be case-hardened only and should work on a hardened pin. The G.W.R. use as a standard for outside cylinder engines a big end having plain bronze bush, a practice now adopted by other companies (see Fig. 206).

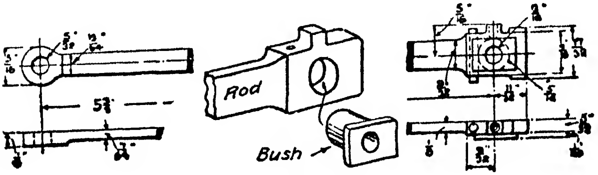


Fig. 207.—Simple Model Connecting Rod.

The ordinary rectangular big end may be modelled very satisfactorily by turning up a brass bush with a square outside flange and riveting this into a hole in the connecting rod, as illustrated in Fig. 207.

The type of big end shown in Fig. 208 is a common one and is standard on the G.N.R. The rod is forked, and a block is bolted in the open end of the fork after the split brasses have been inserted. A cotter with two safety set-screws provides for the adjustment of the split bearing brasses. The particular design is taken from one of the older engines. In later and larger examples the proportions are increased to suit a bigger crank-pin.

Fig. 209 shows how the bearing brasses may be adjusted by a wedge block or gib actuated by a screw. It is not a very common arrangement, but is quite good.

A connecting rod with a marine-type big end is shown by Fig. 210.

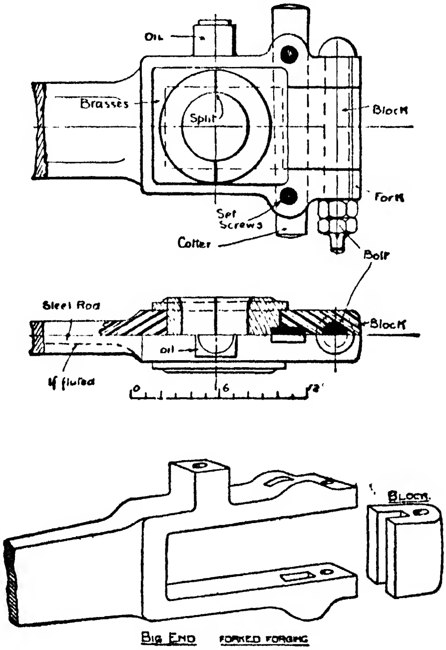


Fig. 208.—G.N.R. Type Big End.

For a large model the author designed a big end as shown in Fig. 211. The rod was made from a steel casting, complete with flutes, the end being of the box form. The brasses were split, the rear one being lipped over on the inside on one edge only, the cotter holding the front brass in a lateral direction. To increase the amount of oil carried a hole was drilled at A and sealed by a removable screw cap bolt. The horizontal hole needs plugging up permanently on the outside. The cycle lubricator on the top also carries a little thick oil, or preferably grease which would melt if the end got warm.

For an engine of similar size a forged rod with a marine-type big end was provided. The bolts in this case are relieved in the centre so that a passage is formed for the oil from the lubricator. The little end was bushed with bronze.

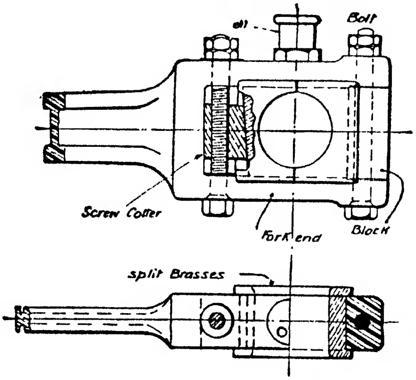


Fig. 209.—Box Big End with Screw-wedge Adjustment.

Crossheads.—These are somewhat troublesome items in model locomotive construction, and in their making good workmanship will well repay any extra time spent on them. Very small engines may be run quite successfully without crossheads or with such that do no actual work in guiding the piston rod. In that case, however, the length of the stuffing box and gland should be increased as much as possible and a large-diameter piston rod used.

A very simple yet effective arrangement is shown in Fig. 212. Here the piston rod is extended to work in a guide and the connecting rod is forked. It is quite a good idea

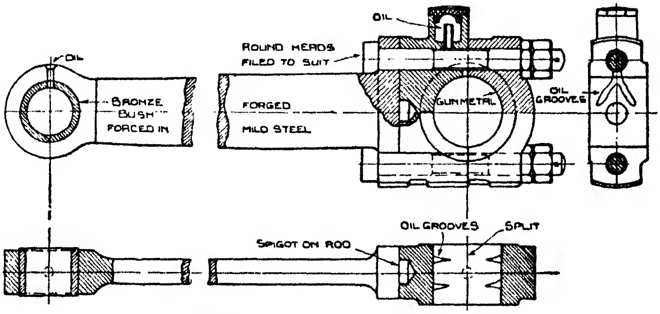


Fig. 210.—Connecting Rod with Marine-type Big End.

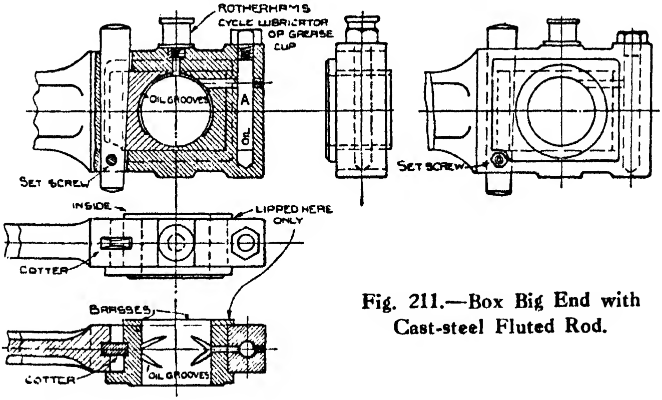


Fig. 211.—Box Big End with Cast-steel Fluted Rod.

for a model locomotive with a single inside long-stroke cylinder.

Crossheads are mainly of three forms for one, two or four slide-bars respectively. In large models the two-bar system, which is perhaps the most used, may have a crosshead cast in steel or gunmetal of the form shown in Fig. 213. The pin should be hardened, and as the fitting of a small flat cotter may be considered difficult the piston rod should be secured with two or more standard taper pins driven into carefully reamered holes. More than one taper pin is absolutely essential to maintain the strength of the fixing, and three taper pins fairly close together is nearly as effective as a flat cotter in resisting the shearing stresses.

As it is not always possible to get a satisfactory cored casting the recess for the little end must be provided for in other ways. The crosshead may be machined out of a piece of steel bar and have separate slippers attached to them, as shown in Fig. 214, by soldering or brazing.

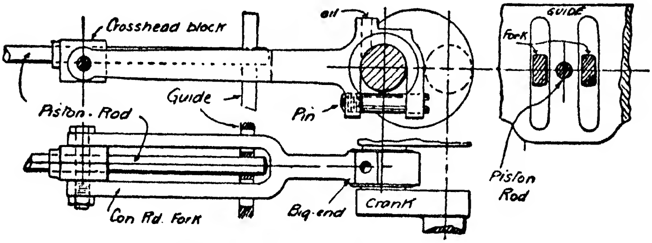


Fig. 212.—Forked Connecting Rod for Simple Model with Inside Cylinder.

Very small models ($\frac{1}{2}$-in. scale and smaller) are usually fitted with crossheads having one side wall only, the pin being overhung. The standard crossheads for $2\frac{1}{2}$-in. gauge locomotives made in this way are illustrated in Fig. 215. For inside cylinders $\frac{3}{16}$-in. slide bars are employed in this size, and the crossheads are cast end to end in pairs in gunmetal or machined out of flat steel bar.

The two ends are turned between centres and drilled, and the recess for the little end is formed by a pin drill. On being cut and the shaped profile formed with the file, the sinking cut by the pin drill will be cleared of superfluous metal and allow the connecting rod to swing to the required angle. Mild steel bar is usually employed for outside cylinders, as it is often very desirable to reduce the thickness of the crosshead to the minimum to provide for the swing of the bogie wheels. The procedure in making these crossheads is the same as with the cast pattern.

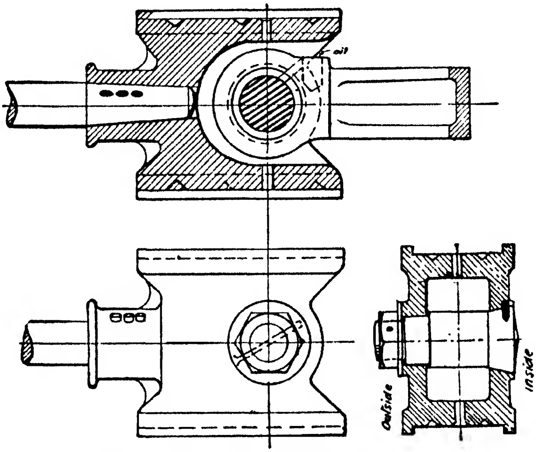


Fig. 213.—Cast Two-bar Crosshead.

The forked little end will require a crosshead of a design similar to that shown in Fig. 216. Here the pin moves with the connecting rod and takes a bearing in the crosshead. If made of steel the latter should be bushed with brass.

A typical four-bar crosshead is illustrated in Fig. 192 (see Chapter X). In a very large model separate slide blocks would be used in place of the one-piece crosshead shown in this drawing.

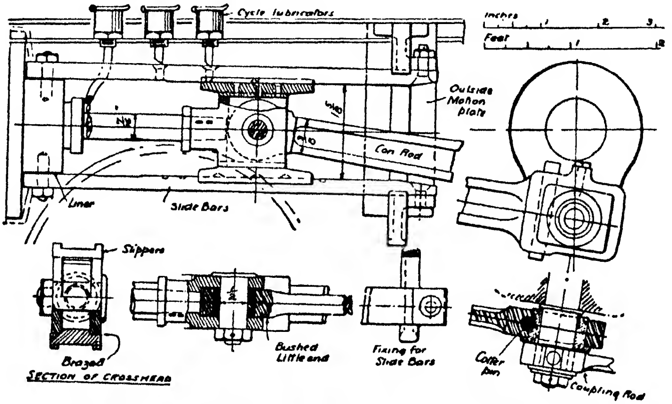


Fig. 214.—Outside Connecting Rod and Motion with Built-up Two-box Crosshead.

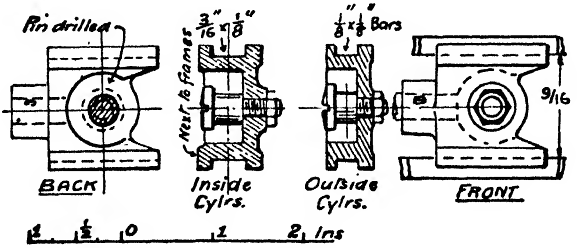


Fig. 215.—2½-in. Gauge Model Crossheads.

The single bar crosshead is exclusively used on some

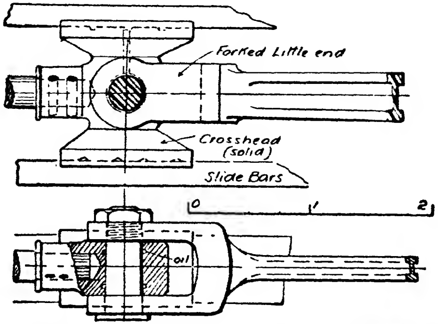


Fig. 216.—Crosshead for Forked Connecting Rod.

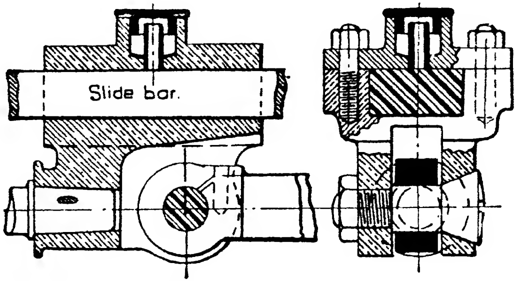


Fig. 217.—Single-bar Crosshead.

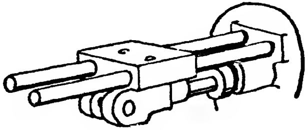


Fig. 218.—Simple Single-bar Crosshead.

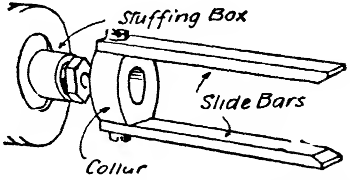


Fig. 219.—Method of Supporting Slide Bars in Small Models.

railways. A typical design is illustrated in Fig. 217. Its only merit is that it makes gland packing a little easier and less troublesome.

All types of slide bars, single, two-bar and four-bar, are often modelled by employing round rods, the crossheads being drilled to suit them, after the manner shown in Fig. 218. The tubular slide bar may also be employed where the cylinders have cylindrical stuffing boxes and no other provision for fixing the bars. In such cases a separate socket is often made to hold the bars, and then, complete with the bars, pushed on to the cylindrical stuffing box as shown in Fig. 219.

For small models Figs. 218 and 220 show two simple modifications of the orthodox pattern. In the first the crosshead is drilled for the slide bars, which are two rods projecting from the cylinder cover. The other is provided with a slotted slide bar. The holes for the crosshead, Fig. 218, need to be carefully jig-drilled to ensure alignment with the tapped holes in the cylinder.

Motion Plates.—The illustrations (Figs. 221 and 222) are typical of those employed for inside- and outside-cylinder engines respectively. They, in all cases, need modification to suit the disposition and dimensions of the particular form of valve gear and motion adopted. In the normal engine with a leading bogie it will be found necessary to allow plenty of clearance for the bogie wheels and frames at the points marked A on the two drawings. The special pattern of outside bracket is necessary in some forms of six- and eight-coupled engines, and is sometimes made up of plate material as a pierced or "spectacle" plate.

The forked pattern of bracket is perhaps the best, but in some cases the characteristics of the prototype require

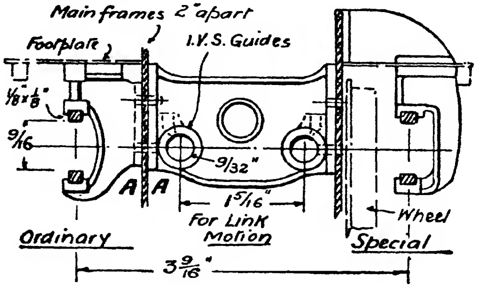


Fig. 222

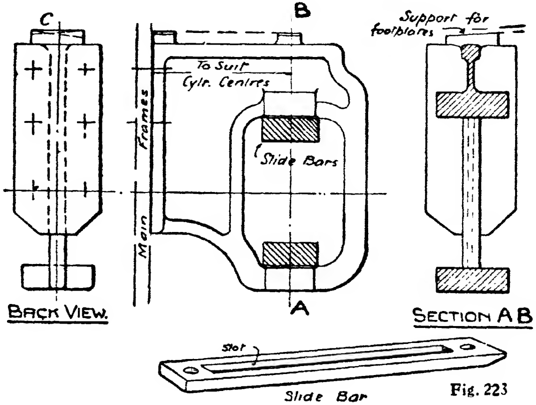


Fig. 223

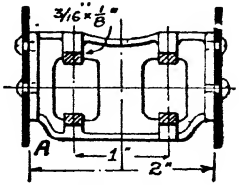


Fig. 221

Fig. 220.—Slotted-bar Crosshead.

Fig. 221 —Motion Plate for Inside Cylinders with Two-bar Slides.

Fig. 222.—Outside-cylinder Motion Plates and Valve Spindle Guides (2½-in. Gauge Standard).

Fig. 223.—Pierced Outside Slide-bar Bracket.

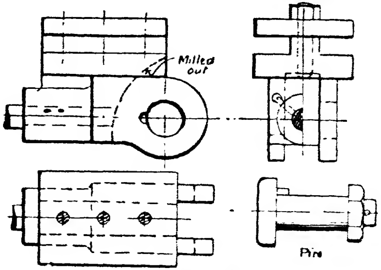


Fig. 220

a motion plate of the style shown in Fig. 223. It is also convenient in some instances to provide lugs or bosses on the upper edge to carry footplates. In the casting these are left square and, if necessary, are filed one way or the other to suit the inclination of the cylinders, as indicated at C (Fig. 223).

Slide Bars.—The general practice is to carry slide bars from the rear-cylinder cover and a lug or lugs are cast on the motion plate, as shown in Fig. 214. When slide bars only measure $\frac{1}{8}$ in. or $\frac{3}{16}$ in. wide the fixings require modification. In $\frac{1}{2}$-in. scale practice the arrangement shown in Fig. 131, Chapter VIII, is employed, the slide bars being turned down and screwed to bolt to a flange formed on the cylinder cover. When secured in this way the only function of the motion plate is to prevent the bars spreading. This is provided for in the two designs of motion plates illustrated in Figs. 221 and 222.

Coupling Rods.—For the same reasons as applied to connecting rods, coupling rods are made in nickel silver instead of the orthodox mild steel, and in all larger models rods should be bushed with brass or bronze bushes forced into holes in the rod ends. For small engines the scheme A, Fig. 224, is quite good and saves quite a lot of work in dealing with the rod. The arrangement at B is common, but more or less of an imitation. For six- or eight-coupled engines without springs rods may be made in one piece, otherwise it is necessary to joint the rods to cater for the vertical movement of the axle boxes when the engine is standing on a surface that is out of level. The usual method is shown in Fig. 224 (C), but Figs. 225 and 226 illustrate alternatives, the first being a modification of the orthodox arrangement to suit the smaller models.

The "Atlantic," "Pacific," 4—6—0 and other types of

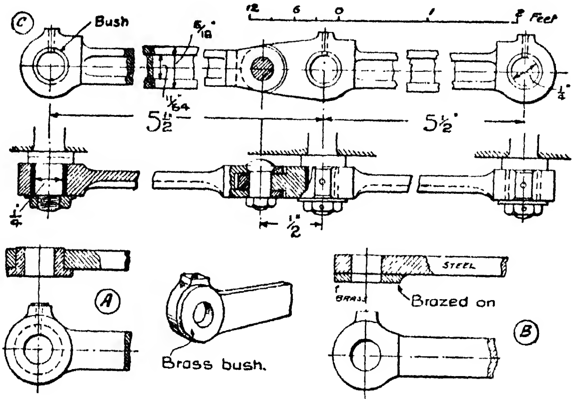


Fig. 224.—Types of Model Coupling Rods.

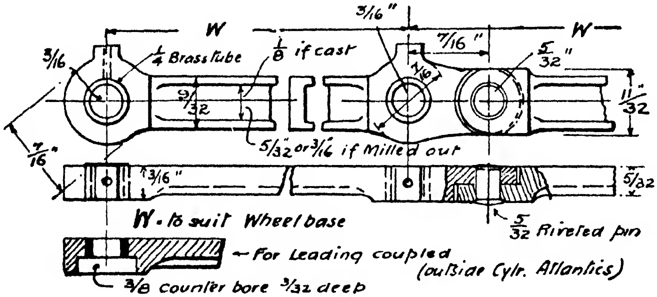


Fig. 225.—Coupling Rods for 2½-in. Gauge Models.

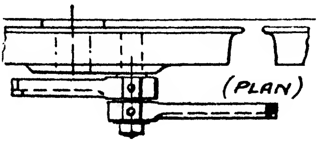


Fig. 226.—Arrangement of Coupling Rods to Avoid Joints.

outside-cylinder locomotives with a leading coupled wheel must be provided with a specially thin retaining nut, one form being illustrated in Fig. 89, Chapter VI. For tiny models a countersunk-headed crank pin is sufficient, or the device shown in Fig. 227. For a large locomotive the author uses the design shown by Fig. 228. The arrangement for securing the bush in an ordinary pattern of coupling rod end, shown in Fig. 229, is also a good one. Coupling rods should be measured off from the centres of the wheels after the latter have been fitted to the frames. This will provide for any inaccuracies which may occur in making the frames and fitting up the axle boxes.

Where the rods are jointed, as in the case of a six- or eight-coupled engine running on springs, all the joints should be made and fitted up before the holes for the crank pins are marked out and drilled. When this is done one pair of wheels (the drivers for preference) should be secured .to their axle at the orthodox 90° angle. The coupling rods should then be fitted on the crank pins and the other wheels secured in their positions without removing the rods. The latter act as a jig, and if the crank pins are all at the correct throw and are fitted quite squarely into their wheels the rods should rotate quite freely without binding in the "dead-centre" positions.

Eccentrics and Straps.—Where the eccentrics are not turned up solid with the shaft and, as arranged in Fig. 235, have to take up a position between the adjacent crank webs of the axle they may have to be cast in pairs and split, as shown in Fig. 230. The screws are fitted after splitting and the sheaves are then turned on a suitably centred mandrel. Cast iron or mild steel should always be used for the sheaves. Straps are best made of bar brass or cast gunmetal. The lugs should be long, so that the bolts

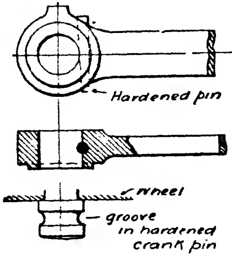


Fig. 227.—Coupling-rod Retainer for Leading Ends.

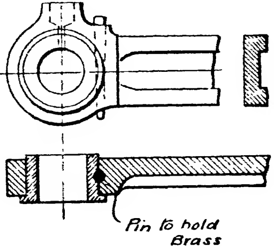


Fig. 229.—Method of Fitting Bush in Coupling-rod End.

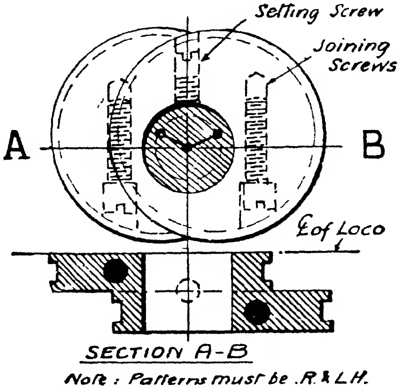


Fig. 230.—Eccentric Sheaves Cast in Pairs.

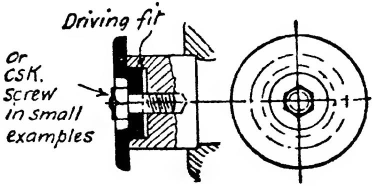


Fig. 228.—Crank-pin Retaining Cap for Large Models.

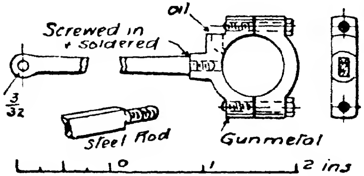


Fig. 231.—Standard Strap for 2½-in. Gauge Models.

may lie close to the sheave. Figs. 231 to 233 show various methods of fixing the eccentric rods. Of course, in very small engines with slip or single eccentrics the strap and rod may be cast in one piece, the strap not being split, or a ring may be turned out of the solid bar with a round

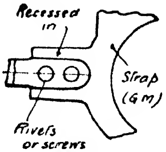


Fig. 232.—Method of Fixing Eccentric Rods to Straps.

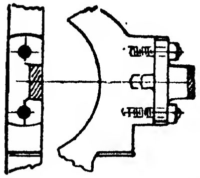


Fig. 233.—Orthodox Design for Large Models.

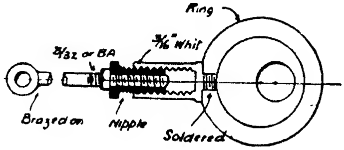


Fig. 234.—Method which Provides for Adjustment in Length.

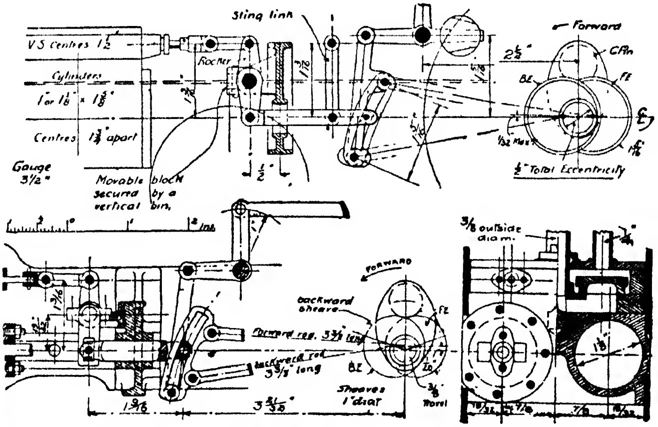


Fig. 235.—Two Designs of Indirect Link Motion.

rod fixing in the manner shown in Fig. 234, which provides a differential screw form of valve adjustment at the same time.

In small engines eccentric sheaves are often grooved in the centre and a rib formed on the bearing surface of the strap to freely fit this groove. This reduces the overall size of the sheave, which is important where they are cut solid with the axle.

In large engines, and where this consideration may not apply, the groove is best arranged in the sheave. The double-flanged sheave, shown in Fig. 230, is not often used. By adopting the central rib or groove method just described, the dimensions of overall width can be cut down to the minimum.

The two designs for "indirect" link motion, i.e. a valve gear in which the motion is transmitted through a rocking shaft to valves on top of the cylinders, illustrated in Fig. 235, are interesting arrangements suitable for 3½-in. gauge (and larger) models. The upper one is the better of the two, as it eliminates the careful fitting necessary in making and assembling the intermediate valve spindle, rocker and die block used in the other scheme. All wearing surfaces are either round pins or drilled holes.

CHAPTER XII

Boiler Construction

Simple Boilers.—The type of boiler fitted to toy models in which the flame of the lamp impinges on the lower outside surface of the barrel is usually made of extremely thin brass with a lapped bent-in seam along the bottom. The ends are flanged over the barrel and the whole is secured with a good grade of soft solder. Such boilers are quite safe up to a pressure of about two atmospheres (30 lb.), and, as already stated, owe their steaming power to the very thin metal (No. 24 or 26 S.W.G.), of which they are made and to the fact that a spirit lamp burns best in the open air. Details of this method of construction are shown at A in Fig. 236. There are limits to their usefulness, and, therefore, for all home-made models using direct-acting slide-valve cylinders made up from castings, other systems of boiler construction providing greater heating surface are essential. With the type of model illustrated in Fig. 151, Chapter VIII, which has a small cylinder fixed on or quite near to the boiler and connected to a shaft geared to the driving axle, it is possible to rely on a plain outside-fired boiler, although one or two water tubes might be introduced into simple designs of this character, especially in the larger gauges.

Water-tube Boilers.—The water-tube boiler is one which fulfils the requirements of the average model locomotive builder, and while it can be made up without brazing or silver-soldering this is undoubtedly the simplest and safest method of construction. Fig. 237 shows a 2½-in. gauge inner boiler made up with screwed or spun joints caulked with tinman's solder. The barrel should be a piece of fairly stout copper tube; normally, No. 20 S.W.G. material is quite strong enough, but for this particular purpose No. 18 gauge would be advisable. The ends should

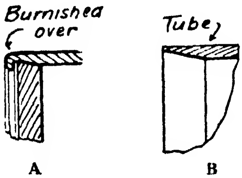


Fig. 236.—Method of Fitting Boiler Ends.

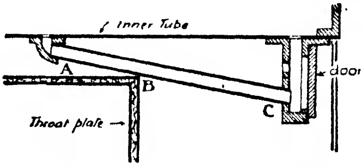


Fig. 238.—Large Water-tube Boiler Construction.

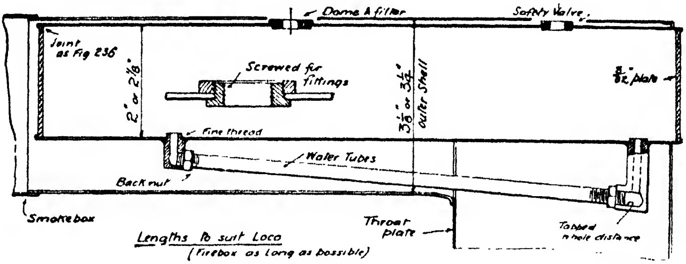


Fig. 237.—Water-tube Boiler Built with Screwed Parts and Soft Soldered

be turned true and the inside surface skimmed to a taper, as detailed at B, Fig. 236. A stout brass plate (No. 14 S.W.G.) should then be turned up, with a taper edge, a driving fit in the tube. The surfaces should be tinned with soft solder, and after fitting together the taper edge of the tube should be spun over the end with a burnisher. The water-tubes must be fitted into screwed elbow-sockets, back nuts being employed to secure steam tightness at the joints.

Of course, the sockets at one end (the rear) must be provided with sufficient length of thread to allow of fixing by the running-joint method, the tube being screwed in farther than required, so that the front sockets can be introduced into the boiler tube. By using fine threads soft solder will be found to securely caulk all joints. The water tubes must, however, be on the large size to prevent them reaching too high a temperature. This means that a smaller number of tubes—three at the most—will be all that can be got into a 2½-in. gauge boiler. A longitudinal stay is not required where the inner boiler barrel is under 3 in. diameter unless a proportionately thinner end than that shown is used.

As mentioned in Chapter IV large water-tube boilers can be made on similar principles, a cast upcomer and downcomer being arranged to receive the tubes. The downcomer at the back end would be fitted with a door, so that the tubes can be expanded in or fixed with a running screw as desired. The critical point in setting out the tubes is at the throat plate. The tubes between A and C must just clear at point B, Fig. 238. The use of inclined or curved throat plates sometimes assists matters in this connection.

For front ends of water-tube boilers flanged spinnings out of the same thickness of metal as the barrel are often used and are quite satisfactory, especially if slightly dished. They should be a tight fit in the tube, and if properly silver-soldered need not be otherwise secured. For the back plates castings 1/16 in. to ⅛ in. thick are commonly employed. These are made in either of the shapes shown in Figs. 239 and 240, and have flanges to carry the outer shell. Water tubes are fixed either by silver-soldering or brazing, this work being accomplished at

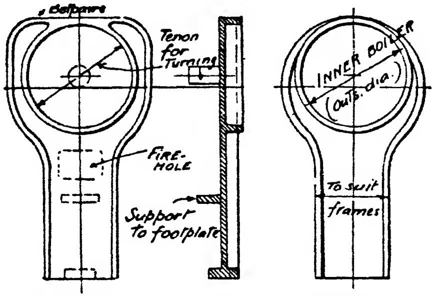


Fig. 239.—Back Plates for Fireboxes.

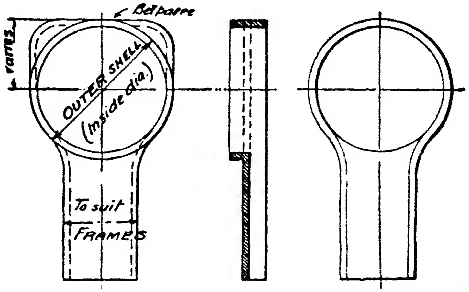


Fig. 241.—Throat Plates for Narrow Fireboxes.

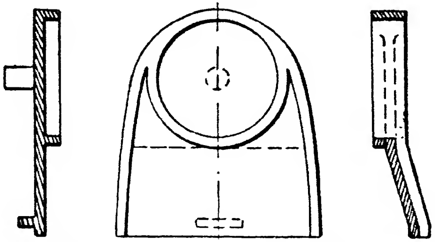


Fig. 240.—Firebox Plates for "Wootten" Boilers.

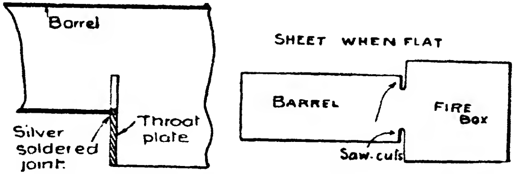


Fig. 242.—Boiler and Firebox Shell from One Sheet.

the first heat when fixing the front end. The cast back plate must be run with a finer solder (a silver-solder with a lower melting point) than that used for the copper parts. Back plates for both "Belpaire" and round-topped boilers may be made from castings. The flange supporting the outer casting should, in an unlined boiler, be finished as thin as possible at the top, so that the inner boiler nearly touches the outer shell at this point. This is important. Where a piece of drawn tube is employed for the outer shell it is not always possible to obtain enough length of metal for the sides of the firebox out of the tube itself; therefore cast throat plates are used as shown in Fig. 241. Such are essential in the "Belpaire" type, as a separate wrapper plate for the firebox must be used. The same applies to the "Wootten" firebox plates which are illustrated in Fig. 240. The shell of a boiler with a round-topped firebox may be rolled up out of a flat sheet, the barrel and firebox wrapper being made out of the same piece. This method of construction is illustrated in Fig. 242 and eliminates the cast throat plate. The latter is a piece of sheet metal brazed into the saw cut.

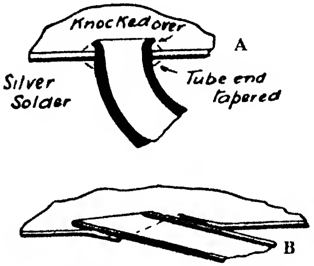


Fig. 243.—Methods of Fitting Water Tubes.

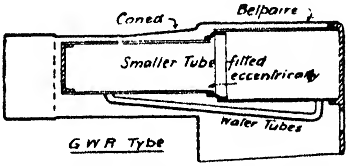


Fig. 244.—G.W.R.-type Coned Boilers.

Fig. 243 shows two methods of fixing tubes. The first (A) is used at either the front or the back, while the second

(B) is often adopted at the former point. The hole is drilled and then elongated to suit the tube by inserting and bending over a piece of steel rod of the same diameter as the tube.

In all soldering work absolute cleanliness must be observed at all joints. All oxides must be removed by scraping. When silver-soldering is to be followed by soft-soldering pickling for a few hours in a weak solution of sulphuric acid (1 to 20), warming the work to hand-heat before plunging, in addition to the scraping is essential. The work in either soft- or hard-soldering must not be raised to a temperature much above that of the melting point of the solder used. This is important in using tinman's solder, as it is so easily "burnt" and the surfaces oxidised and rendered unclean. When this happens the scraping process will again be necessary and the parts require re-soldering together.*

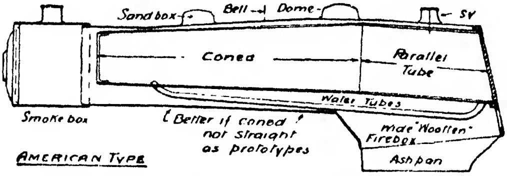


Fig. 245.—American-type Coned Boilers.

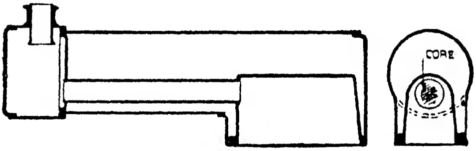


Fig. 246.—Single-tube Boiler.

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* Brazing temperatures are 1,400° to 1,500° Fahr. } Flux for both, Borax
Silver solder „ „ 1,100° to 1,130° „ }
Tinman's.. „ „ 380° to 550° „ Flux, Zinc Chloride

Water tubes which are not screwed should be of the thinnest material obtainable, but only solid-drawn (seamless) copper tube should be employed for such work.

Where the outer shell is not perfectly cylindrical, as in American boilers and in the G.W.R. coned "Belpaire" firebox boilers, the inner tubes may be either stepped or coned, as shown in Figs. 244 and 245.

As the difficulty in the smallest boilers [for example, those required for No. 1 (1¾-in.) gauge locomotives] is to provide enough air space and water capacity at the same time, the form of boiler shown in Fig. 51, Chapter IV, but with the addition of water tubes, is worth experimenting with. This type of boiler is generally used in conjunction with the plain spirit wick or vaporising lamp, and for this reason the good natural draught and more or less perfect combustion of the fuel when the locomotive is either standing or running are both obtained without the least complication. A boiler of this kind should be made of the thinnest plates that are strong enough to resist bursting or handling during the making of the boiler.

In all water-tube boilers it is essential that the inner barrel should not be too large, or made of too thick a metal. The outer shell may be thick and also made of sheet steel, either lined with asbestos in a single thickness or fitted with a sheet-iron liner of the same general form. Downcomers have no actual value in the evaporation of steam, and should only be used where more convenient from a constructional point of view, as in Fig. 238.

Loco-type Multitubular Boilers.—With reference to the use of the more satisfactory and cheaper solid fuel, namely, charcoal, there is apparently no reason why it should not be adopted in most of the water-tube boilers already described if the firebox is properly lined with asbestos and the outer shell double-cased. Although these water-tube boilers have been successfully applied to models of large scale fired by vaporising paraffin or petrol burners the orthodox loco-type boiler reigns supreme. In gauges below 2½ in. modifications may be necessary or worthy of experiment. The simple single-tube boiler shown in Fig. 246 is not of much use because of its small heating surface. The whole of the heat which passes as a core through the centre of the flue is wasted. Inserting cross water tubes would improve matters only slightly. A successful single-flue boiler might be arranged as shown in Fig. 247, applied to a solid-fired No. 1 gauge single-cylinder locomotive. The furnace in this case is simply a "tin box" tacked on underneath. The water-surrounded portion of the firebox is formed out of the single-flue tube, and to increase the heating surface two or more longitudinal water tubes are silver-soldered in. These also promote the end-to-end circulation, the lack of which is

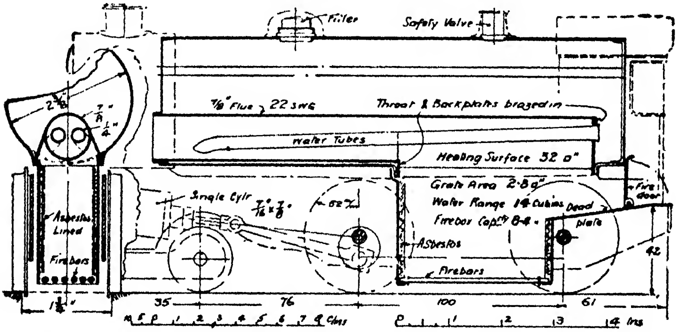


Fig. 247.—Single-flue Boiler with "Basket" Grate for Solid Fuel.

an inherent weakness in the loco-type boiler and, conversely, its presence makes for success in the water-tube generators described in the preceding pages. The cross water tubes in the firebox are employed mainly as stays. The furnace tube should be fairly thin (say, No. 21 or 22 s.w.g.) and the sheet-iron furnace lined with asbestos and tin-plate. Both ends of the boiler, it will be noted, are circular. An amplification of this idea of round ends is contained in Figs. 248 and 249. In the first scheme it is desired to get as wide a firebox as possible, the depth being of secondary importance because of the method of firing. A vaporising oil or petrol burner would be employed. The tube area is also valued, and therefore the firebox is swelled at the top. Solid fuel not being used the firebox is, in addition, filled with cross water tubes and the usual fire-door is eliminated. The firebox, therefore, can be built up by brazing the plates together and then fixing it at the foundation ring, by rivets, to a cast gunmetal outer firebox preferably, all the lower stays being screwed and soft-soldered in place. The solid-drawn copper boiler barrel is next prepared for the circular flanged ends, and after cutting a rectangular hole in it for the firebox the latter is introduced at the rear end, dropped into position, and the joints screwed and soft-soldered. The firebox being shallow can rest on the top of the frames. A modification of the same idea is illustrated in Figs. 249 and 250. This boiler is arranged for solid fuel with the largest "basket" dry-sided furnace the axles and frames will accommodate. The coupled wheels (six of them at least) being without springs, a very capacious firebox is obtained by mounting the centre pair of these coupled wheels on to studs riveted to the main frames. Both these designs (Fig. 248 and 249) are arranged for 2½-in. gauge locomotives, the latter being a 4—8—0 type goods engine, only the trailing wheels and the pony truck having springs. Where the fire-door is arranged in the position under the barrel, as shown in Fig. 249, then there is no objection to the introduction of four to six cross water-tubes near to the crown, as it would be difficult to entirely fill the firebox with fuel. The alternative method of making the firehole is shown in Fig. 250. This is accomplished by screwing a piece of thick tube with a fine thread and driving the same through the back plate into the firebox. If the threads are fine and the plates accurately tapped the joint can be made quite tight with soft solder. The front water tubes may also be retained, only those marked A and B (Fig. 249) being omitted. Instead of a stay a similar but smaller tube to act as a firehole for the inspection of the flame may be introduced at Z in the boiler illustrated in Fig. 248.

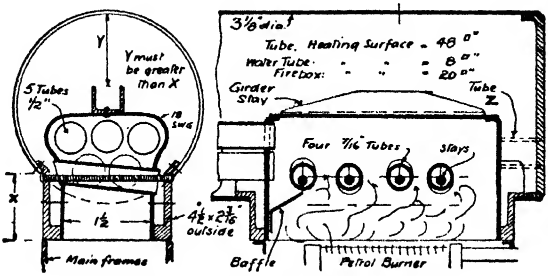


Fig. 248.—Boiler with Shallow Firebox.

The author's standard arrangement for 2½-in. gauge solid-fuel boilers of the narrow firebox type is shown in Fig. 251. The barrel may be 3⅛-in. or 3¼-in. diameter, and five tubes ½-in. diameter will be found to give a satisfactory evaporation. As the value of a water space at the back end is negligible, the writer devised the "dry back" arrangement shown. This allows a large firehole (1 in. × 1 in.) to be employed. The back plate, front tube plate, throat plate, and in some cases the firebox tube plate, are made of sound gunmetal castings. As leakage due to the porosity of the castings used for various flanged plates is an annoying kind of failure—one which is not usually discovered until the boiler is finished—the castings should be carefully hammered all over before machining or filing up to size. Recourse can be made to tinning the castings all over before assembling to lessen the risk of this porosity.

This tinning process cannot, of course, be resorted to where any boiler parts or castings are required to be silver-soldered together afterwards. The use of solid-drawn tube is recommended for the barrel, and both the spigot of the throat plate and the circular front end should fit the barrel tightly. The joints of the firebox must be silver-soldered throughout, sufficient screws or rivets being used in the flanged joints to hold the parts together during this operation. The wrapper plate of the outside firebox may then be riveted and soft-soldered to the throat plate, all joints being drawn up quite tightly.

The firebox tube plate having been previously screwed for the tubes the complete inner firebox unit (see Fig. 252) may be fitted into the shell, the wrapper being riveted, or screwed where rivets are impossible, to the back plate. The foundation ring is made up of brass strip carefully fitted and riveted with $\frac{3}{32}$-in. copper rivets. The tubes are fitted last. They are screwed with a fine (40 per inch) thread slightly tapered, and on being soft-soldered will remain tight under all conditions. The front ends are quite satisfactory if carefully expanded and soft-soldered. Other methods of fixing tubes are described on page 218. As an alternative the method shown in Fig. 265c may be employed. Where rivets cannot be used, and, as in an unlagged boiler, the surface must be quite flush and cleanly finished, countersunk brass screws may be used, the countersinking being only half the usual amount. The screws can then be filed off flush as indicated in Fig. 253.

Stays.—Screw stays made from a good quality brass or bronze rod in the form shown in Fig. 254 are quite satisfactory. The nick should be just deep enough to allow the stay to break off when driven home. The holes must be tapped right through the two plates at one operation, a specially long tap being often necessary to accomplish this. Stays are caulked with soft solder, the inside ends generally being nutted. In a "Belpaire" firebox boiler the top row of horizontal side-to-side stays are generally fitted

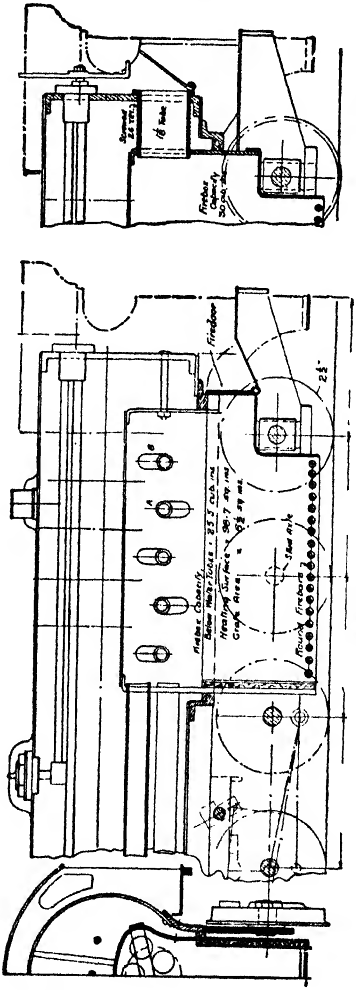


Fig. 250

Fig. 249

Figs. 249 and 250.—Other Boilers with Shallow Fireboxes.

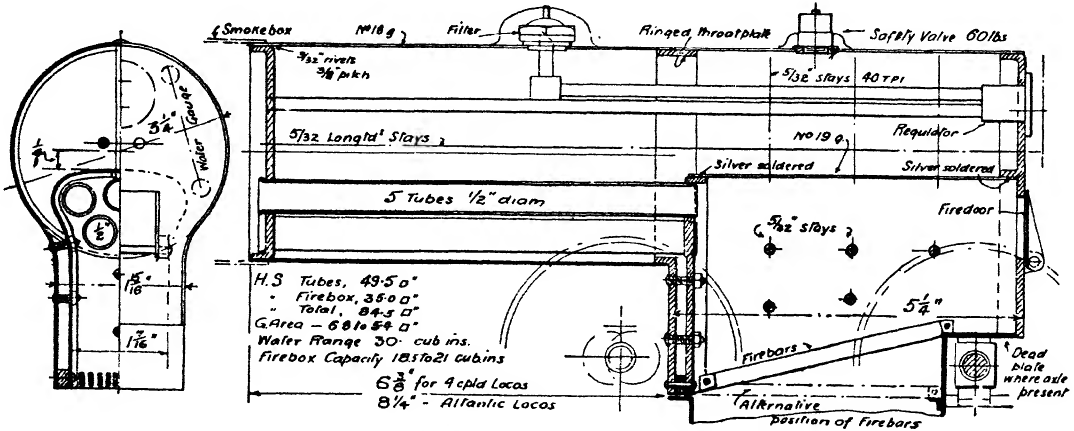


Fig. 251.—Solid-fuel Boiler for 2½ in. Gauge Model.

with bright brass nuts outside to represent washout plugs. Where it is desirable that the stayheads should finish quite flush the metal of the outer plates of the boiler may be dented in and finished smooth with solder, as indicated in Fig. 255.

The keynotes in the construction of small brass and copper loco-type boilers are, therefore, clean plates, good fitting joints, secure riveting or screwing, and screwed fittings all being caulked with soft solder. The main joints of the inside firebox, because of the possibility of the water level falling below the crown, should be silver-soldered. For inner boilers of water-tube generators brazing and silver-soldering only is to be recommended. As thin plates help the heat transmission to a considerable degree, inner firebox plates, tubes, and every part which can be considered as efficient heating surface should not be any thicker than the dictates of safety would suggest. As the dry-back boiler is such a satisfactory one, there is no reason why suitable wooden former blocks should not be prepared and the whole of the plates, more especially of the inner firebox, flanged over by hand. It is usual to employ a casting for

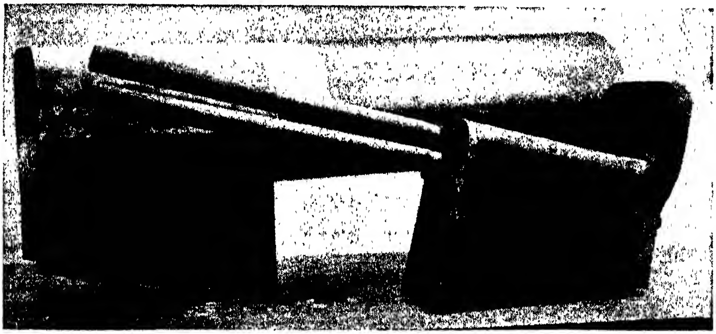


Fig. 252.—Solid-fuel Boiler during Construction.

the firebox tube plate, because such provides thicker metal in which to form the screw threads for the tubes. There is no reason, however, why the tube plate holes should not be flanged inwards, to ensure a sufficient number of threads for securing the tubes.

Large Boilers.—Larger boilers for ¾-in. and 1-in. scale locomotives are always better if made up from the sheet copper and riveted in the orthodox manner. As such boilers are always lagged, rivet heads are left showing. Non-ferrous metals are always employed up to 1½-in. scale. Steel boilers with plates not less than 5/32 in. or 3/16 in. thick are commonly made for locomotives in 7¼-in. gauge. The steam tightness of steel boilers depends on secure riveting and corrosion (or "taking up") of the plates touching one another. Tubes are always expanded in and steel tubes give the best results. Of course, the heating surface is reduced if the rather more coarsely constructed steel boiler is employed instead of the thinner copper one, and the author has therefore, for his most successful engines up to 9½-in. gauge, employed copper throughout. The model ⅛ full-size G.C.R. locomotive boiler, built to the author's design by Bassett-Lowke, is an excellent example of this construction. If this material is adopted it is better to rely on the use of soft solder for caulking than attempt to get steam tightness by the use of the caulking tool. In a small steel boiler the tinier "weeps" of water which may be many and usually appear even on the final hydraulic test can usually be stopped by a washing out of the whole boiler with a solution of sal-ammoniac. In copper boilers it is important that all fittings and fixtures in contact with the water should be of brass or copper, not iron or steel.

Typical designs of large model loco-type boilers are given by Figs. 256 to 258. The components of the ordinary boiler with a round firebox are shown in the photographic reproduction (Fig. 258). The plates at the throat in this type may be set out either as shown at A or B (Fig. 259). With the "Belpaire" firebox the throat plate extends to the top as shown at C. It is because the throat plate takes this form that a casting is so convenient in small-gauge models (see Fig. 241). In any case, whether the plate is flanged out of sheet material or cast the boiler barrel will have a square end, as at A, and the firebox wrapper, which is not notched (see B), will be bent over a flat-topped wooden former to suit the square head portion of the throat plate (C). The boiler (Figs. 260 and 260A) for a model 4—4—2 type tank locomotive of 7¼-in. gauge may be made in copper

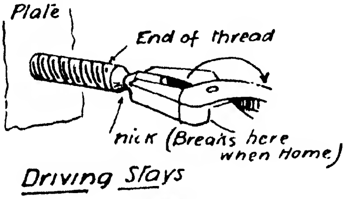


Fig. 254

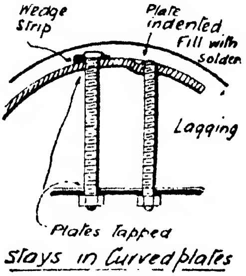


Fig. 255

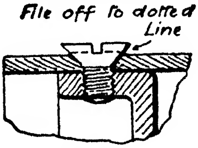


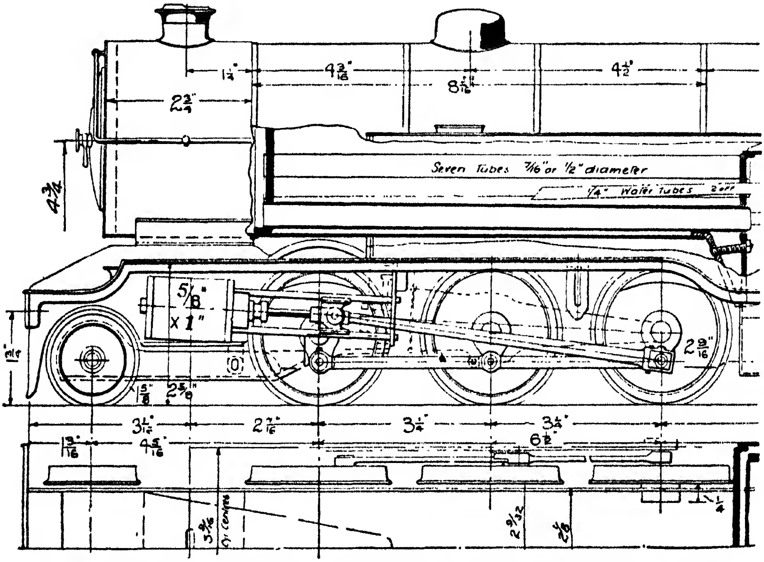
Fig. 253

Fig. 253.—Showing Use of Screws instead of Rivets.

Fig. 254.—Method of Fixing Screw Stays.

Fig. 255.—Method of Fixing Screwed Roof Stays.

or steel. Copper plates $\frac{5}{32}$ in. or steel $\frac{3}{16}$ in. thick would be employed, with possibly a $\frac{3}{16}$ in. firebox tube plate in either case. The barrel, failing the supply of 8 in. solid drawn tube, would be made up of the plate material and riveted with a lap seam with rivets in two rows. For a steel boiler the rivets would not be less than $\frac{1}{4}$-in. diameter,



Figs. 256 and 256a.—Design for Wide-firebox Boiler in Large 2½-in. Gauge 2—6—4 Tank Engine.

and a butt seam might be used if the plates were first acetylene-welded, the strip being placed on the outside. Larger rivets are always required where a caulking chisel is used. There is no reason why welding in a small steel boiler should not be employed in several instances, not only as an ultimate joint, but as a means of caulking seams and joints. The boiler illustrated has a roof supported by a girder. This is slung from a **T**-bar riveted or bolted on to the wrapper. The total area of the rivets or bolts used should be sufficient to safely support the crown with a factor of safety of at least 10.

Wide or "Wootten" Fireboxes.—In view of the large capacity, grate area and number of tubes to be obtained by

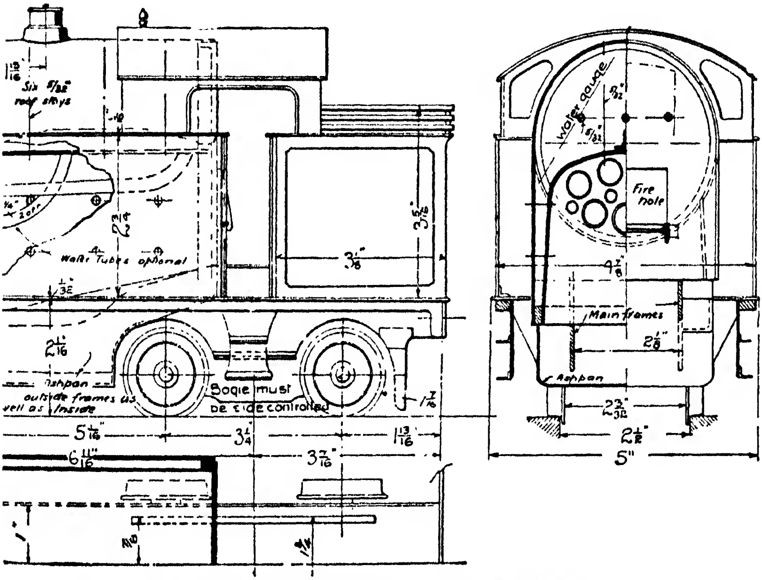


Fig. 256a.—(See illustration on preceding page.)

employing the well-known "Wootten" firebox a considerable amount of skill has been shown by free-lance designers of model locomotives in arranging the frames and wheels in such a way that the largest and deepest firebox the loading gauge will allow is provided. Fig. 256 shows a 2½-in. gauge engine of the 2—6—4 type, the wheel arrangement being specially designed to provide the widest firebox practicable. Seven flue tubes are possible against the five usually fitted in a 2½ in. gauge model locomotive boiler, and also a firebox capacity of 32 cub. in. This, coupled with a heating surface and grate area of 123 sq. in. and 13¼ sq. in. respectively, resulted in a very successful model burning charcoal. The water range works out at 45 cub. in. and the firebox capacity 29 cub. in.

A slightly higher efficiency may be obtained by introducing four water tubes. These are introduced to improve the end-to-end circulation and take the water from the front end of the barrel. If used, they must, of course, be silver-soldered into the crown and tube plates. The positions are indicated on the drawing. A boiler of practically the same dimensions was also fitted to the 2—8—2 type goods engine model illustrated in Fig. 266.


Fig. 257.—G.C.R. Locomotive Boiler in Copper with Castings in Gunmetal for All Flat End-plates.

A Simple Charcoal-fired Boiler.—Figs. 261 and 262 show the simple construction adopted with success for a very small (No. 1 gauge) model burning charcoal. Here the tubes do most of the evaporative work, the firebox being of the wide type and without water spaces, the sides being lined with asbestos millboard and tinplate. Simi-

Fig. 258.—Component Parts of Locomotive-type Boiler made up of Flanged Plates.

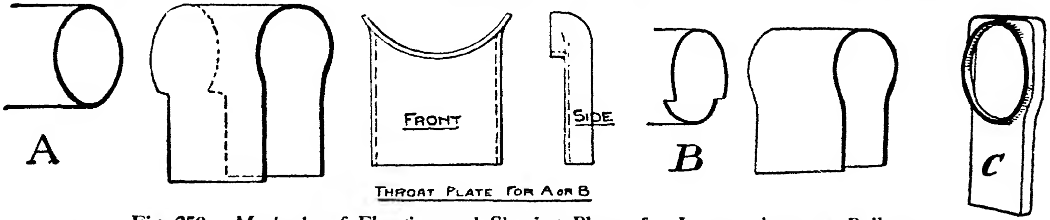
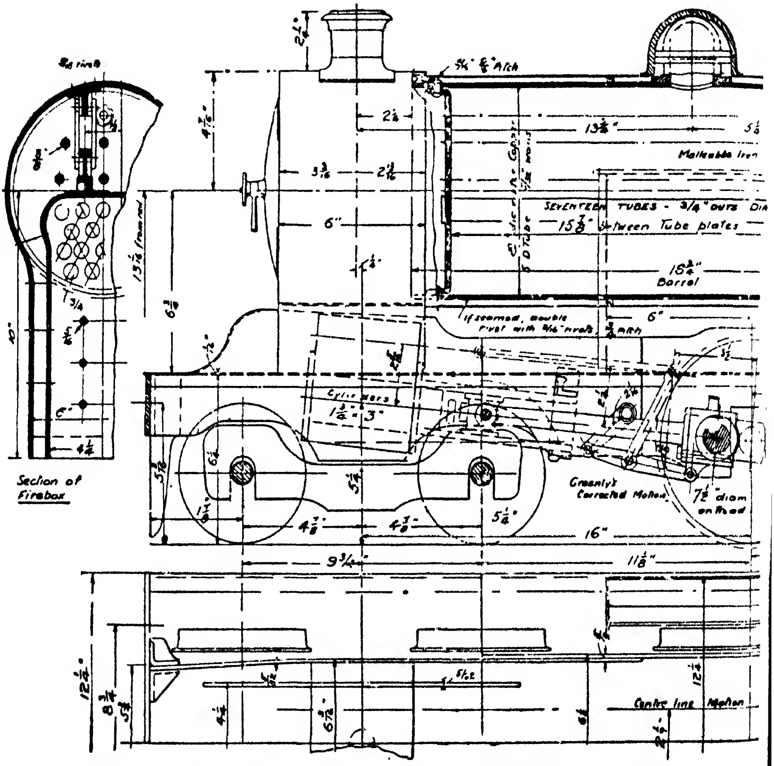


Fig. 259.—Methods of Flanging and Shaping Plates for Locomotive-type Boilers.

lar boilers have been suggested in which the sides of the firebox are protected by water tubes, the latter being carried across at the bottom to form the fire-bars.

Tubes.—The table given on p. 216 will give a good



Figs. 260 and 260a.—Design for 7¼-in. Gauge L.N.W.R. Tank Locomotive.

idea of the spacing, material, and size of tubes suitable for models of various sizes.

Girder Stays.—In place of stays made of rod girders may be employed to support the firebox crown of a round-topped boiler. In a large model these will require to be slung to the outer wrapper, as shown in Fig. 260a, to relieve the foundation ring of stress. For small boilers the girders may be made up of plate or angle brass. In larger examples cast girders attached by screws from underneath are necessary. The firebox crown should, if at all possible, be slightly rounded.

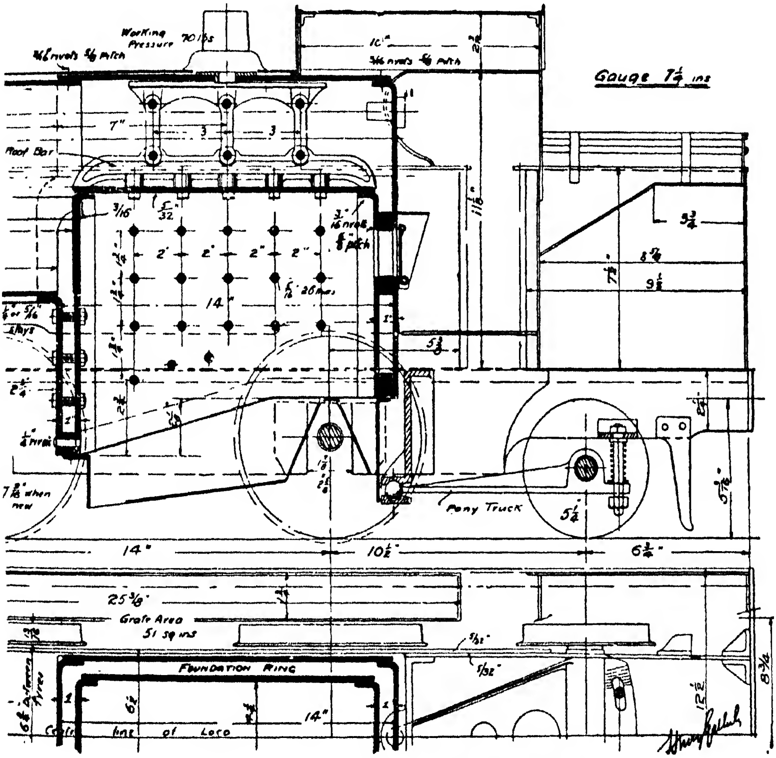


Fig. 260a.—(See Illustration on preceding page.)

For "Belpaire" fireboxes flat surfaces are more or less essential to the successful and easy fitting of "direct" rod stays. The corners of the box should, however, be well rounded.

Size of Model	*Size Tube*	*Gauge of Material*	*Spacing Between*	*Fixing*
$1\frac{3}{4}$ in. Gauge	$\frac{5}{16}$ in. to $\frac{3}{8}$ in.	No. 20 Gauge brass or copper	$\frac{1}{16}$ in.	Silver-soldered throughout or screwed at fire-box, expanded and soldered at smoke-box.
$2\frac{1}{2}$ in. Gauge	$\frac{7}{16}$ in. to $\frac{1}{2}$ in.	No. 20 Gauge brass or copper	$\frac{3}{32}$ in.	
$3\frac{1}{2}$ in. Gauge	$\frac{1}{2}$ in. to $\frac{5}{8}$ in.	No. 18 Gauge brass or copper	$\frac{1}{8}$ in.	Screwed and expanded as above
$4\frac{3}{4}$ in. Gauge	$\frac{1}{2}$ in. to $\frac{9}{16}$ in.	No. 18 Gauge brass or copper	$\frac{1}{8}$ in.	Ditto
$7\frac{1}{4}$ in. Gauge	$\frac{9}{16}$ in. to $\frac{11}{16}$ in.	No. 18 to No. 17 Gauge brass or copper	$\frac{3}{16}$ in.	Ditto
$7\frac{1}{4}$ in. Gauge	$\frac{3}{4}$ in.	No. 15 Gauge steel	$\frac{7}{32}$ in.	Expanded only
$9\frac{1}{2}$ in. Gauge	$\frac{3}{4}$ in.	No. 16 Gauge brass or copper	$\frac{3}{16}$ in. to $\frac{7}{32}$ in.	Screwed and expanded
$9\frac{1}{2}$ in. Gauge	$\frac{3}{4}$ in. or $\frac{7}{8}$ in.	No. 15 or No. 14 Gauge steel	$\frac{1}{4}$ in. to $\frac{5}{16}$ in.	Expanded only
15 in. Gauge	$1\frac{1}{8}$ in. to $1\frac{1}{4}$ in.	No. 10 Gauge steel	$\frac{1}{2}$ in.	Ditto

N.B.—Where the tubes of the smallest models are silver-soldered only and not screwed the gauge of the tubes may be reduced.

Fireholes.—These should always be much larger than the scale equivalent of the prototype for convenience in firing. The rectangular type is also much to be preferred, with a drop-down door. As shown in Fig. 264, the plates may be pressed out to obtain a joint, with or without an intervening ring. There is, however, not always sufficient width for this in narrow fireboxes, as the bends of the plates occupy a certain amount of room. For charcoal-fired engines the opening should be quite near to the top of the box, as this fuel may be heaped up.

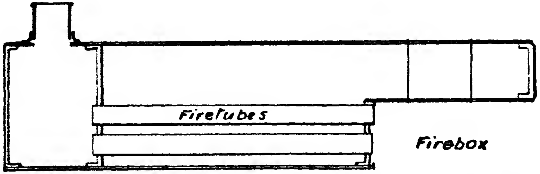


Fig. 261.—Simple Tubular Boiler without Waterspace in Firebox.

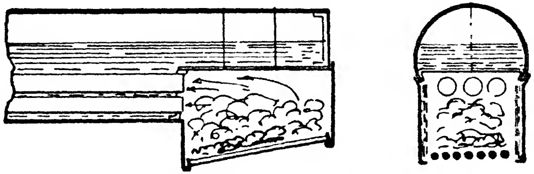


Fig. 262.—Boiler with Firebox and Grate.

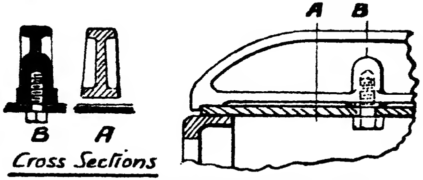


Fig. 263.—Girder-type Roof Stays.

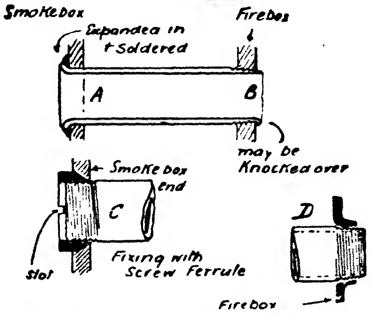


Fig. 265.—Methods of Securing Copper or Brass Flue-tubes.

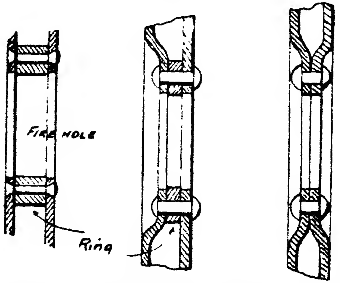


Fig. 264.—Fireholes in Back Plates.

Fixing Tubes.—The sketch (Fig. 265) illustrates methods of fixing flue tubes for copper or brass tubes to boilers made of non-ferrous materials.

Long Stays.—To save screwing very long stay-rods throughout their whole length the nipple device illustrated in connection with fixing regulator steam pipes (Chapter XIII, Fig. 303) may be adopted for one end—that fixed last—the other end being screwed a short length and having a nut inside and outside the plates. It is not always possible to double-nut both ends.

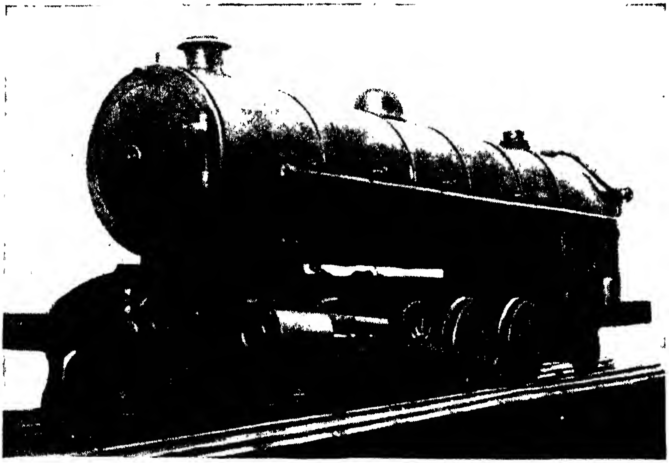


Fig. 266.—2—8—2-type Goods Locomotive with Large Boiler and Wide Firebox.

CHAPTER XIII

Boiler Mountings and Cab and Other Fittings

Safety Valves.—During recent years the fitting of standard safety valves made by outside firms has become a common practice by railway engineers, and therefore the distinction which this fitting gave to a particular company's engine is being lost. However, the Ramsbottom duplex safety valve is by far the most common to locomotives of this country.

It is not advisable to make a model of this valve for locomotives of a scale of less than $\frac{3}{4}$ in. to the foot, and even then it is difficult to get a satisfactory tight valve unless the lever has the jointed front pivot indicated in Fig. 267 at A. The use of a lever with the two fixed points, i.e. both being integral with the lever, does not allow the valves to find their proper seatings naturally; leakage is the result. Sometimes the spring is of the tension type, but the compression spring shown is to be preferred.

Where the Ramsbottom valve is not enclosed in a casing a small model may be made to closely represent the actual thing by using one valve only, as illustrated in Fig. 268. The working spring is hidden inside the cab. The device is then virtually the same as the spring-balance safety valves largely used during the Victorian era, the M.R. standard pattern (Fig. 269), placed on top of the dome, being the best known.

Where the valve is hidden by an ornamental casing the model-maker can make what alteration he pleases to the working parts so long as the exterior outlines are preserved. Fig. 270 shows a simple direct-loaded valve which has an easing lever fitted to the spindle. The exterior design is quite representative of a cased Ramsbottom valve.

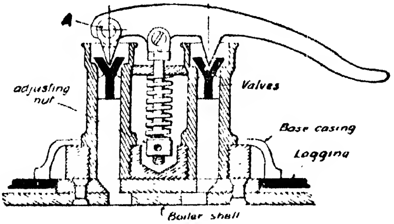


Fig. 267.—Open-type Ramsbottom Safety Valve.

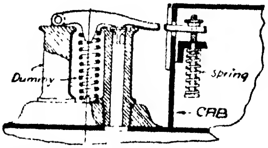


Fig. 268. Imitation Ramsbottom Safety Valve.

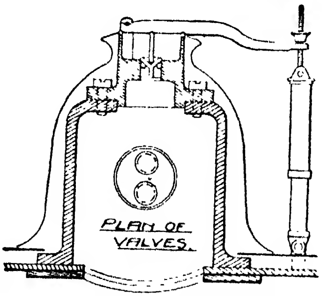


Fig. 269.—Midland Railway Safety Valve on Dome.

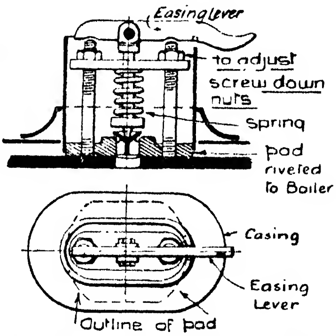


Fig. 270.—Simple Valve, Direct-loaded, Ramsbottom-type Casing.

In all models up to 3½-in. gauge one valve, so long as it is a good one, is ample. The diameter of a valve should be determined by the following table, additions being made according to the circumstances of the case. An engine with a very large grate area and heating surface will require a slightly bigger valve than that stated:

No. 1 Gauge,	$\frac{1}{8}$ in. diam.	$3\frac{1}{4}$ in. Gauge,	$\frac{1}{4}$ in. diam.	$7\frac{1}{4}$ in. Gauge,	$\frac{1}{2}$ in. diam.
$2\frac{1}{2}$ in. ,,	$\frac{3}{16}$ in. ,,	$4\frac{3}{4}$ in. ,,	$\frac{3}{8}$ in. ,,	$9\frac{1}{2}$ in. ,,	$\frac{5}{8}$ in. ,,

$$15 \text{ in. Gauge, Diam.} = \frac{\sqrt{\text{Grate Area, inches}}}{200}, \text{ or equivalent.}$$

The direct-loaded valve enclosed in a cylindrical casing is an excellent type, and is much used by Scottish locomotive engineers. Its application inside the casing of a different type of valve is shown in Fig. 271, taken from a set of designs for a 2-in. scale G.N.R. "Atlantic" engine, which prototype has two Ramsbottom valves side by side. The arrangement provided for the twin levers which were, in the model, loosely connected to the spindle of the valve so that they could act as easing levers. The inner valve represents the writer's standard practice, and a valve designed for a smaller model is illustrated in Fig. 272.

The parts of this valve consist of (a) a bushing which should be either screwed and soldered or silver-soldered to the boiler shell, (b) a valve seating with a knife-edged orifice, (c) the valve made of hard gunmetal or nickel, (d) an outer casing screwed on to the seating made of tube, (e) the spring, (f) the pointed spindle which should deliver the load into a recess in the top of the valve, and (g) the adjusting cap to the casing. The last named should be drilled with a number of holes.

A "pop" action (a sudden discharge of the valve) can be obtained by making the head of the valve nearly fit a cylindrical recess in the seating (b). The steam will then act on a larger area as soon as it is released, and the valve will lift quickly and to a visible amount. By experiment the leakage area referred to in the drawing may be so adjusted that the valve shuts as suddenly as it lifts, with only a few pounds' loss in pressure between rising and falling. The "pop" valve works better with dry steam, and to prevent priming and upsetting its action the throat of the valve orifice may be restricted as indicated in the valve shown in Fig. 271. The head of the valve should not be too large, and where two valves are employed they should be rather smaller than usual, and one should be set at a slightly lower pressure than the other.

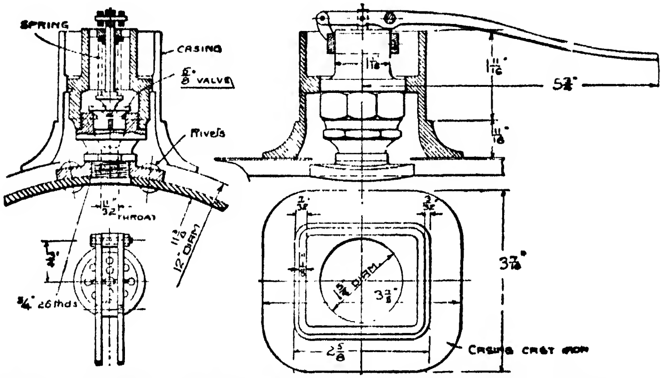


Fig. 271.—Safety Valve for Model 2-in.-Scale G.N.R. Locomotive.

The author has made successful "pop" valves as small as $\frac{3}{16}$ in. diameter. The G.W.R. type of casing shown on page 227 is perhaps the simplest and neatest for enclosing a "pop" or other similar type of cylindrical valve.

As nothing is so annoying than a continuously leaking safety valve, model-makers should take care to see (1) that the valve is turned truly round and fits the seating freely, (2) that the seating is of the knife-edged variety and is also true, (3) that the pressure of the spring spindle is *delivered to a point on the valve below the level of the*

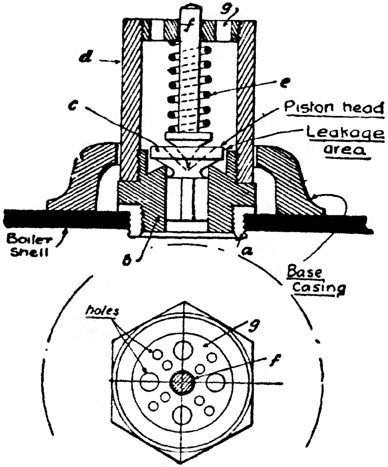


Fig. 272.—Greenly's "Pop" Safety Valve.

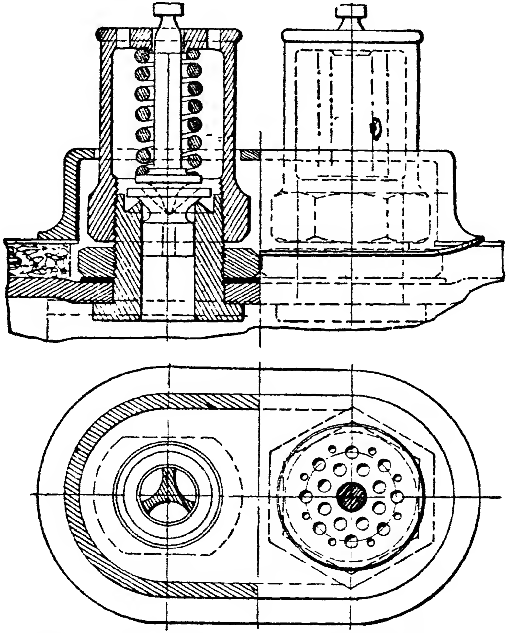


Fig. 273.—Twin Valve for Large Model, Direct Loader-type.

seating, and (4) that the spring spindle is quite separate and not a part of the valve except where the valve is of spherical shape.

A direct-loaded twin valve for a large model is shown in Fig. 273.

Bronze balls may be used as safety valves. Two methods are illustrated on page 225. In the first (Fig. 274) the ball is screwed and soldered on to a spindle, the bronze wire spring being inside the boiler. This is perhaps the only satisfactory type of internal spring safety valve, a variety which is sometimes necessary in a small-scale model. In the other valve (Fig. 275) the ball is pressed down on to a knife-edged seating by a spring pillar having a rounded undersurface. This makes a very good valve. In both cases the seating is trued up by hammering on it a steel ball of the same diameter as the bronze ball. Grinding in cannot be resorted to.

To obtain steam tightness with the ordinary **V**-seated valve grinding in must be carefully done. Emery should not be used with brass valves; grindstone-mud is much to be preferred. Further, the part of the seating in contact with the valve should never be much more than .01 in. wide in model locomotives of small size.

Domes.— Domes are used in actual engines to provide for the extraction of the steam from a point high up above water level. While their efficacy in real practice is doubted by many engineers, model-makers will find them very useful in preventing "priming." As a rule, in large engines the regulator is fitted inside the dome. This is not practicable in a small model, and therefore the dome simply houses the end of the pipe leading to the regulator valve, and further provides a ready means of filling the boiler. Domes should always be double cased, the outer ornamental covering being made from a stamping or spinning or turned up from a casting. In modern engines the dome is usually much more squat than those on older locomotives, due to the restrictions of the loading gauge and the use of high-pitched boilers. The diagram (Fig. 276) illustrates typical shapes, their relative dimensions being obtainable from the appended scale.

Chimneys.—The scientific importance of the locomotive funnel has already been discussed in Chapter IV. In this country the engineer generally attempts to give the funnel an ornate character, and some of the distinctive shapes are illustrated in the diagram. Where a free-lance design of model is being built, a proportion in which the smallest diameter of the stalk is in a ratio of 1 to 3¾ to that of the smokebox on which the chimney rests will be found to give a good appearance. Built-up chimneys are usually distinguished by the joint lines across them, cast-iron ones usually being quite plain; and

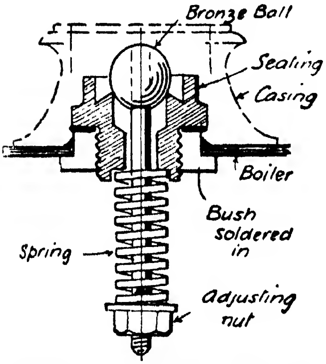


Fig. 274.—Ball Safety Valve with Internal Springs.

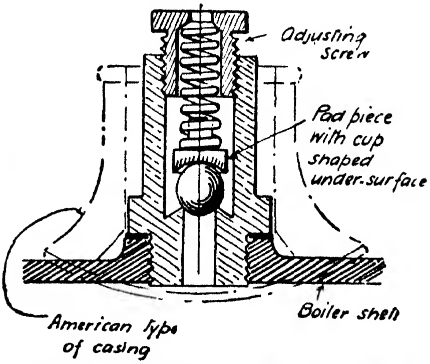


Fig. 275.—Ball Safety Valve with External Spring.

while a chimney may taper either way on the outside the internal diameter always tapers outwards towards the top. Short chimneys are usually extended down into the smokebox to make up for their deficiency in apparent height. This extension in a model may be cast with the funnel or, in small engines, consist of a short length of tubing, as at B in Fig. 277.

Cab Fittings.—These vary very much with the size of the model. The smallest (No. 1 gauge) engine with a spirit-fired brazed water boiler may be used with no fittings other than a regulator, but a pressure gauge and a steam blower are respectively very convenient and useful fittings. Working pressure gauges on the Bourdon principle are made as small as ¾-in. diameter, and if obtained with a reading 50% more than the maximum pressure used will remain accurate for a long time. Such gauges must not be overloaded and, further, must be fitted on a **U** or syphon pipe to protect the mechanism from the heat of the steam. A fourth fitting, namely, a try cock, may be added, but, if used, a screw-down type should be chosen in preference to the common plug cock. In small sizes especially plug cocks soon leak and seize.

For a solid-fuel boiler a steam blower is an essential, and the simplest arrangement is shown in Fig. 278. The steam is taken from the dome (or the highest point in the boiler) and is controlled by a screw-down valve which may be glandless in small engines. The steam is conducted to the smokebox and emerges from a fine orifice. The usual fault with such blowers is that the orifice is so large that the boiler will not make steam against its consumption. In a 2½-in. gauge model, if the hole is not more than $\frac{1}{32}$-in. (the diameter of an ordinary household pin), success may be expected. The blower should be low

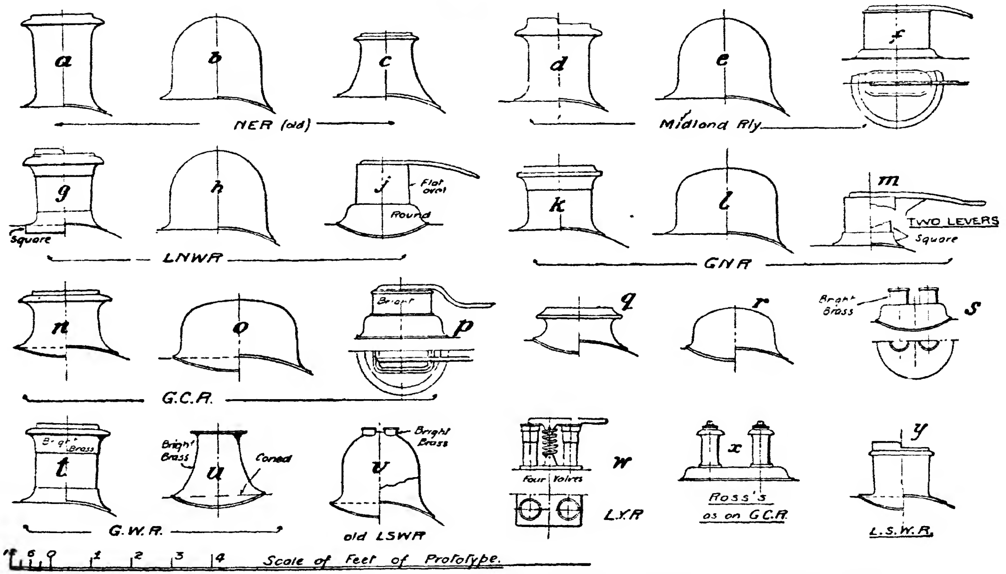


Fig. 276.—Types of British Locomotive Chimneys, Domes and Safety Valves.

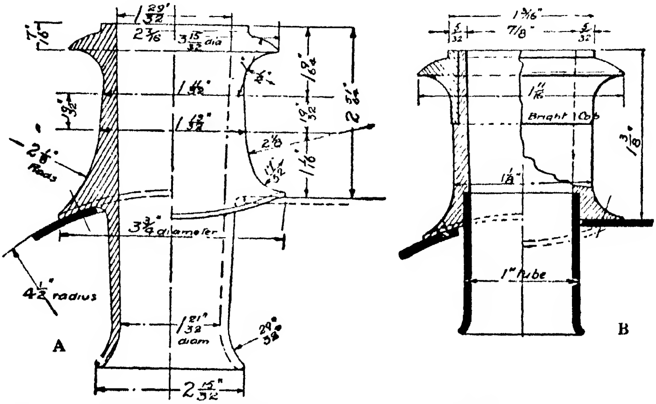


Fig. 277.—The Inner Extension of Short Chimneys: A, Cast Type; B, Added Tube Type.

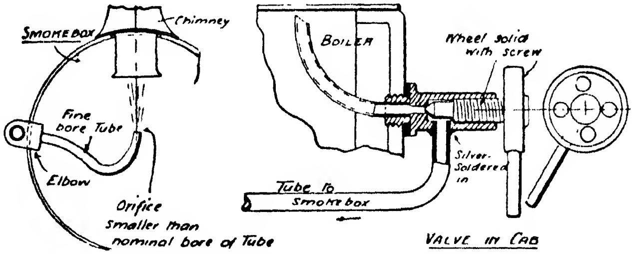


Fig. 278.—Steam Blower for 2½-in. to 3½-in.-Gauge Models.

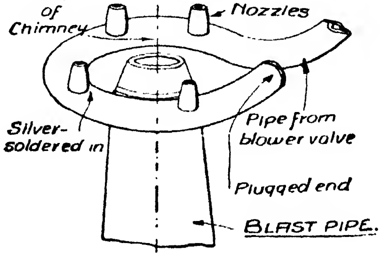


Fig. 279.—Ring Blower for Large Models.

down in the smokebox alongside the blast pipe and delivering a jet as nearly central in the chimney as possible. Sometimes the blower steam may be conducted through a hollow stay in the boiler (see Fig. 282), and in large models a ring of jets may encircle the blast pipe orifice (Fig. 279).

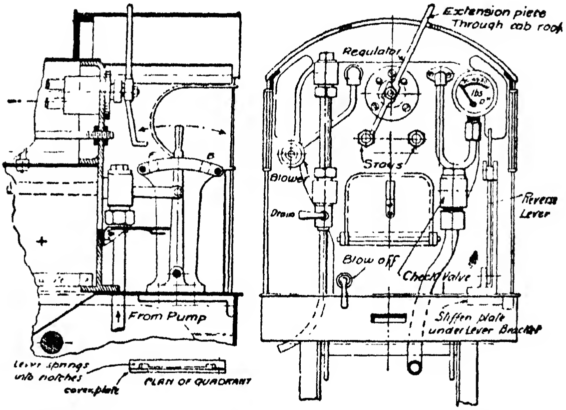


Fig. 280.—Cab Arrangement for 2½-in.-Gauge Model.

Table of Blower Jets.

Small models	single	orifice	$\frac{1}{32}$ in.	diameter
¾-in. scale models	,,	,,	$\frac{1}{20}$ in.	,,
1-in. ,, ,,	three	,,	$\frac{1}{32}$ in.	,,
1½-in. ,, ,,	four	,,	$\frac{1}{20}$ in.	,,
2-in. ,, ,,	,,	,,	$\frac{1}{16}$ in.	,,

In some cases it is possible to introduce the blower pipe into the centre of the blast pipe. This is an easy matter where the exhaust pipes are of the inverted **Y** pattern, as in many outside-cylinder locomotives.

For large solid-fuel models, or in locomotives with the orthodox loco-type boiler a water gauge is essential. The internal bore of the passages and glass should be at least ⅛ in. or $\frac{5}{32}$ in. to prevent capillary attraction causing a wrong reading of the water level.

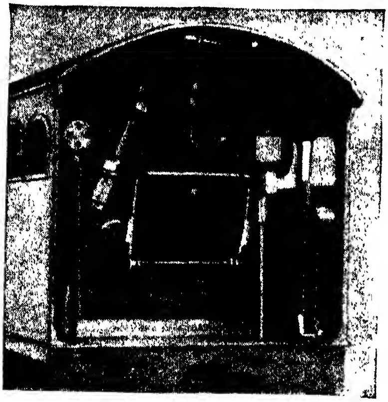


Fig. 281 —2½-in.-Gauge Cab, Showing Fittings and Flap-down Fire-door.

The drawings, Fig. 280, and the photographs, Figs. 281 and 282, show various cab arrangements.

All the larger working models require feed check valves, while for 1-in. scale engines and above good automatic injectors are obtainable. Steam pumps are to be avoided as troublesome appliances, and perhaps the most symmetrical arrangement of fittings ever applied to a working model is that shown in Fig. 282. These were arranged for a 1½-in. scale model G.C.R. express engine. The pressure gauges were in duplicate simply to "balance" the effect, but where vacuum brakes are used one gauge could be attached to that. An interesting photograph of the steam-raising operation is shown by Fig. 283.

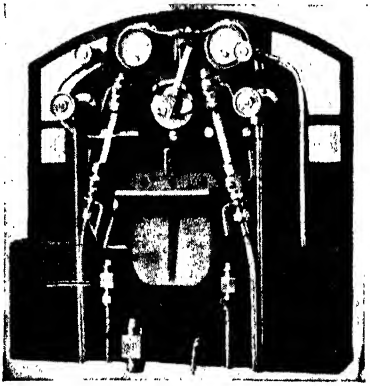


Fig. 282.—Cab Fittings of 1½-in.-Scale G.C.R. Locomotive.

Reversing gear fitments in the cab will depend on the motion used. For a hand-controlled gear two devices are in use, (1) the older lever and quadrant, Fig. 284, and (2) the screw-reversing device, Fig. 285, which, although slower, requiring **about** twenty turns of a wheel or handle, is more powerful. The latter characteristic does not count in model practice, but the screw gear is often found to be simpler to construct as a model. The lever, with its catch handle and notched quadrant, involves rather delicate and precise work if it is to look reasonably true to scale. In large models (i.e. "miniature railway" engines) the author has usually found that a lever modelled to scale was insufficiently robust to withstand rough and continuous usage. In one of his later designs he introduced a plain push-and-pull handle on the end of the reversing rod, as illustrated in Fig. 286. The leverages necessary to give the necessary mechanical advantage were arranged outside the cab as shown. The rack and locking device used is illustrated in Fig. 287. The gear saved a considerable amount of room in the cab.

Fig. 283.—Half-tone Reproduction showing a Locomotive during Steam-raising.

To save drilling a large number of holes in the boiler

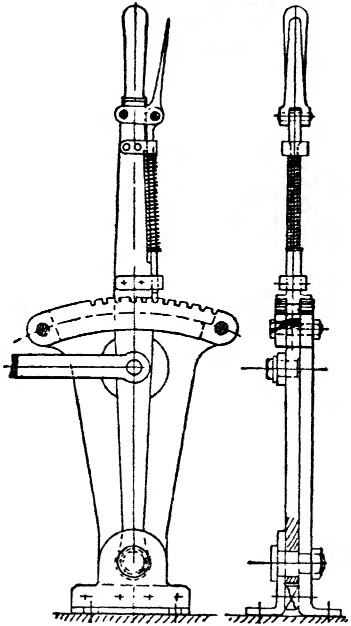


Fig. 284.—Reversing Lever and Quadrant.

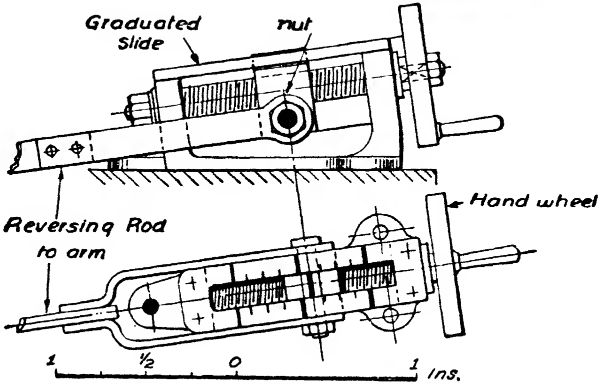


Fig. 285.—Screw Reversing Gear.

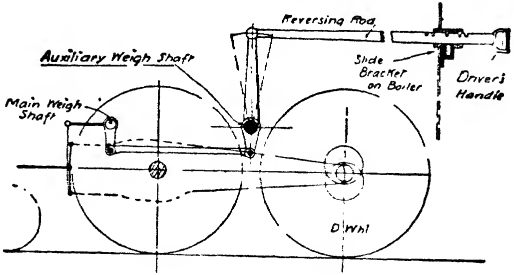


Fig. 286.—Direct Push-and-pull Reversing Handle.

a three- or four-way branch is often fitted to the top of the boiler just behind the cab weatherboard. To this is connected the steam gauge, injectors, blower and (if used) the steam vacuum-brake fittings.

In fitting check valves (Fig. 289) to the back of the boiler, it is always advisable to arrange an internal pipe leading to a position half-way along the boiler barrel and below the water level. Where these fittings are screwed into the back plate and not fitted by flanged connections the internal pipe may be screwed into the valve, and just before fitting unscrewed the same number of turns (or one more) that the check valve requires to screw it home. Of course, the internal pipe, although not absolutely steam-tight where it joins the valve body, will ensure that most of the water will be carried clear of the firebox plates.

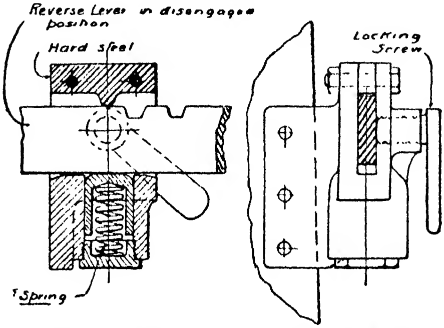


Fig. 287.—Locking Gear for Push-and-pull Reversing Handle.

The same idea may be used in collecting the supply steam for injectors and blowers by internal pipes from the dome.

In large models the check valve should be provided with an auxiliary screw-down stop valve of the full bore of the pipe.

The simplest type of model water gauge (Fig. 288) is always the best, and although not obtainable in the ordinary way the design with one bottom "blow-through" cock has been found by the author to be the most satisfactory in the smaller working models.

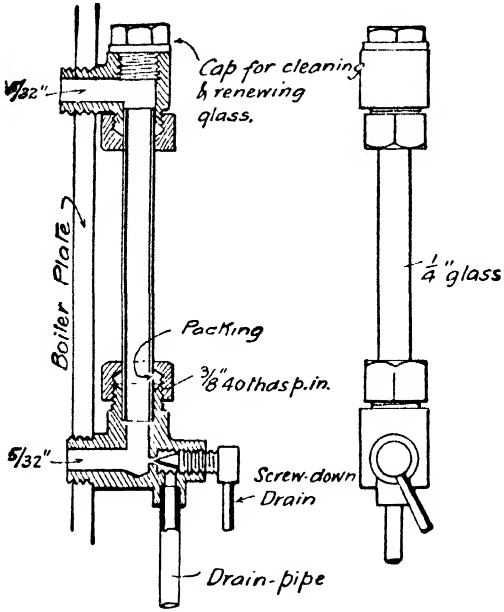


Fig. 288.—Simple Water Gauge with One "Blow-through" Cock.

Various patterns of blow-off cocks are illustrated in Fig. 290.

A method of attaching small fittings which, like pressure gauges, do not require a large flow of steam or water through them is shown in Fig. 291. The pipe is silver-soldered to a small collar, and this collar is attached by a screw which has been grooved and filed to an almost triangular section below the groove. The steam gets past the flats into the groove and so to the pipe connection. Jointing washers are required on both faces of the collar, and B.A. screws are recommended in preference to the Whitworth form for the fixing of the collar. Iron or steel screws should never be used in attaching fittings to copper boilers, and where brass is used it should always be of a good quality.

Fire-doors are usually fitted to work outside the firebox, and the "kitchen-copper" type of door one so frequently sees fitted to locomotive models should not be used. The flap type (shown in Fig. 282) has the drawback that it makes it difficult to view the fire, and therefore the author has of late years used the flap-down style in its place. The sliding type of fire-door is also worthy of consideration; two parts, each sliding the opposite way, are generally fitted, the doors sometimes being connected by links to a single hand lever.

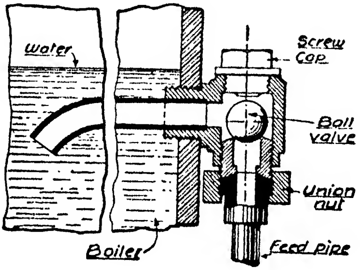


Fig. 289.—Check Valve with Internal Delivery Pipe.

Smokebox Arrangements.—Roughly speaking, the smokebox of a model locomotive will contain the exhaust and steam pipes, the blower and, in the case of a loco-type boiler,* the superheater. Space must also be provided for the inside extension of the chimney and petticoat pipes (if any), so that even in a large passenger-carrying model there is seldom any great amount of wasted space in

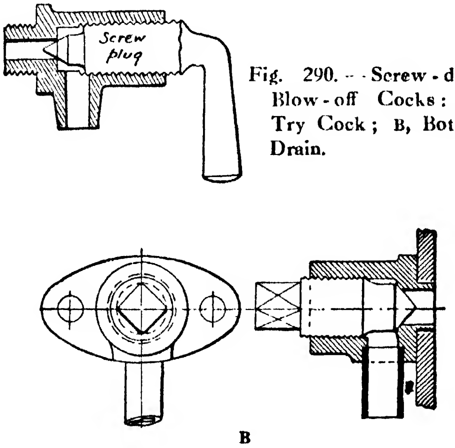


Fig. 290.—Screw-down Blow-off Cocks: A, Try Cock; B, Bottom Drain.

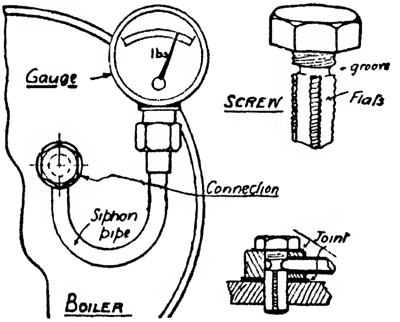


Fig. 291.—Method of fitting Pressure Gauges.

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* With a water-tube spirit-fired boiler the superheater is always carried back through the flames of the lamp.

the biggest smokebox. The various fittings in a solid fuel model should not be arranged in such a manner that the sweeping of the flue tubes is hindered or rendered impossible.

It is quite a safe procedure to allow as much flexibility as possible in the steam pipes in the smokebox, and, in addition, it is highly desirable that the superheater pipes or units should be removable in case of their failure.

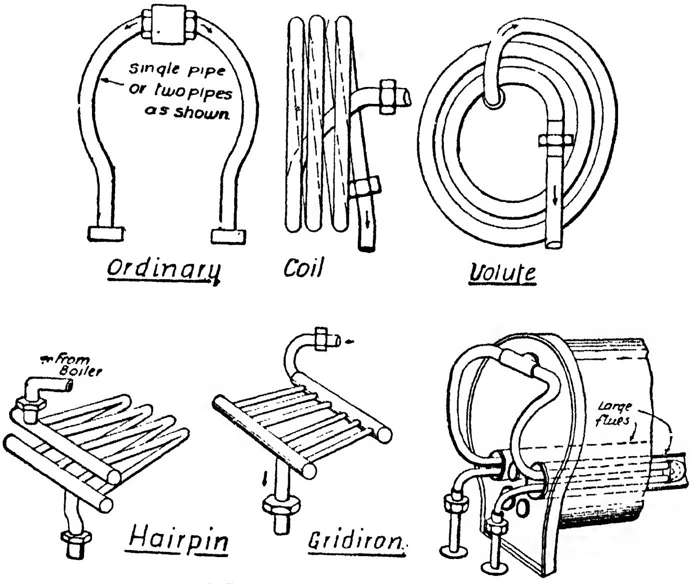


Fig. 292—Forms of Steam Pipes and Superheaters in Smokeboxes.

To do this it may be policy to attach the front of the smokebox in such a way that it can be removed bodily for the purpose of repairs to the steam pipes, and it is therefore the author's practice even in the very largest models to use a cast smokebox front with turned flanges fitting into the end of a cylindrical smokebox.

Fig. 292 illustrates several arrangements of steam pipes, and for large-scale models the right- and left-hand cylinders may very well be supplied by separate systems of piping, the two dividing at the connection on the smokebox tube plate. The "gridiron" and "hairpin" types should be designed to miss the blast pipe and the jet of exhaust steam; while the coil patterns should do this the pipes should also not block up the lower row of tubes and prevent the latter being cleaned.

Where the flue-tube superheater (Fig. 292) is employed a steel superheater tube is recommended, with possibly a protective cap at the bend inside the flue, and as the temperature of the steam may be very high the use of iron cylinders and mechanical lubrication is advisable if not essential to continued success.

It is very important that the smokeboxes of solid fuel boilers should be absolutely airtight. Holes in the bottom at the steam pipe entrances may be plugged up with wet asbestos yarn. With water-tube boilers using a plain spirit lamp or oil burner the blast need not be so fierce or the smokebox quite airtight.

Smokebox Fronts and Fittings. — As in the small model the smokebox door itself does not provide sufficient room for getting at the pipes and steam connections, the front, if of the modern circular pattern, may be made solid with the door, all fittings and hinges being pure imitations, the whole being arranged to be readily removable. All large models, more particularly those using solid fuel, should have hinged doors which fit closely into a recess formed in the front ring. In modern loco-

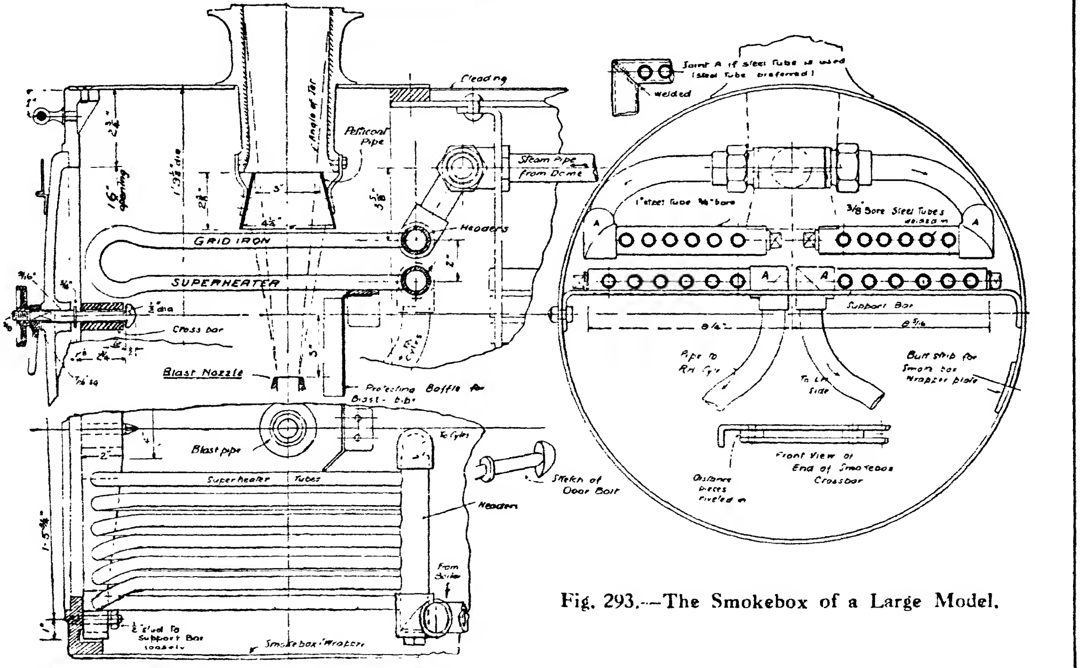
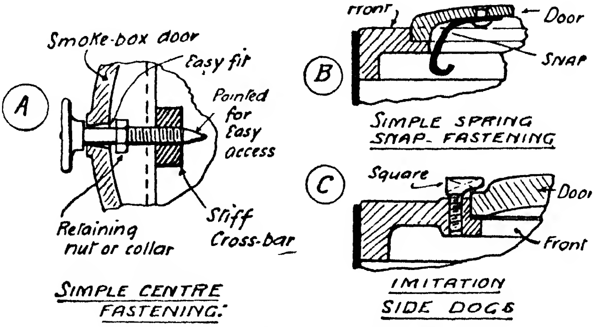


Fig. 293.—The Smokebox of a Large Model.



SIMPLE CENTRE FASTENING.

SIMPLE SPRING SNAP- FASTENING

IMITATION SIDE DOGS

Fig. 294.—Simple Smokebox Fastenings.

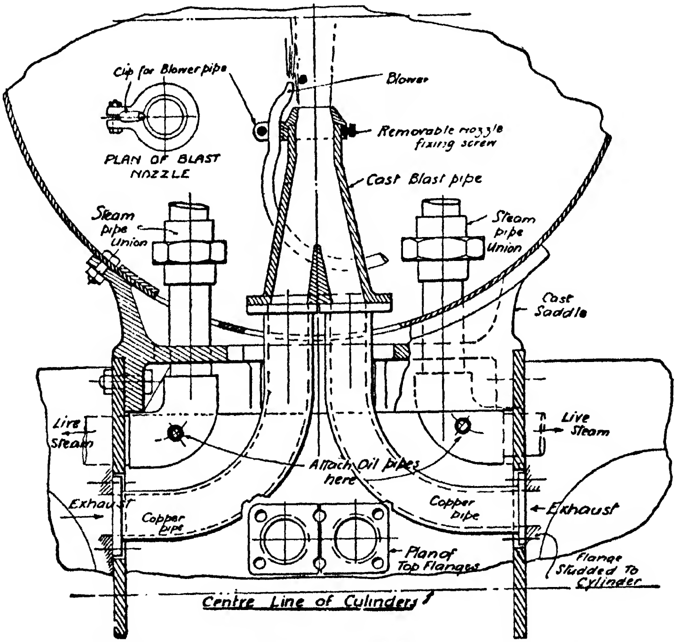


Fig. 295.—Steam Pipes for Model Shown by Fig. 293.

motive practice the central bolt fastening is often omitted, and buttons or dogs secured by bolts and wing nuts are fitted all round the edge of the door to ensure that the latter takes an even bearing. The arrangements of the smokebox of a large model are shown by Figs. 293 and 295.

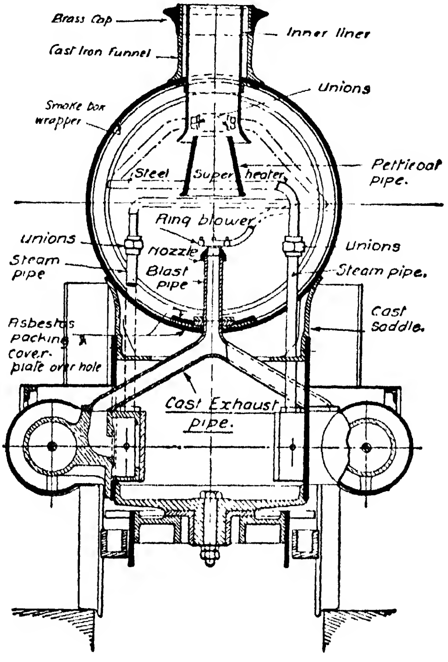


Fig. 296.—Cast Y-type Exhaust Pipe.

Where the ordinary inside crossbar is employed it should be borne in mind that it acts as a beam loaded in the centre. The metal should therefore be arranged to lie with the wide face horizontally, and the greatest width

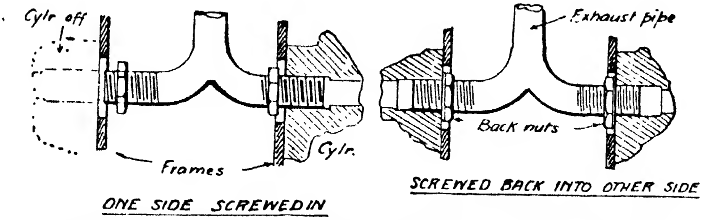


Fig. 297.—Running-joint Fixing for Exhaust or for Steam Pipes.

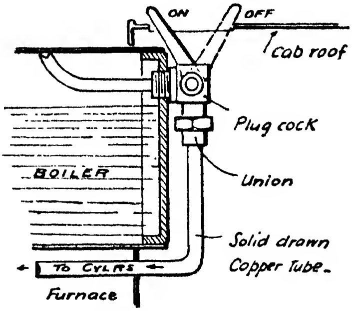


Fig. 298.—Simple Plug-cock Regulator on Back Plate.

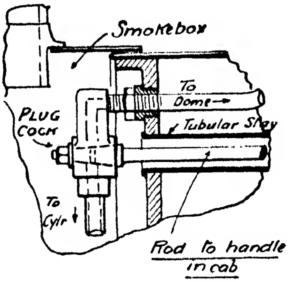


Fig. 299.—Plug-cock Regulator in Firebox.

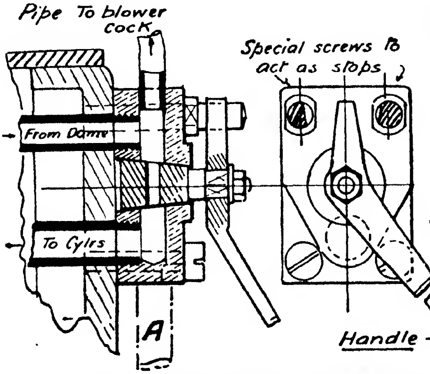


Fig. 300.—Improved Back-plate Regulator.

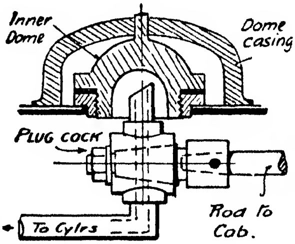


Fig. 301. — Plug - cock Regulator in Dome.

should be in the centre. Such bars should also be readily removable. The locking handles or wheel nuts should be in duplicate. As a rule, the inside handle is squared for the bolt, but free to move up and down the bolt. This only controls the position of the latch head or **T**, the screwed outside handle or wheel being the tightening device. Simple constructions are illustrated in Fig. 294. Smokeboxes should be blacked with a heat-resisting black paint (egg-shell black), and may be lagged inside with a sheet-iron casing where no objection is raised to the extra labour involved in this.

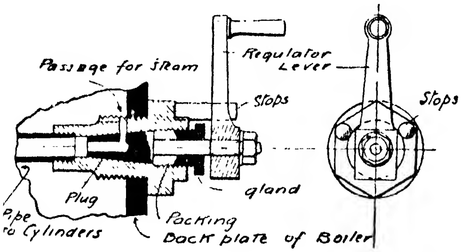


Fig. 302.—A Standard Model Regulator.

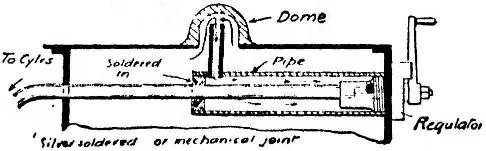


Fig. 303.—Method of fitting-up Valve (Fig. 302) to take Steam from Dome.

Blast Pipes.— Information bearing on the importance and position of this very vital part has already been included in Chapter IV. The use of a removable or renewable cap is always to be recommended, while the concentricity of the jet in respect to the chimney is a point on which the utmost care should be exercised. The provision of an adjustment to the orifice in larger engines is worthy of experiment.

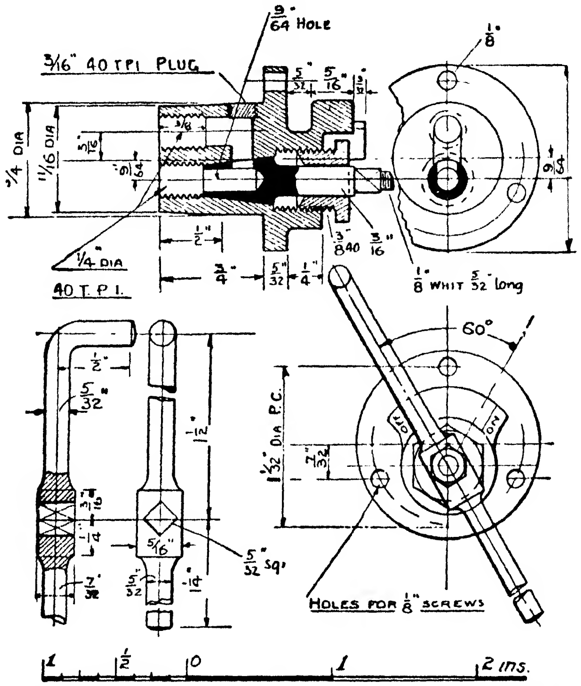


Fig. 305.—Author's Standard Regulator for Smaller Models.

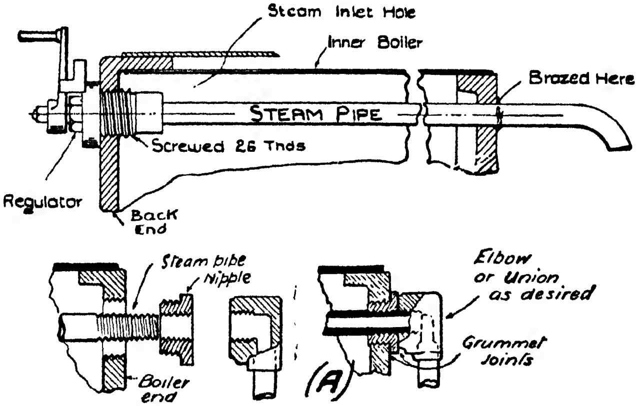


Fig. 304.—Method of fitting-up Regulator (Fig. 302).

The exhaust steam from the cylinders should be led as directly as possible to the blast pipe orifice. Great changes in the cross-sectional area of the pipes, as well as any baffling of the flow of the steam, should be avoided. If only a single hole is made in the smokebox bottom so much the better. Fig. 295 shows an arrangement of exhaust steam pipe fitted to one of the author's latest 15-in. gauge designs. In earlier engines he usually fitted a cast brass "breeches" pipe (Fig. 296), but trouble was experienced by mechanics forgetting to put the cast pipe in place at the proper time during the assembly of the locomotive, this necessitating cutting the casting and making new joints.

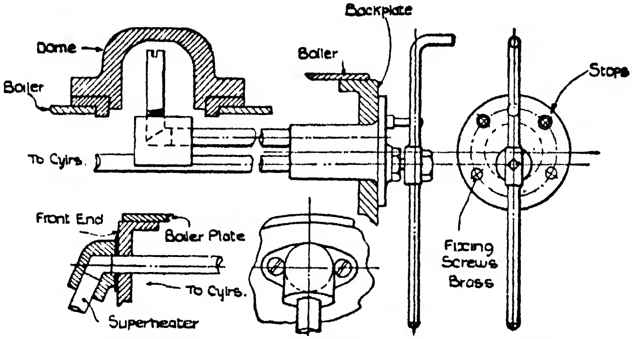


Fig. 306.—Method of fitting-up Regulator (Fig. 305).

Where the valve chests are outside it is often possible to braze up the forks of the **Y** pipe solid and fix by a running joint, an arrangement well known to pipe fitters. This is indicated in Fig. 297. Back nuts, of course, prevent steam leakage at the cylinder joints.

Regulators.—The main steam stop valve of a locomotive, as its name "regulator" implies, regulates at the driver's will the flow of steam to the cylinders, the lever operating the steam valve being placed in a convenient position in the cab. There are innumerable types of handles and valves, and as there is no one particular pattern that can be employed in all cases several will be described.

Where the engine is a simple one, and a realistic arrangement of fittings in the cab is relatively unimportant, a plain plug cock fixed outside the back plate of the boiler may be fitted, the steam pipe passing down through the flame of the lamp as shown in Fig. 298. The handle of the cock is arranged to project though the roof of the cab, a device which has many merits in a small working model, especially for tank engines with an enclosed cab.

A plug cock may be fitted in the smokebox and operated by a stout spindle passing through a hollow stay tube to a lever in the cab (Fig. 299). This arrangement has no great merit, as in a model that needs an airtight smokebox, the likelihood of the cock leaking and destroying the draught must be considered. Further, the heat of the smokebox may interfere with the working of the cock.

The scheme illustrated in Fig. 298 is also to be preferred as a more convenient method of passing the steam through the fire in an outside-fired engine or in one with a water-tube boiler. An improvement on the regulator (Fig. 298), from the point of view of appearance, is shown in Fig. 300. The body of the plug cock is of special form, and takes steam from the dome and passes it through the boiler again to the steam-pipe connection in the smokebox. As an alternative, indicated at A, the steam may be conducted through the fire as already described. The regulator is screwed to the back plate of the firebox by four screws, two of which act as stops for the handle. The

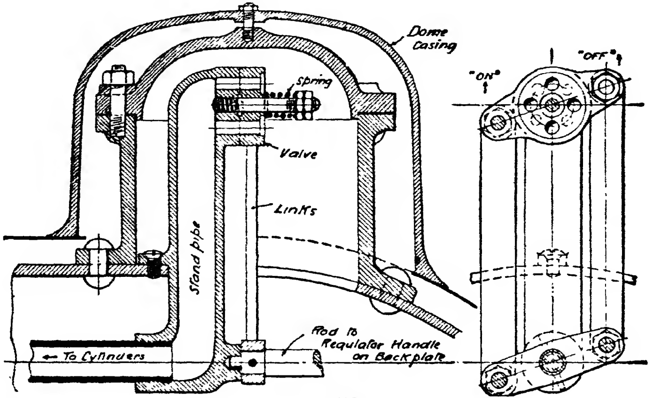


Fig. 308

Fig 309

Figs. 308 and 309.—Model "Stroudley" Regulator.

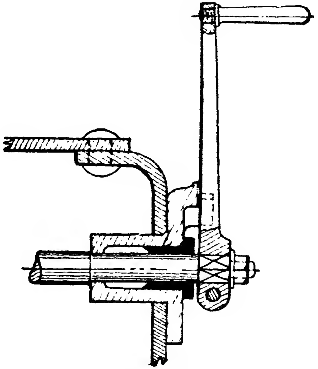


Fig. 307.—Regulator Handle and Gland to suit Fig. 308.

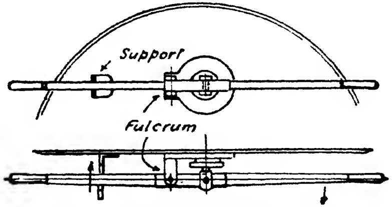


Fig. 310.—Pull-out Regulator Handle.

latter is of the down-turned pattern, after the style of those fitted to modern G.W.R. locomotives.

A plug cock may be fitted to the steam pipe inside the boiler under the dome, as illustrated by Fig. 301. This arrangement is defective in that it lacks accessibility in case of repair or replacements to the moving parts, and, further, will, under ordinary circumstances, require to be inserted in the boiler before the latter is finally put together.

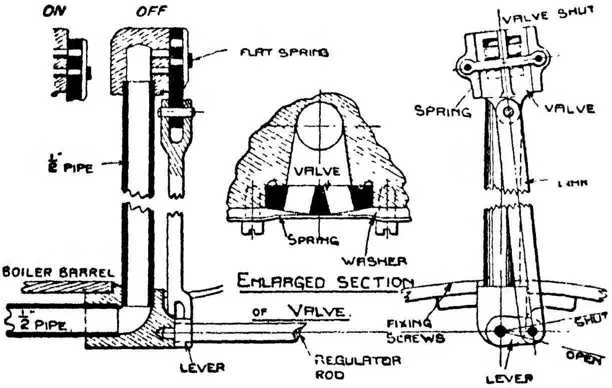


Fig. 311.—Slide-valve Regulator.

Among the regulators made by trade firms the plug-cock type illustrated in Fig. 302 is perhaps the best known. The regulator body is screwed with a fine thread into a tapped hole in the cast back plate of the boiler. The only drawback to the arrangement is the fact that steam is admitted through a small hole on the top of the regulator. As this hole may not be very near to the crown of the boiler and accentuate the surging of the water in the boiler at starting, some means of preventing water being carried over with the steam (i.e. "priming") must be devised. One of these involves fitting the regulator inside a larger tube (see Fig. 303) which is fed by a short pipe from the dome. Another practice which is commonly adopted by trade firms is to braze (or silver-solder) the steam pipe into the front plate of the boiler. This is most reprehensible, as the replacement of a faulty regulator is rendered difficult. The scheme sketched at A, Fig. 304, is an alternative. Here the steam pipe is screwed with a fine thread for a nipple having an outer thread of larger diameter but with the same pitch. The nipple can be screwed on the pipe and into the boiler end at the same time, and the joint made secure by a back nut or by the elbow or union employed to connect the superheater pipe.

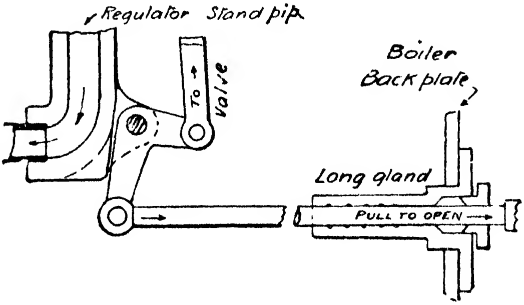


Fig. 312.—Pull-out Regulator Mechanism.

The plug cock regulator (Figs. 305 and 306) is better than the one just described in that the body provides for the connection of a second collecting pipe from the dome. The regulator takes a little more room on the boiler back plate, but is much to be preferred in spite of this. The illustration also shows a good method of connecting the superheater steam pipe at the smokebox end. The small brass block under the dome serves as a support and an elbow to the collecting pipe for screwing in the short vertical pipe from the highest point in the boiler.

The standard type of regulator used on domed engines in this country comprises a stand-pipe in the dome with a sliding or rotating valve at its head. The valve is connected by links and levers to a long regulator rod which passes through a stuffing box on the back plate of the firebox to the driver's regulator handle.

The valve in the dome is usually duplex, one part being a pilot to the other. This scheme is not necessary in a model, as the valves are small relative to the power available to move them. The rotating or "Stroudley" type of regulator is illustrated in Figs. 307, 308 and 309, and is a very satisfactory arrangement so long as the valve is properly made. The centre portion of both valve and port face *must be recessed.* The only complaints in large model practice investigated by the author showed that the leakage was caused through the mechanics failing to observe this important point. Two links are employed to connect the valve to the levers. This is an excellent feature, as the valve is always "pulled" open or shut.

In some cases a push-and-pull lever is employed in the cab (see Fig. 310). This arrangement was standard at one time on the G.N.R., and was used in conjunction with domeless boilers, a slide valve regulator in the smokebox at the end of a long perforated collecting box being used.

The sliding type of regulator, arranged in a built-up form for a fairly large model, is illustrated in Fig. 311. The stand-pipe is made of tube, and is screwed into a solid head and elbow. The valve should be of a different grade of material from the seating and may have two sets of ports as shown. The regulator rod has a single lever set to operate the valve at an angle, the connecting link being stiff enough to act as a push rod against the friction on the valve created by the pressure of steam on its surface. All parts should be of cast iron, brass or gunmetal. The flat spring and screws must be of non-ferrous material to resist corrosion.

The type of regulator shown in Fig. 311 may be operated by a pull-out regulator rod and lever by altering the scheme of levers at the heel of the stand-pipe, as illustrated in Fig. 312. As the surface of the regulator rod is more likely to score in grooves at the gland, a long gland and stuffing box is advisable with this style of lever to prevent an annoying leakage of steam. The packing must also be quite tight, otherwise the pressure of steam acting on the rod will tend to open the regulator.

A horizontal slide-valve regulator placed in the smokebox under a dome or in a raised firebox is sometimes employed. In whatever way it is arranged, the subsequent removal of the valve and repair of the port face should be considered.

A design for a rotating valve regulator suitable for a domeless raised-firebox boiler (G.W.R. type) is illustrated in Fig. 313. The regulator valve is situated at the bottom of the tube, as far away from the back plate as possible, and is operated by a **T**-headed spindle working through a gland, the valve being maintained in place by a bronze spiral spring. The valve and its facing must be both recessed centrally and chamfered at the edges, so that it bears only over the shaded portion indicated on the enlarged view of its surface. The space between the ports should be greater than the diameter of the holes.

The arrangement of the cab so that the regulator is accessible is shown in Fig. 314.

Whistles.—The laws of acoustics will not allow a very

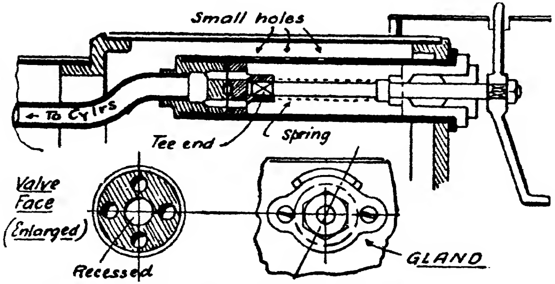


Fig. 313.—Internal Rotating Regulator Valve.

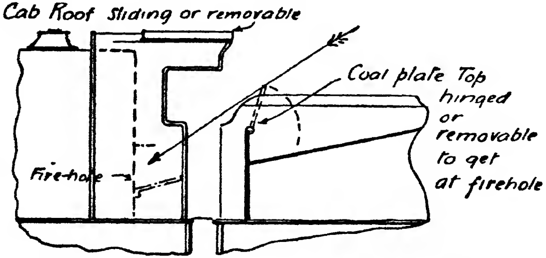


Fig. 314.—Arrangement of Cab so that Regulator, etc., is Accessible.

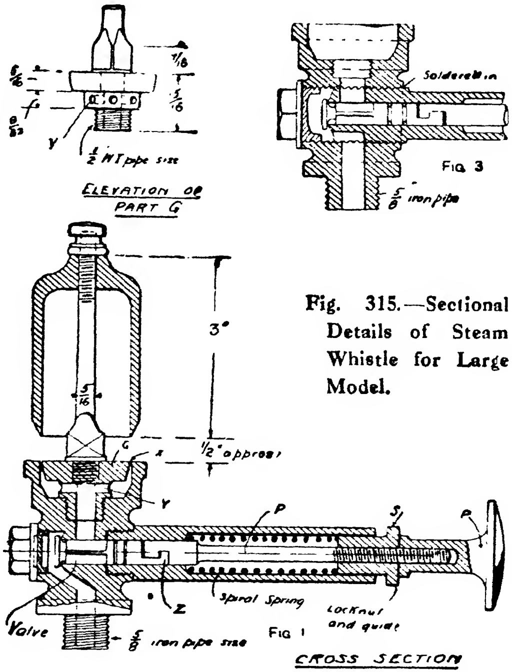


Fig. 315.—Sectional Details of Steam Whistle for Large Model.

small model whistle to be made and make a noise comparable to the full-sized article. To preserve the scale effect from an external point of view a whistle may be partly concealed in the cab. It may be placed so that only the top bell protrudes through the cab roof. If connected to a part of the boiler below the highest level it should be supplied by an internal, not an external, steam pipe to prevent radiation condensing the steam. Plug cocks are not entirely satisfactory, and are seldom if ever used in real practice. A good whistle, audible at half a mile, made for a 1½-in. scale, is illustrated in Fig. 315. This has a push valve worked by a spring-loaded plunger loosely attached at z. The additional sectional view shows an alternative method of making the valve seat and guide.

Pipe Arrangements for Articulated Locomotives.—The steam pipes of model articulated locomotives will need special consideration, and in all smaller types of models advantage may be taken of the flexibility of the superheater coils. The detail drawing (Fig. 316) shows an alternative arrangement of hollow pivot for the design Fig. 46, Chapter II. The trunnion is a piece of tube fixed into the saddle and takes the exhaust and steam pipes. The small screw acts as a retainer for the motor-bogie when the engine is lifted off the rails. The exhaust pipe emerging into the smokebox directly under the chimney may be rigid, the tube being set over inside the smokebox so that its centre coincides with the centre line of the funnel.

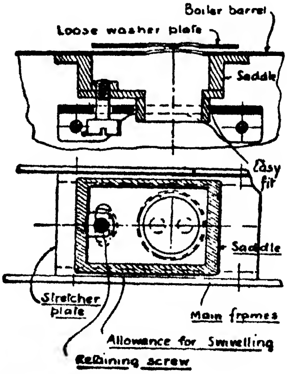


Fig. 316.—Pivot or Trunnion for Articulated Model. (See Fig. 46.)

CHAPTER XIV

General Fitments, Tenders and Drawgear

Superstructures.—While sheet materials for all the superstructures of the model locomotive are strongly recommended, for amateur use castings are sometimes provided. This latter method of construction can also be adopted for engines which have to be made in small quantities. Where four or more wheel splashers are required, and their design is identical, it often pays to make a metal pattern complete with fixing lugs and send away for castings in brass or iron. For toy and the cheaper scale models—more particularly the low-pressure outside-fired locomotives the model railway enthusiast buys complete and ready for use—tinplate stampings involving a considerable outlay on press tools are essential to success. Aluminium castings cannot, in the light of the author's experience, be recommended for tenders or locomotive superstructures.

For small models tinplate and thin brass sheets can be so easily bent and soldered that the small saving in cost effected by the use of mild-steel plate is not worth the extra trouble this material involves.

Plates from $\frac{3}{16}$ in. to $\frac{1}{4}$ in. thick are used in real practice, but sheets less than $\frac{1}{32}$ in. thick cannot be handled satisfactorily even on the smallest model. In a 1-in. scale model the ruling thickness would be No. 16 S.W.G. ($\frac{1}{16}$ in.) to No. 14 S.W.G. Angle brass as small as $\frac{1}{4}$ in. × $\frac{1}{4}$ in. can readily be obtained, but where a water container is used the combination of steel sheets (other than tinned plate) and angle brass should be avoided. Brass throughout or a brass or copper inside tank is to be preferred, the inside of the body of the superstructure masking the inner tank being thoroughly painted before the tank is fitted into place.

Along the edges of the footplating of a locomotive it is customary to fit stiffening angles, and in almost all cases the footplating overlaps this edging. Angle brass may be used, although in a smaller model the use of a solid brass rod of rectangular section is the best practice, especially where the footplates have curves introduced into them. Figs. 317 and 318 show various methods of construction at the ends of such stiffeners, and Fig. 319 how steps are usually fitted to the footplates.

Cabs.—In building up the splashers, tanks and cabs of small models, instead of employing a continuous length of angle or lug strip for fixing two plates at right angles, short lengths of, say, 1 in., may be utilised, the first operation being to solder and screw or pin the angle or square strip to one plate slightly short of the edge and then attach to the other plate by screws after the manner indicated in the section of a dummy side tank (Fig. 320). The plates may, of course, be soldered along the whole joint afterwards if a permanent fixing is desirable. If any accident should subject the upper works of the engine to flames, or if further soldering is to be done to the work, it will not fall to pieces in the way it would if no positive fixing were employed other than the solder.

For edging cabs and tender sides it is possible to obtain half-round brass wire from $\frac{1}{16}$-in. diameter, while from $\frac{3}{32}$-in. diameter upwards a section of wire (see Fig. 321), known in silversmith trade as "catch wire," is extremely useful and readily obtainable. There is no need to go to the

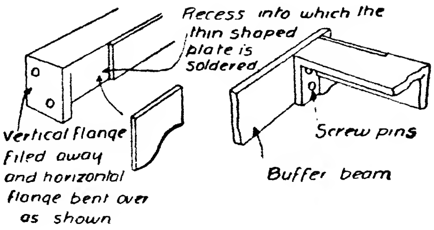


Fig. 317.—Angle Edgings for Footplates.

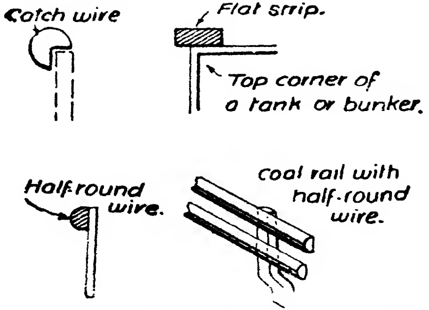


Fig. 321.—Method of Beading Edges of Cabs, Tanks, etc., and Making Coal Rails.

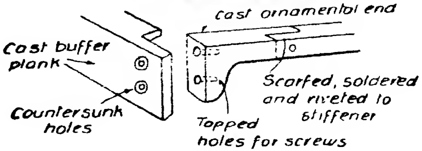


Fig. 318.—Rectangular Edgings.

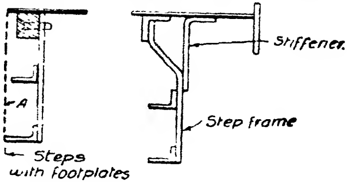


Fig. 319.—Method of Making and Fixing Footsteps, which should not extend beyond Line A.

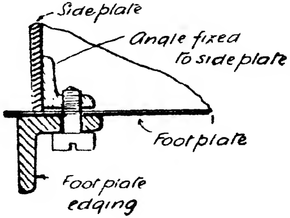


Fig. 320.—Method of Holding Superstructure Plates Meeting at Right Angles.

trouble of specially splitting tube or milling wire to fit on the edges or corners of plate structures.

Repairs to both engines and tenders will be greatly facilitated if splashers, cabs, tanks, etc., are made entirely separate from boilers and underframes, and also secured in such a manner that the component parts may be readily removed. In a tank engine having water space side and bunker tanks, the arrangement of fixing down to footplates illustrated at A Fig. 322 may be adopted. Where wheels interfere with side tanks the tanks can be of the full width

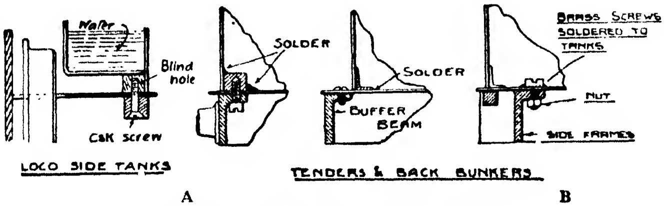


Fig. 322.—Methods of Tank Fixing.

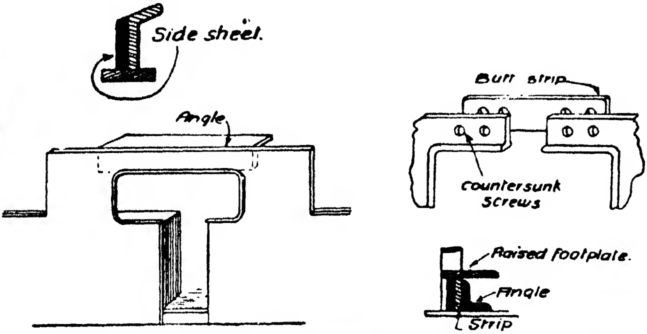


Fig. 323.—Building-up Side Sheets and Roof of Tank Engine Superstructures.

and recessed locally or may be of the narrow width throughout their whole length as shown. The additional views, B, of this illustration show methods of fixing-down tender tanks.

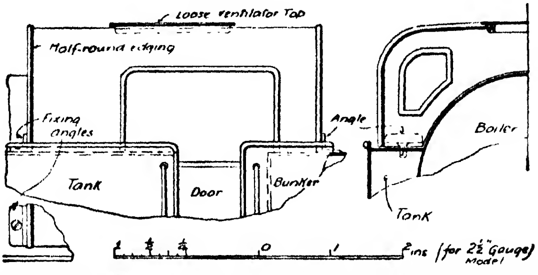


Fig. 234.—Separate Form of Tank Engine Cab, G.N.R.

Connecting side tanks to bunkers where the side plates are flush is a feature which needs attention from the point of view of construction and also taking the components

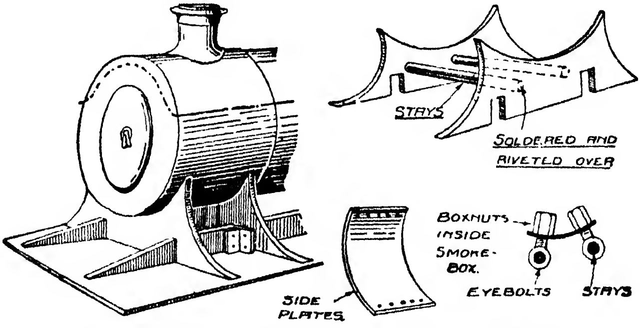


Fig. 325.—Built-up G.W.R.-type Smokebox Saddle.

apart for repairs. The side sheets may be cut over and below the doorway and fishplate strips arranged to connect the two sheets. Where the bunker and side tanks can be in one piece and lifted off clear of the boiler the raised footboard in the cab may allow a continuous side sheet to be used, the narrow strips connecting top and bottom being reinforced by short lengths of brass rod or angle (Fig. 323).

In many designs it is possible to make the cab as a separate structure. An example of this is illustrated in Fig. 324. In this way the connecting screws with their obnoxious slots do not come on the painted and lined faces of the tanks and bunkers, but on the relatively unimportant top surfaces. The L.N.W.R. type of cab allows a similar construction in the case of tender engines owing to the design having two or three component parts, i.e. the lower side sheets on each side and the covering portion.

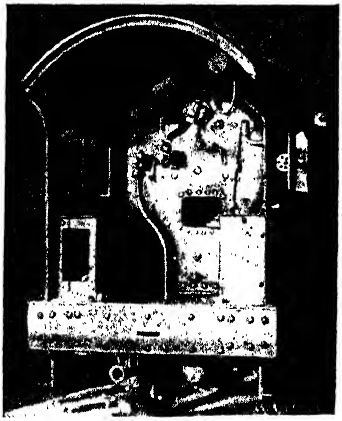


Fig. 326.—Cab of Model 1-in. Scale N.E.R. Locomotive.

Saddles for Smokeboxes.— Saddles to carry smokeboxes and cover steam pipes are advisable wherever possible. Fig. 325 shows a built-up construction savouring of G.W.R. practice.

The use of box or blind nuts is common in smokebox work, as the ends of the bolts and their threads are pre-

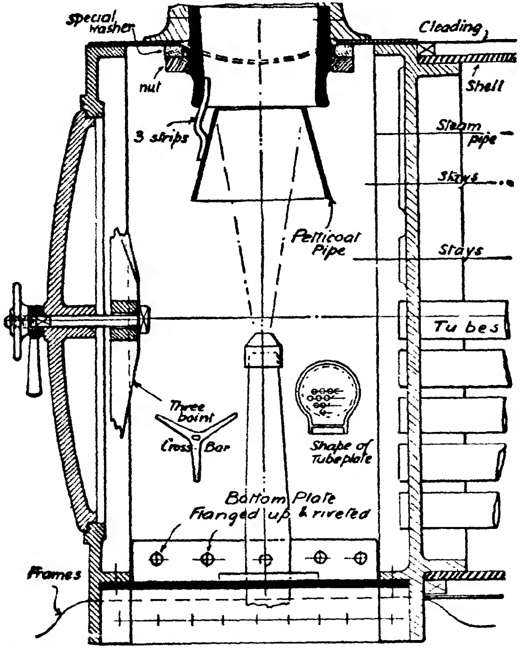


Fig. 328.—Large Midland Railway Model Smokebox.

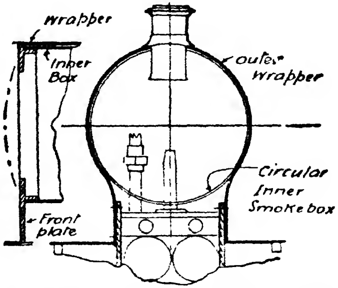


Fig. 327.—Small L.N.W.R.-type Smokebox.

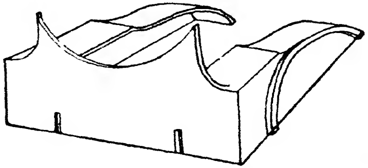


Fig. 329.—Front-coupled Locomotive Smokebox Saddle.

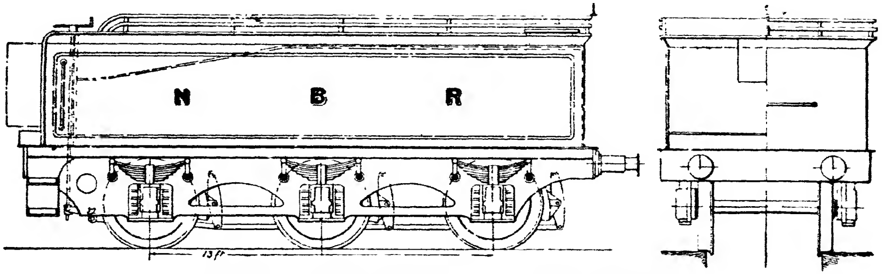


Fig. 330.—Typical British Loco. Tender (N.B.R.).

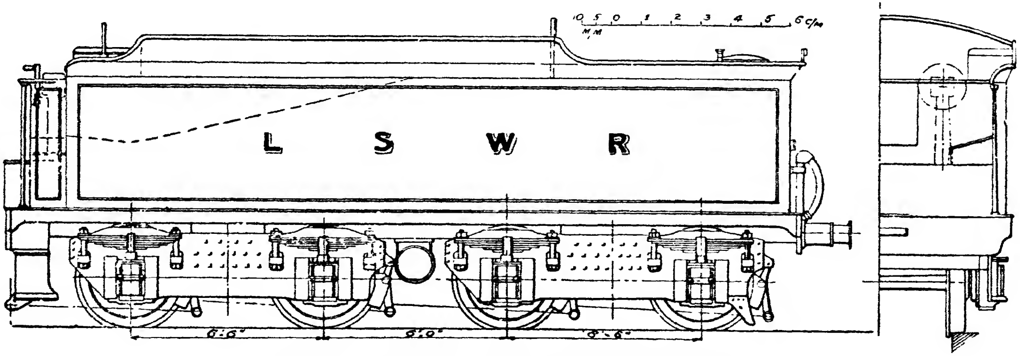


Fig. 331.—L.S.W.R. Latest Double-bogie Tender.

vented from corroding. The cast saddle is also used now to a very great extent, and provides a sound and easily-fitted connection between the frames and the smokebox. With the use of the old standard form of smokebox some difficulties in fitting in the bottom occur, especially where the boiler is not pitched well above the rail level. If possible a circular inner smokebox should be employed with an outside wrapper over it. This wrapper can extend down to the frames. Otherwise the orthodox form of front tube plate must be copied and a square floorplate fitted into the smokebox. This is best done by the use of castings.

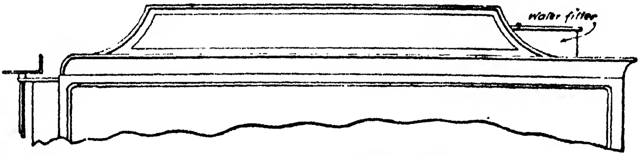


Fig. 332.—G.C.R. Sheet-metal Coal Guard.

Figs. 327 and 328 illustrate these points fairly clearly. Fig. 329 shows how a circular smokebox can be very simply supported in the case of a front-coupled tank or goods engine.

Fig. 326 is a photograph of the cab of a 1-in. scale N.E.R. locomotive.

Handrails, Knobs, etc.—Many excellent models are often spoiled by disproportionate handrails and handrail knobs. The latter are commercial articles in the model world and not worth the trouble of making. In full-size practice 1⅛-in. or 1¼-in. tube is employed, but in a small model the handrail may be a little thicker than a strict scale equivalent would suggest. For a 1-in. scale engine use No. 12 s.w.g. steel rod, for ¾-in. scale No. 15, and for smaller models No. 16 or No. 18 gauge according to the scale of the locomotive.

In a lagged boiler handrails are fitted to the cleading, which is locally strengthened by a strip of thicker metal inside; otherwise they must be screwed into the boiler and possibly made steam-tight. Steel knobs should never be put into the shell of a copper boiler. German-silver fittings should always be employed in such cases.

Tenders.—The function of a locomotive tender is to carry the fuel and water required by the engine, and, as its name implies, it is quite a separate vehicle, often weighing when loaded nearly two-thirds that of the engine itself. Two types are shown by the drawings Figs. 330 and 331.

The standard British tender is a six-wheeled carriage, the total wheel base, which is rigid, varying from 11 ft. (L.Y.R.) to 15 ft. (G.W.R.). Where the railway is provided with water troughs and pick-up tenders the capacity averages 3,000 to 4,000 gallons and three to four tons of coal. Large bogie tenders are used on lines not so equipped, on the L.S.W.R. the latest tenders carrying on two bogies no less than 5,600 gallons of water. An example of the standard type of tender is that of the N.B.R., although on the G.C.R. and the M.R. more particularly, the open coal-rail has been replaced by a plate, as shown in Fig. 332.

Most tenders have outside frames, the old Brighton six-wheelers and Mr. Drummond's L.S.W.R. bogie tenders being notable exceptions in having all wheels with inside axle-boxes and therefore being easy to model. The springs in modern engines are almost universally on top of the axle boxes and below the footplate level. Water pick-up apparatus is not workable in any but the largest models for physical, not mechanical, reasons. Some details of tender construction are shown in Fig. 333.

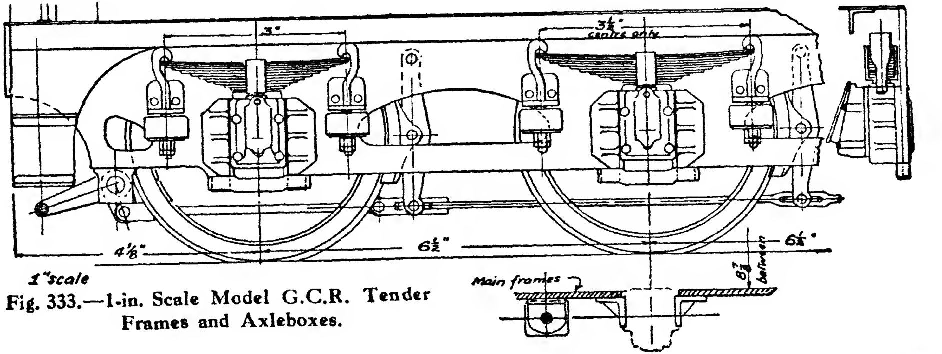


Fig. 333.—1-in. Scale Model G.C.R. Tender Frames and Axleboxes.

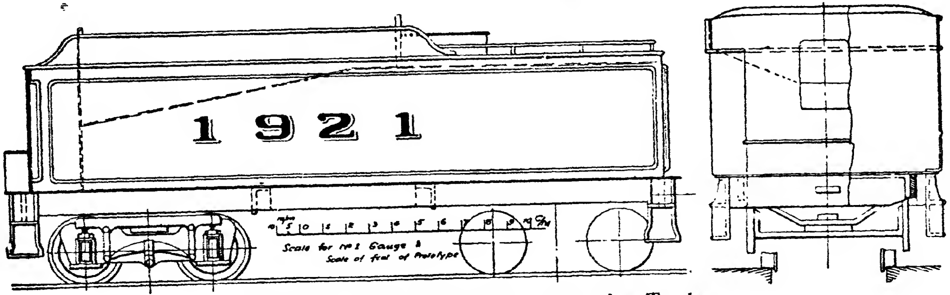


Fig. 334.—Typical American Locomotive Tender.

In some older engines the axle-box frames were separate and attached to the main frames, as in the case of a wagon or carriage. This is not a bad idea for a model, as only one pattern for these frames and the dummy springs need be made, six being cast off it. A double-bogie tender requires pivots for the trucks only; no side play is necessary, and the turning movement on a curve is very small indeed. American locomotive tenders (Fig. 334) are almost all eight-wheeled vehicles of comparatively great length, carrying as much as 10,000 gallons of water.

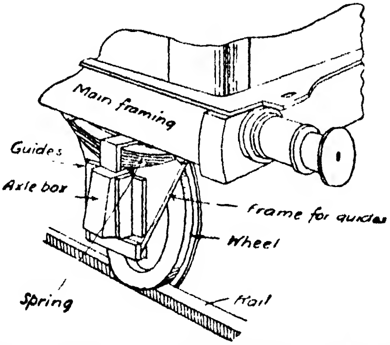


Fig. 335.—Frame of Old L.N.W.R.-type Tender.

A detail of an old L.N.W.R.-type tender is shown by Fig. 335.

Bunkers.—As model tenders often have to become spirit or oil carriers instead of "coal carts," the arrangements of bunkers or tanks require consideration. Sometimes the maker of the model will choose to mask the presence of spirit or oil tanks; others will not mind the liquid fuel containers being seen. This, of course, affects the internal design of the tender body. Fig. 336 shows three forms of bunkers and tanks.

Tender side frames may, if several engines of small gauge are to be made, be cast in soft iron or brass in one piece complete with all springs, axle-box guides, etc.

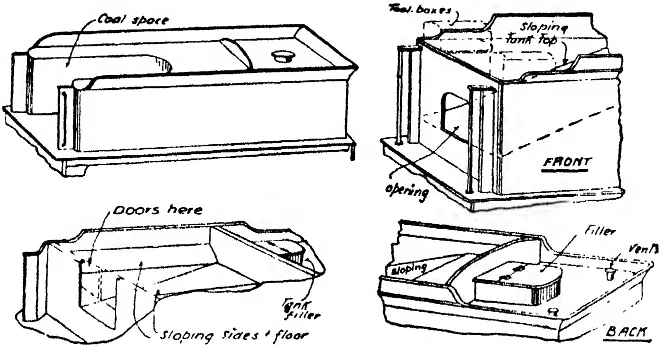


Fig. 336.—Types of Tender Bogies.

Where the wheels are sprung the horn-stays should be cast solid with the frames at the bottom of the axle-box guides. The spring can then be concealed in the spring buckle as shown without disturbing the horn-stay. This is important where an iron casting is used. Another point needing special attention is the relative position of the

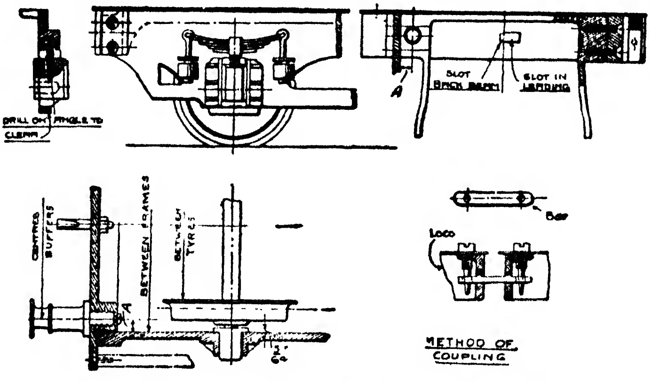


Fig. 337.—Cast Tender Frames and Coupling.

buffers, and the joint of the main frames and buffer planks indicated at A in Fig. 337. Here a cast plank is used into which the buffers screw, sufficiently large bosses being arranged at the back of the plank for this purpose and for providing a fixing for the screws attaching the side frames. A simple method of arranging the guard irons and coupling the locomotive is also illustrated. The former are cast in brass solid with the plank. They may be bent to any shape.

In the case of plate frames the dummy springs may be cast separately and slung in the usual manner as if they were real laminated springs, acting spiral springs in the buckle or on the spring hangers being employed, as already described in another chapter.

Buffers.—There are two patterns in general use, one with the conical and the other with the parallel stock. The heads are sometimes oval, when keys and keyways in the stalk of the buffer or other means must be provided to prevent them turning, devices for this purpose not always being entirely successful in real practice. The conical buffer illustrated in Fig. 338 represents one made for a large model, the spring washers on the spindle being made sufficiently long to prevent the spring from damage under full stress. Springs may be duplicated, one being placed inside the other, and one being much stronger and shorter, so that it only comes into action during the last part of the stroke. A pair of spring buffers should just close when loaded to a weight equal to one-fourth that of the engine. This is a rough guide to the required strength of the springs. A simple arrangement of spring buffers (parallel type) is illustrated in Fig. 339, a method of preventing the heads turning (where they are of oval shape) being indicated in the lower part of the sketch. Buffer heads should be made of steel or nickel silver in small models, and may be separate from the spindle, as shown in Fig. 338, if a secure fastening of the heads on to the spindle is devised.

Drawhooks.—These should be made of steel or nickel silver, and in small models are often screwed or riveted and soldered into the buffer planks. The illustrations (Figs. 340, 341 and 342) show three methods of providing a certain amount of resiliency.

In such cases the shank of the hook, where it passes through the plank, must be squared to prevent the rotation of the hook in service. In engines having long overhanging frames at the leading or trailing ends, it is necessary to allow a wide slot in the buffer plank and to extend the shank back some distance to a suitable fixing so that the hook can swing from side to side.

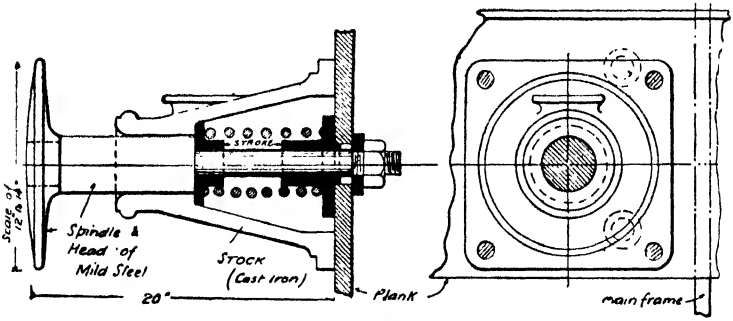


Fig. 338.—Conical-stock Buffer for Large Model.

Special forms of hooks and shackles are necessary in small-gauge models operating on excessively sharp curves. In these it is usual to arrange an inverted T-slot in the hook and a rigid shackle. In this way the train can be pushed through the couplings and "buffer-locking" eliminated. A pivoted drawhook with ample lateral play is essential to this device.

Lagging. — The lagging of a model boiler with asbestos yarn or millboard, flannel soaked in alum, the whole being covered with a cleading of sheet metal (tinplate, Russian iron, or rolled-brass sheet), is not always a satisfactory or interesting job to the amateur. For

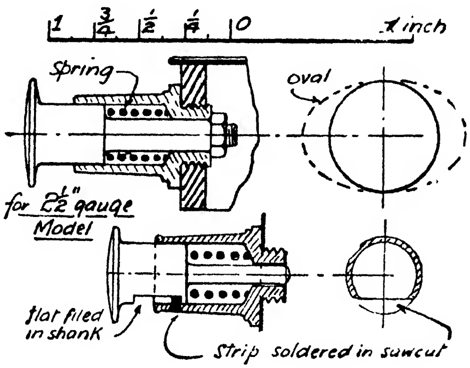


Fig. 339

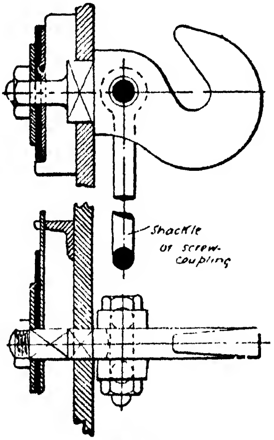


Fig. 340

Fig. 339.—Parallel-stock Buffers for Small Models.

Fig. 340. — Form of Spring-tension Drawhooks.

smaller models the use of lagging cuts down the internal dimensions of the boiler an appreciable amount, and if a reasonably smooth, clean job is made of the boiler itself there is no need to bother with lagging. The saving in heat loss is likely to be less than 10%, while the reduction in heating surface and boiler may prove to be a more serious item. Contrary to accepted theory, the enamelling of a surface increases its capacity for radiation, which is a point in favour of lagging.

The cleading in real engines is laid on in several sheets, and the circular joints are covered by bands of thin metal. The width of the bands employed in actual practice varies from 1¾ in. to 2½ in. For models strip brass, upwards of $\frac{1}{32}$ in. thick, can be obtained in various widths. Fig. 343 shows two methods of joining up the ends at the underside of the barrel.

Water-tube boilers having outer casings in contact with flame and not cooled by the water are subject to the rapid deterioration of the enamel. Paints without oil or varnish in their contents have been tried, but even then colours are not permanent, and the proper shiny surface is absent. The only thing to satisfactorily overcome the trouble is to use a double casing—virtually a lagging of the outer shell—this double casing being packed with asbestos. An air space may be provided between the two casings in place of the asbestos.

For a large model (1½-in. scale and upwards) asbestos yarn or "string" is the most convenient material to use for the lagging. It can be wound round and round the barrel and laid in ropes side by side over the firebox portion.

Two styles of paint lining are shown in Fig. 344.

Fixing Boilers.—Boilers are usually firmly fixed to the

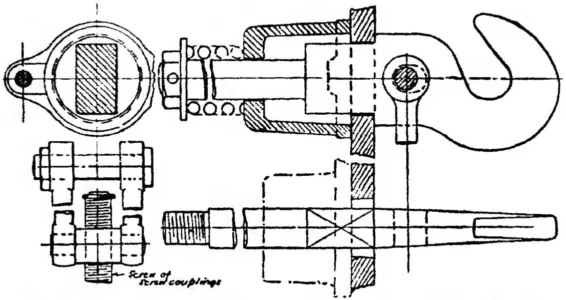


Fig. 341.—Another Form of Spring-tension Drawhook.

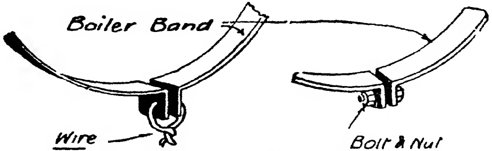


Fig. 343.—Two Methods of Fixing Boiler-lagging Bands.

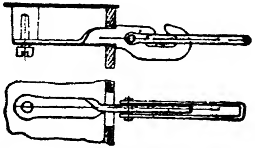


Fig. 342.—"Push and Pull" Drawhook and Coupling for Small Models.

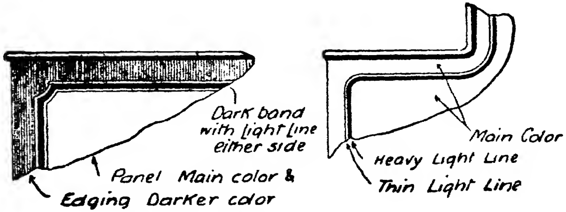
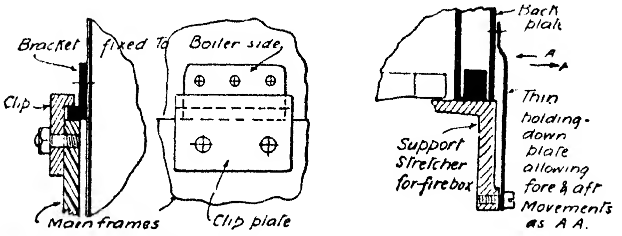


Fig. 344.—Methods of Paint Lining.

frames at the smokebox end, but at the back some scheme must be devised to hold the firebox down to the frames and at the same time allow it to slide. The usual method is to fit an angle to the firebox side which shall rest on the top edge of the frames and to bolt another angle to the latter, clipping over the boiler angle. Mr. Ivatt's system has also been used by the author with success.



ORDINARY SIDE JOINT

IVATT'S FLEXIBLE PLATE

Fig. 344A.—Two Forms of Expansion Fixings for Boilers to Main Frames.

The back plate of the boiler is then fitted with a deep transverse plate of thin material. The lower end of this plate is secured to the frames. The bending of the plate provides for the longitudinal movement of the boiler during expansion and contraction. In a boiler 30 in. long provision for a movement of $\frac{1}{16}$ in. should be made. Two forms of expansion fixings are shown by Fig. 344A.

CHAPTER XV

Firing and Boiler-feeding Devices

Spirit Firing.—The externally-fired engine requires either a plain wick lamp or one in which the spirit is vaporised by a regenerative action coupled with the heat obtained from a small wick tube or pilot light. The vaporising burner (Fig. 345) is exceptionally good where there is a free (i.e. natural) ventilation of the flame, but does not appear to have been used with any degree of success in a closed firebox with induced draught. Methylated spirit (alcohol) vapour has a very characteristic flame. If the speed of the vapour issuing from a jet rises beyond a very low limit it will not remain ignited—the flame will leave the jet. This evidently prevented the author obtaining great success with his earlier experiments, wherein the spirit was boiled in a container in the tender and the spirit led to Bunsen burners in the firebox. For a few moments an intense heat would be obtained, but the slightest change in the induced draught would cause the flame to go out.

The spirit wick lamp most often gives trouble in home-made engines through its component parts being made of heavy copper tubes. The heat is conducted through these pipes to the reservoir, causing the spirit to boil. Care should be taken to select the thinnest tubes; further, the open drip trough so frequently used is the cause of many a "flare up," especially under the circumstances just mentioned.

Another point to remember in applying a spirit lamp to an internally fired engine is that while an induced draught is essential in promoting combustion, the furnace should not be so small or the wick lamps so closely arranged that the blast of the engine lifts the flame off the wicks and simply draws unburnt spirit up the chimney. The fuel is not only too expensive to waste in this way, but the vapour fumes are highly objectionable where the railway is indoors. It is possible with a small firebox and a sharp draught that less steam will be evaporated when the engine is running than when it is standing still and the lamp burning under natural draught only or with the help of a small steam blower.

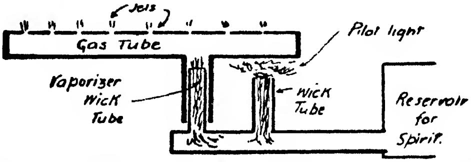


Fig. 345.—Vaporising Spirit Lamp for Externally-fired Boilers.

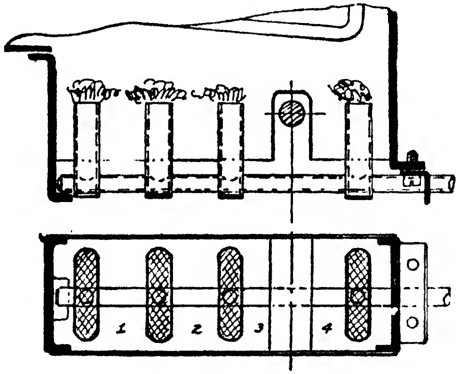


Fig. 346.—Lamp for Transverse Wick Tubes.

Wicks should not be crowded too close together, and, in any case, the tops of the wick tubes should be as far away as possible (up to 2 in.) from the underside of the water tubes. In connection with the subject of spacing, for any locomotive with a long narrow "grate" the system of oval wicks placed transversely across the firebox, as sketched in Fig. 346, may be favourably considered. Here there are four intermediate air spaces of relatively large dimensions, and as the draught induces the flame across these air spaces cold air playing on the tubes will be to a certain degree eliminated. Threading strands of wick across the open spaces is often practised for the same reason, as indicated in Fig. 346. Another method of moderating the less desirable effects of a sharp draught on a wick lamp is to drill holes (see Fig. 353) in the top of the wick tubes, more particularly the sides facing the spaces between the wick tubes. Vaporised spirit emerges from these holes and is ignited by the wicks. A development of these ideas is a lamp designed for a wide firebox engine (refer to Fig. 351). The lamp is an annular trough, across which wires are stretched for supporting asbestos yarn. Holes are drilled all round the inside of the wick trough in addition, the intention being to provide an incandescent mass in the centre reproducing the effect of a thin coal fire, the large area of the firebox only requiring a very moderate induced draught.

The spirit lamp is not of any great service in firing a loco-type boiler with tubular flues. The only condition under which any great measure of success will be obtained with a flue-tube boiler is where water tubes in the firebox are present and where all the heat-conducting surfaces are of the thinnest material consistent with the strength required. Some of such water tubes should be arranged to promote an end-to-end circulation of the water in the boiler.

An auxiliary blower, as illustrated in Fig. 347, is of service in raising steam with an internally fired spirit lamp engine. The rubber bulb and bag are the same as used for scent sprays, the extension chimney being fitted with a jet of a size that will allow the air bag to remain distended during the periods of compressing the air bulb.

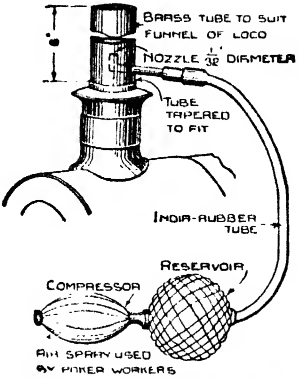


Fig. 347.—Auxiliary Hand-blower for Steam Raising.

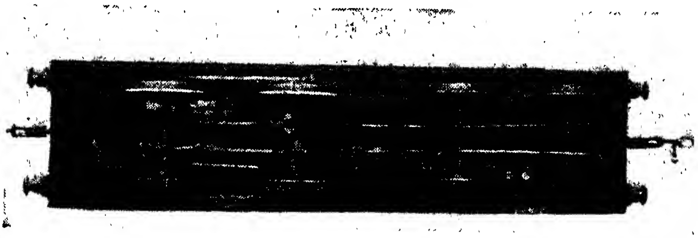


Fig. 348.—Under-side of Model 0—4—4 Locomotive showing Lamp and Feed Sump.

Wicks should be made up of asbestos yarn. This material conducts the spirit quite well and does not char.

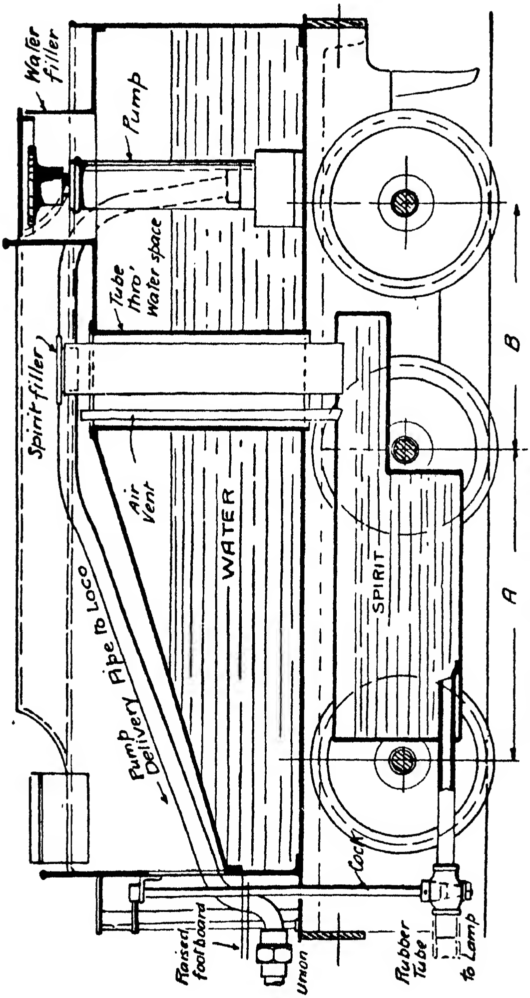


Fig. 349.—Tender with Reservoir at Lamp Level.

The average consumption of spirit is 1 cub. in. to every 3.3 cub. in. of water evaporated. Any lower efficiency than this demands careful investigation.

Fig. 348 is a view of the underside of Mr. P. Blankenburgh's model 0—4—4 type tank engine showing the spirit lamp and fuel sump.

Spirit-lamp Feeding Devices.—There is not often sufficient room on the locomotive itself for a capacious spirit reservoir, and therefore the main portion of the supply is carried in the tender or on the locomotive. One arrangement of tender which provides for the additional supply of spirit is illustrated in the sectional view (Fig. 349). In this the tank is level with the lamp and a flexible connection is obtained by a short length of rubber tube. This is really the only weak spot in the scheme, as the rubber will require rather frequent renewal. The spirit tank is bounded by the axles of the wheels, and in some six-wheel tenders (G.N.R. for example) advantage may be taken of the difference in the wheel spacing A and B to obtain the largest possible tank. This reservoir is filled by a tube passing through a larger one arranged in the water space, and its outlet is controlled by a cock operated from the front coal plate of the tender. The water pump is placed under the orthodox water-filler and delivers its supply through an overhead pipe which should be free to move in all directions. The union for this is under the raised footboard. The latter is a feature of modern practice, and can be a loose and easily removable fitment.

An open drip-feed scheme is shown in Fig. 350. This is an improvement on the usual arrangement in that the open trough is behind the tender buffer-beam, and therefore more or less protected from the flame of the lamp. A further protection against this annoying fault, present in most lamps, is the baffle plate w, which also forms a means of fixing the lamp, and a drip plate. When a spirit lamp overflows the flaming fuel tends to run along the supply tubes and ignite the open sump. This plate should prevent this occurring. For engines working on excessively-sharp curves the open-topped tube leading the drops of spirit to the sump may have to be oval instead of round as shown. This is a matter to be considered in designing a lamp for a particular locomotive. The overflow pipe should be extended laterally clear of the wheels, so that an excess of feed may be readily observed. In view of the lighting-back troubles, present in ordinary open sump lamps, and the objections to the chicken-feed arrangement, the author evolved the siphon-wick feed illustrated in the application of the system to the No. 1 gauge articulated tank

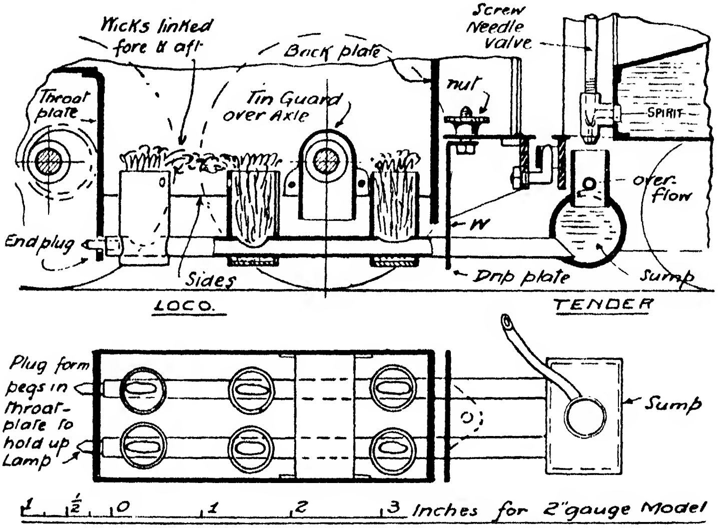


Fig. 350. Tender with Spirit Drip Feed.

locomotive (Fig. 46, Chapter II) detailed in Fig. 351. Experiment proved that 25 strands of darning wool delivered about 2.2 cub. in. of spirit in 20 minutes, which is enough for most lamps, and, further, on a four-wick lamp there appeared to be some sort of compensation established in the rate of feed when the siphon scheme was coupled to a lighted lamp. Although an overflow pipe was provided no sign of excess or insufficient feed was noticed with lamps of a varying number of wicks. The overflow acted immediately all the wicks were extinguished. The success of the scheme was reported against by one manufacturer, but it was found to be due to faulty workmanship. The feed tube was so thick that capillary action was set up, and, further, the flexible coil in the pipe from engine to tender was so carelessly wound that air locks were introduced. Such a coil should have a constant fall, as illustrated in Fig. 352.

The best position for a tender feed is undoubtedly in the front. An alternative to the coiled feed pipe is shown in Fig. 353. The spirit tank is placed at the front end of the tender, as it would be in a real liquid-fuel engine. The author's wick-siphon feed tube is of the largest diameter of pipe that can be accommodated, and to allow the lamp and its supply pipe to be practically a fixture on the engine the spirit tank has a conical internal stand pipe soldered inside it. This is oval in cross-section to provide for the lateral swing of the tender on curves. The umbrella top of the siphon pipe is a spring fit, and is placed in position in the pipe when the tender is coupled up. This umbrella supports the wick and prevents waste of spirit. The complete arrangement eliminates flexible piping, and also provides a large-diameter supply tube to the lamp.

In all these wick-siphon feeds the spirit supply may be

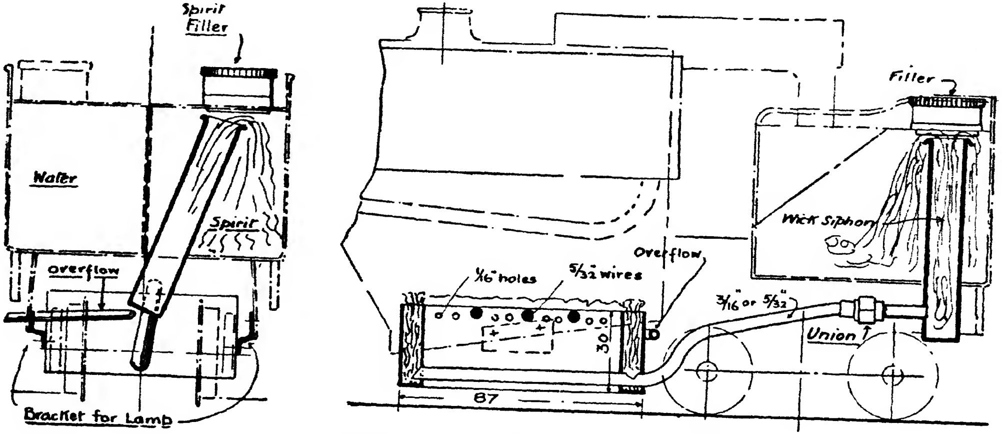


Fig. 351.—Wick-siphon Spirit Feed for Tank Locomotive.

stopped by withdrawing the wick. Alternatively a cock may be fitted on the supply pipe or means provided for compressing the wick at the top. A simple method of stopping the feed temporarily would be to lift the lid and to lay a thick disc of lead or steel on the top of the wick tube. The "chicken-feed" scheme in its simplest form is illustrated in Fig. 354. A high-level tank which is sealed by an airtight filler is essential. The level of spirit in the lower sump is determined by the large-diameter notched-feed tube which is soldered into the bottom of the tank and projects into the sump.

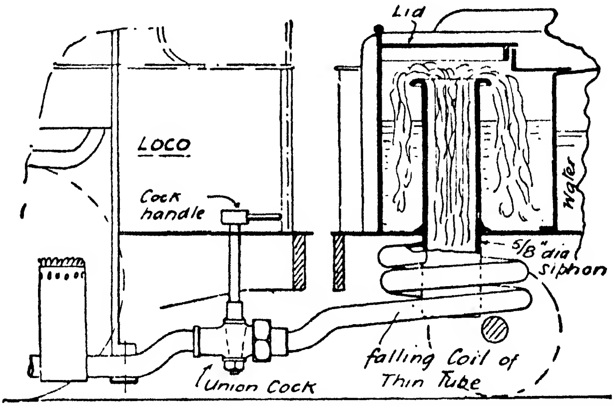


Fig. 352.—Wick-siphon Spirit Feed with Siphon Tube fixed in Tender.

When filled the spirit flows until the level in the open sump seals the notch. The system as sketched requires that the tank shall not be refilled until the system is entirely empty. To provide for refilling at any time two feed pipes are often fitted. One is a short feed pipe with a packed needle valve which may be shut off when the tank needs replenishing. The other is an air pipe which extends from the normal level in the sump to the top of

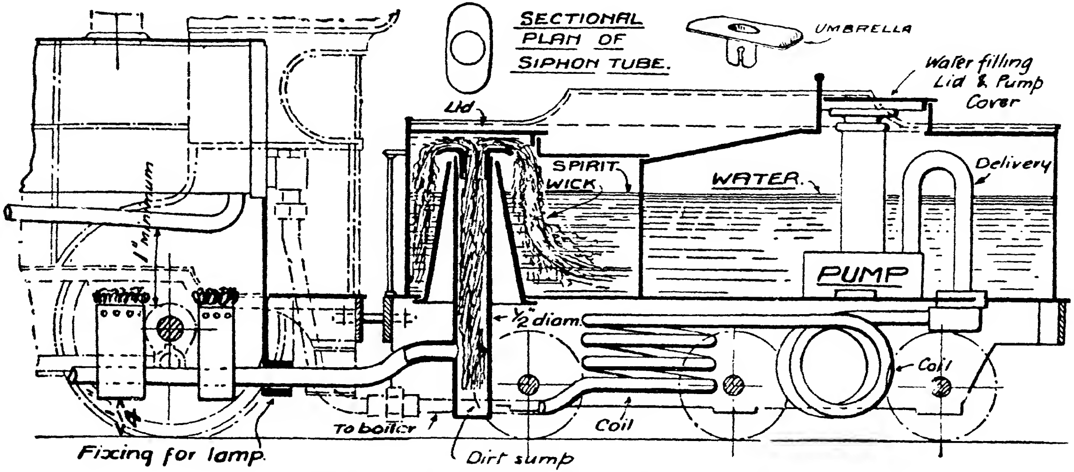


Fig. 353.—Tender Siphon Feed Integral with Lamp.

the higher tank. This pipe must be of sufficient size to prevent capillary attraction rendering the device unreliable in operation.

Solid-fuel Firing.—Undoubtedly generating steam from solid fuel is highly satisfactory, and wherever it is possible should be adopted. With the spirit lamp and oil burner the fire is not under entire control, and, what is more important than anything, the range of intensity does not vary directly with the load on the engine as expressed by the value of the blast exhaust steam. If a model locomotive fired by a spirit lamp is forced beyond a given point the flame of the lamp is so much "knocked about" by the fierce induced draught that the heat in the furnace is reduced and the evaporation of steam falls instead of rises. This cannot happen, with reasonable attention, to a coal or charcoal fire. As in a real locomotive, the evaporation of steam will increase and diminish automatically with the demands of the engine.

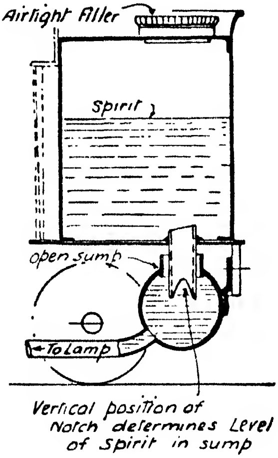


Fig. 354.—Simple Form of "Chicken Feed."

To regulate a solid-fired engine—it must not be forgotten that the skill of a locomotive fireman is as important a factor as that of the driver—the following means are used:

(a) The supply of fuel and its timing compared with
(b) The supply of feed water and its periodicity.
(c) The regulation of the air above and below the fire.
(d) The use of the steam blower when standing.

(e) The intensity of the exhaust blast, which in a large model is variable at the wish of the driver and varies automatically by the resistance of the load.

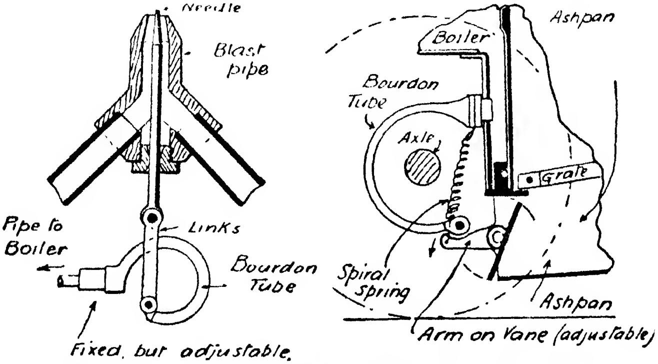


Fig. 355.– Fire Regulators actuated by Bourdon Tube.

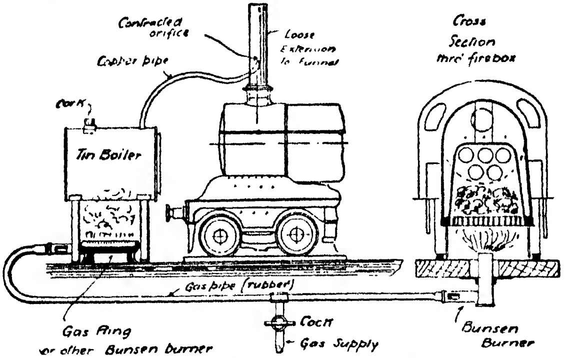


Fig. 356.—Raising Steam with Separate Regulator.

Sometimes in real practice devices are used to vary the area of the blast nozzle.

While there are limits to the thickness of a perfectly incandescent fire if coal alone is used a charcoal fire may be filled up to the crown of the firebox. Firebox capacity is therefore one of the chief aims in the design of a charcoal-fired engine. A thick fire may be used where coke is employed, but such fuel is not to be recommended in a copper firebox or in a boiler with copper or brass tubes.

Where a solid-fuel engine of small dimensions is concerned the only difficulties that will present themselves are due to the absence of a fireman on the engine. If sent away on a continuous run with a heavily loaded train and a firebox crammed to the roof with fuel the steam will soon rise to the blowing-off point. Two regulating devices suggest themselves, both of which are operated by a strong Bourdon pressure-gauge tube. The latter may be taken out of an old gauge, and has the advantage over a spring-loaded piston device in that there is no possibility of leakage. The Bourdon tube can be arranged to open the blast orifice as shown in Fig. 355, but where this is beyond the skill of the mechanician a less delicate device may be employed. The tube may be made to operate the damper of a closed ashpan fitted under the grate bars, opening the damper when the steam pressure falls and closing it when it rises. As an alternative the Bourdon tube may be made to open a firedoor with an increase in pressure.

The door must, however, be loose, so that it can be opened independently for purposes of firing. This last-described device is perhaps the simplest of the three and likely to prove the most reliable.

One great advantage of solid firing is the control obtained over the steam evaporation with an engine at rest. So long as the boiler is full of water and the fire replenished even a tiny model may be left in steam for half an hour at a time without fear of damage. Of course, individual models will have their idiosyncrasies, which will require to be known. Once a model locomotive builder possesses a successful solid-fired engine he will never consider any other scheme. The author has not completed his experiments with firing water-tube boilers, largely, he regrets to say, due to the apathy and conservatism of trade makers, but there appears to be no reason why the spirit lamp should not be ousted from favour in the firing of water-tube boilers. The outer casing should be lined with a heavy gauge sheet-steel liner and the space at the firebox packed with asbestos. A wide firebox engine might even have a third liner of asbestos millboard at the firebox end.

The objection that the solid-fuel engine is a nuisance in the matter of steam raising is more or less of a "bogie." If the proper apparatus is fitted up the trouble is indeed small. The best method for a small model is illustrated in Fig. 356, and if gas is not available spirit may be employed. The small tin boiler is a quick steam raiser, cheap to make and replace when worn out. The tin boiler is filled with sufficient water for ten minutes' work, the gas being lighted right away. The engine is then placed over the gas jet and the firebox filled with a layer of charcoal. When steam is raised and the auxiliary blower commences working the clip on the rubber pipe to the Bunsen burner under the firegrate is removed and the jet lighted. By the time the tin boiler is exhausted steam will be raised and the engine's own blower available for use. The only attention required may be the addition of charcoal to that placed in the firebox at the outset.

Very large models may have an electrically driven fan supplying air to the jet in the extension chimney, although for 9½-in. and 15-in. gauge engines a 15 ft. extension, made of stove pipe, will on most days provide an adequate natural

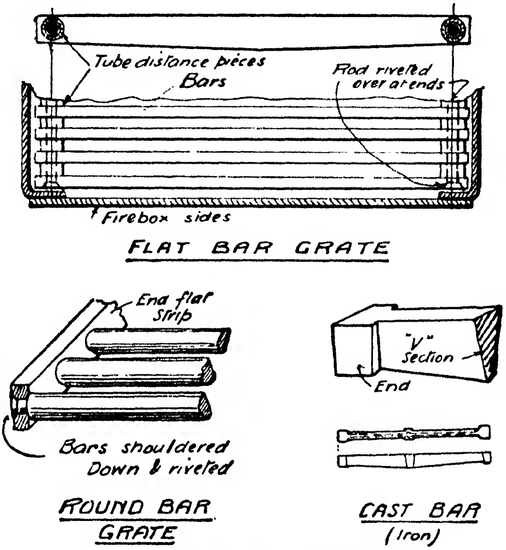


Fig. 357.—Firegrates and Firebars.

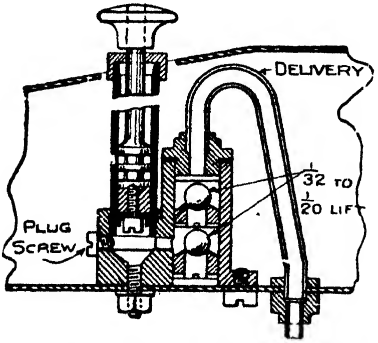


Fig. 358.—Plunger Hand Force Pump (Submerged).

draught. This draught is best started by lighting a fire of paraffined shavings in the smokebox. Then light the usual wood fire in the firebox, using coal when the steam has risen to 10 lb. or 20 lb. per sq. in.

Hard wood charcoal has a higher calorific value than that made from soft wood. A mixture of best anthracite "peas" and good house coal is to be recommended for 1-in. scale and larger engines, while the largest models work well with a mixture of coke and South Wales steam coal (Nixon's Navigation or its equivalent).

Firing a Model.—In designing the cab and tender of a solid-fuel engine convenience in firing should be studied. Sometimes it is necessary to cut a large piece out of the cab and to fit a sliding or lifting roof. The front coal plate of the tender will often be found in the way of the miniature shovel, and should be arranged to be hinged or entirely removable. In a small model tank engine with a closed cab it may pay to fit an inclined chute to the firehole with the door in the back bunker. The firehole should in such a case be as high as possible, so that the furnace may be entirely filled with charcoal. The chute should be straight, so that poking the fuel into the firebox presents no difficulty. Specially-made firing tools should be devised and made to suit the particular engine. Passenger-carrying tank engine models are usually fired from a driving truck.

Firegrates.—Engines burning solid fuel should be provided with a suitable grate made up of bars of oblong section placed at a distance apart not greater than their thickness. To preserve these air spaces "distance pieces" may be employed, as in Fig. 357. Strips of metal, one at each end of the firebox, fixed by studs to the foundation ring, will support a built-up grate. The same applies to

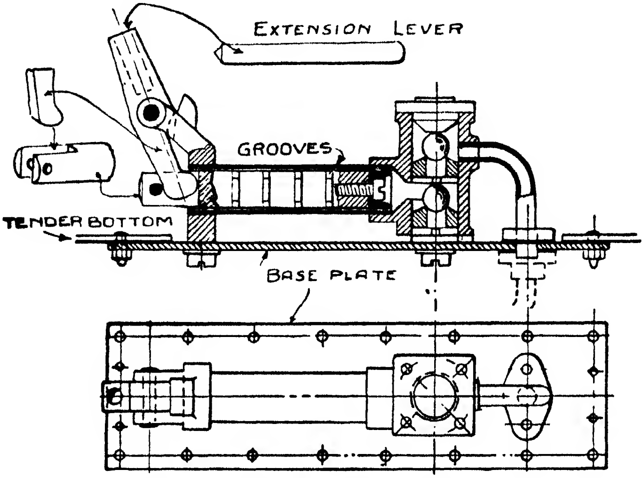


Fig. 359.—Lever Hand Pump Submerged.

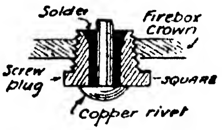


Fig. 359A.—Section through Fusible Plug.

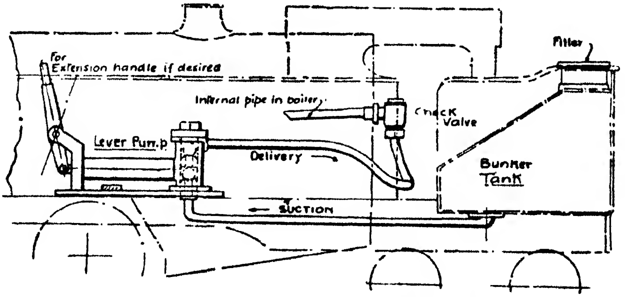


Fig. 360.—Fitting Lever Pump to Tank Locomotive.

an ashpan where used. In all small engines the author has not found any advantage accrue by using an ashpan except that its use tends to prevent grit getting into the motion of the locomotive.

Sometimes it is possible to so arrange the grate that by withdrawing a single pin the grate may be dropped. The whole fire may then be dropped instantly in case of a dangerous shortness of water occurring in the boiler, due to forgetfulness or to the feed supply failing.

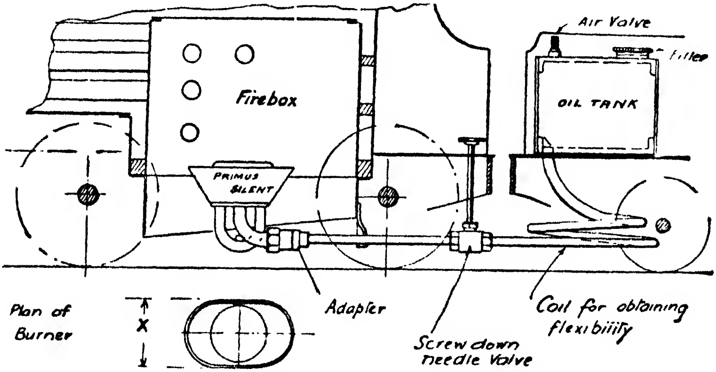


Fig. 361.—"Primus" Vaporising Petrol or Oil Burner fitted to a Model Locomotive.

In all solid-fuel engines burning coal, either wholly or partly, the brick arch should never be omitted. This useful fitting prevents the direct passage of cold air to the tubes, and by turning over the flames tends to the more perfect combustion of the fuel. The brick arch may be a piece of fireproof tile in a large engine or a thick steel plate. The "arch" should only rest on special studs and not be fixed in the ordinary sense of the word.

Fusible plugs are useful fittings in the furnace to prevent damage to the crown of a boiler. They are easily made by soldering in a brass rivet which fits loosely in a hole in a taper-threaded brass plug screwed into the top plate of the firebox. A suitable design is reproduced in Fig. 359A on p. 290.

Firegrates in 1¾-in. and 2½-in. gauge engines may be made out of $\frac{3}{32}$-in. or ⅛-in. round bars. The bars should be shouldered down at the ends and riveted into metal strips, after the fashion of a metal ladder, but with close rungs. The bars should not be too long, and in some cases may run across the width of the firebox rather than lengthwise. Where grates cannot be got into place very easily it may pay to divide the bars into two sets. Engines larger than 1½-in. scale, burning coal and coke, should always be provided with separate cast-iron firebars of the orthodox type.

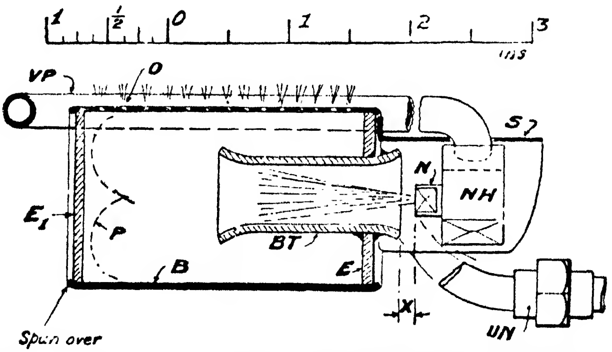


Fig. 362.—Model Locomotive-type Vaporising Paraffin or Petrol Burner.

Force Pumps.—Among boiler-feeding arrangements for very small models the use of a hand pump in a tank alongside the line is the least satisfactory of devices which may be classified under the term usable. The connecting union is always hot and unmanageable just at the time when things require to be done smartly. The pump, therefore, should be placed on the engine even if the water capacity of the tank or tender is absurdly small. It is much easier to tip water into an open tank than couple up a pump on to a hot delivery pipe, and for these reasons the boiler-feed devices should be carried on the engine at the expense of almost any extra trouble the installation may involve.

Pumps are very varied in type, but the most successful are those having large valves arranged below the normal water level, i.e. "drowned" pumps. Two patterns are illustrated in Figs. 358 and 359. Both have single cup leather packings. Where the pumps are not submerged and have to lift their supply, double (reversed) leathers will be necessary. Ball valves on renewable knife-edged seats are provided. The valves are large and must be made of bronze. The seatings are screwed in, screwdriver slots being provided on their underfaces, the lift being restricted.

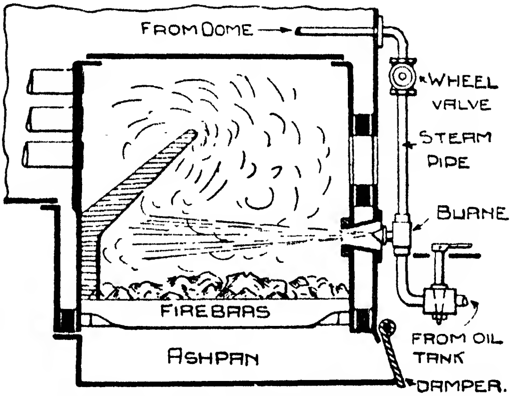


Fig. 363.—Spray System of Oil Burning.

The plunger pump is best used on smaller and unsprung engines, the lever pump being recommended for large models. This pump is illustrated as being fixed on a bedplate, which is studded on to the pierced bottom plate of the tender tank to provide for its easy removal. Further, the lever has a loose extension made of round rod, this projecting through a slot in the top of the tank. The lever type of pump may be as large as the tender will accommodate, the absolute limit to the plunger type being about $\frac{7}{16}$ in. bore, $\frac{3}{8}$ in. being a normally large size. The inside and outside delivery pipes are shown with a flanged connection, the usual rubber composition jointing material being employed to obtain water-tightness under pressure. The drawing of the spirit lamp tender (Fig. 353) shows a very satisfactory method of obtaining the necessary flexibility in feed pump delivery pipes between the engine and tender. The use of rubber and flexible metallic pipes should, as a rule, be avoided by the amateur mechanic.

Injectors. — When inch scale is reached the use of an injector should certainly be considered, and at least one good model injector is procurable ready made. Its success is, however, conditional on—

(a) Pipes of ample bore being used.

(b) A check valve which has a passage through it of greater area than the pipes and also a means of shutting it off from the boiler.

(c) The fixing of the injector below the lowest water level of the tank, so that water will flow through the injector naturally.

(d) A water-cock of full bore with a handle convenient to the driver for adjustment purposes (rule for adjustment is low steam pressure, less water, more steam, and vice versa for high steam pressure).

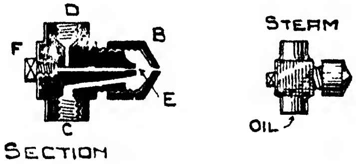


Fig. 364.—Details of Mr. C. Palmer's Spray Burner.

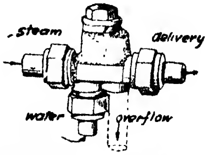


Fig. 365A.—Model Injector.

Fig. 365.—Raising Steam in a Coal-fired Locomotive Boiler with Footpump and Extension Chimney.

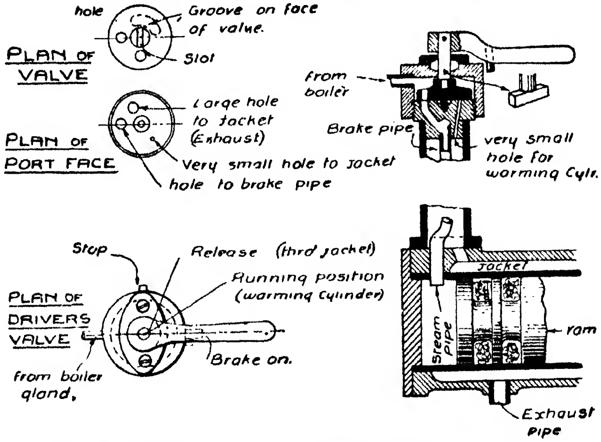


Fig. 366.—Driver's Valve and Piston for Steam Brake.

(e) Dry steam supply with screw-down valve.

(f) Efficient rubber connection between engine and tender. An air leakage here will certainly cause the injector to fail.

(g) Removable connections to tender to allow tank to be cleaned out periodically.

A design for an injector is illustrated in the author's book "Model Engineering." The injector shown by Fig. 365A is substantially the same, and is of the automatic restarting type. These have a valve which releases any pressure accumulating in the combining cone, a state of vacuum being necessary here. The pressure of the fluids is converted into velocity at this point.

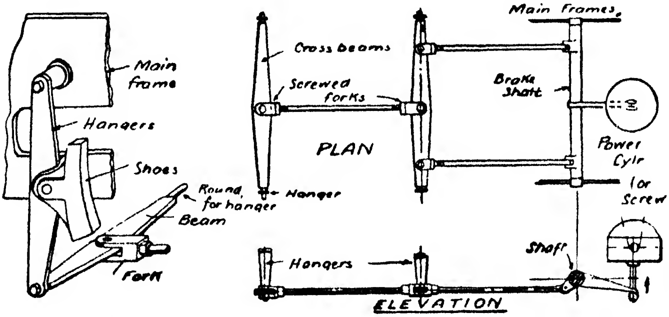


Fig. 367.—Arrangement of Brake Outriggers for Power (or Screw) Brake.

Axle-driven and Steam Pumps.—Axle-driven force pumps are not altogether successful devices on locomotives. If fitted, some means of ensuring their starting, usually a pet cock on the delivery pipe, must be provided. While this works quite well, it is often forgotten by the driver. Steam pumps are much more wasteful devices than injectors, as well as more complicated.

An engine which is large enough for an injector may have a hand force pump fitted as a "stand-by," but very large models should be provided with two injectors, both being maintained in working trim.

Pumps on Tank Locomotives.—Where the back bunker is employed entirely for liquid fuel the force pump may be placed in one of the side tanks. These may be proper water-carrying tanks cross-connected by a suitable pipe. Where it is not thought worth while to make the side tanks hold water the pump may be simply hidden by the tank and connected as illustrated in Fig. 360. This is a detail of the designs illustrated in Figs. 46 and 351.

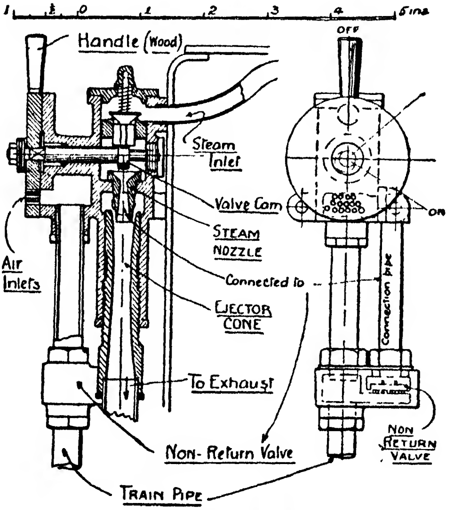


Fig. 368.—Author's Design for Model "Simple" Vacuum Brake Ejector and Driver's Valve.

Oil and Petrol Firing.—Just before the advent of the water-tube model locomotive boiler the use of the "Primus" oil burner saved many model engines with flue-tube boilers from what had been considered abject failure. The oil burner was afterwards applied to water-tube models in place of the usual spirit lamp. There was, of course, some economy in the cost of fuel and in the value of the fire by adopting this arrangement, but the author considers that the difficulties in the regulation of the fire and the lesser relative importance of the blast are against this scheme of firing. It works very well at an exhibition on short runs, but where the use of paraffin is resorted to, as providing the least dangerous fuel, the noise, smell, liability to sudden stoppage, high evaporation during inaction of the locomotive, and the pricking out of the burner nipple, which may be necessary at any moment, constitute grievous faults.

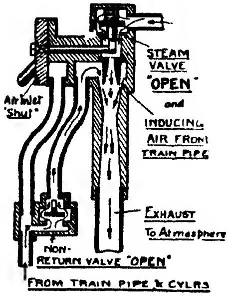


Fig. 369.—Non-return Valve Open.

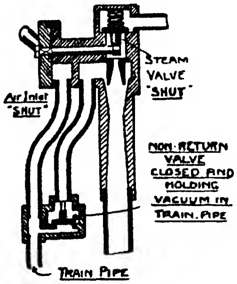


Fig. 370. — Non-return Valve Closed and Holding Vacuum in Train Pipe.

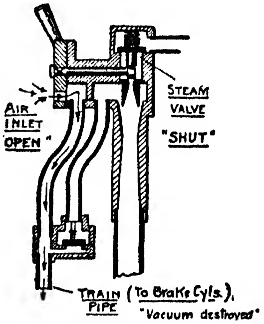


Fig. 371.—Steam Valve Shut and Air Inlet Open.

Of course, the inductive action of the exhaust is still necessary in a moderate degree. Water-tubes in the firebox of a flue-tube loco-type boiler are to be recommended in this instance, except, of course, where the engine may also be required to be run with solid fuel.

The application of a silent "Primus" burner to a model locomotive is shown in Fig. 361. The screw valve is necessary during the heating up of the burner. A special type of nearly silent burner designed for model locomotives is illustrated in Fig. 362.

The parts may be enumerated as follows:

VP Vaporising pipe (solid drawn copper).
B Body tube (solid drawn copper).
E Copper ends (brazed in).
BT Bunsen tube (brazed in).
N Nipple (Primus standard).
O Holes for flame.
N H Nipple holder (brass block).
S Shield (sheet metal).
UN Union to oil supply pipe.
P Deflector plate (optional).

The reservoir in the bunker or tender must be a strong airtight drum fitted with a filler, air-release valve, and non-return valve for attaching to a cycle. These are procurable "Primus"-stove parts. In a large model the pump can be placed within the oil container.

One of the full-size systems of oil firing, viz. Mr. James Holden's, G.E.R., involves the use of a steam oil-spray burner which injects oil on to the surface of a coal fire. A well-known model-maker (the late Mr. Charles Palmer, of New York) made a successful burner of this type, as shown in Figs. 363 and 364. The firebox plates should be protected from the direct action of the jet of oil spray, in large installations especially. For a small model this method of firing offers few, if any, advantages compensating for the extra mechanism it entails. The burner in question on a 1-in. scale model evaporated 6 cub. in. of water per minute from 460 sq. in. of heating surface with a consumption of .6 cub. in. of oil. The hole in the cap B was .02 in. and the jet E .01 in. The steam is introduced at D and the oil at C, the screw F being used for cleaning purposes. The cap B requires adjustment until the burner throws a fine clean spray. The oil should be filtered.

Steam is shown being raised by a footpump in Fig. 365.

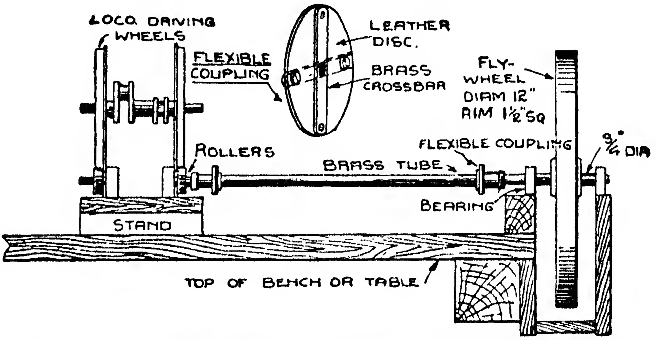


Fig. 372.—Mr. H. Lea's Design for Model Locomotive Testing Stand.

Brakes. — The arrangement of rigging brake blocks will depend on design. In model work it is not worth while introducing complicated compensating levers. If the brakes are much used the amount of wear and tear on the blocks and pins soon puts the relatively short levers out of gear. Blocks should be strongly hung from the main frames (see Fig. 333), and the cross rods tying the bottoms of the brake hangers should be flat beams with the ends turned to form pins. The forked ends of the rods should be pinned to the beams. For small passenger-carrying models steam brakes are practicable on the engine wheels, but as the main weight is behind the engine the retarding effect of the most powerful brake is small owing to the low percentage of weight which is braked. On tender engines from 7¼ in. to 15 in. gauge the most satisfactory brake is a foot brake on the tender with a moderately powerful steam brake on the engine.

A suitable steam control valve and piston is shown in Fig. 366. It may be applied to a brake-rigging in a similar manner to that shown in Fig. 367, which is a steam brake with a trip cock operated from the side of the line.

Vacuum Brake.—The most useful and the simplest power brake the author has employed for passenger-carrying models is the simple vacuum brake. The locomotive is fitted with an ejector and air-release valve worked by one handle. When it is desired to stop, the steam creates a vacuum in the train pipe. The train pipe can be easily connected to the vehicles in the train, each of which is fitted with a brake cylinder and blocks. The most satisfactory cylinder is one having its piston in the form of a circular rubber bellows. Care must be taken to see that the piping is properly coupled up before starting, otherwise an application of the brake would fail when wanted. Fig. 368 is a general view of the ejector as made for 9½-in. and 15-in. gauge models; the other three views are diagrams showing its action in the "brake on" (Fig. 369), "running" (Fig. 370), "brake holding" (Fig. 371), and the "brake released" positions of the driver's handle.

Testing Stands.—For testing small models a wooden frame which has rails for the carrying wheels and rollers for the coupled wheels is a useful bench fixture. The late Mr. Henry Lea, of Birmingham, used a device of this kind (see Fig. 372) with a heavy flywheel fitted to the spindle of the driving wheel rollers. This provided a load in start-

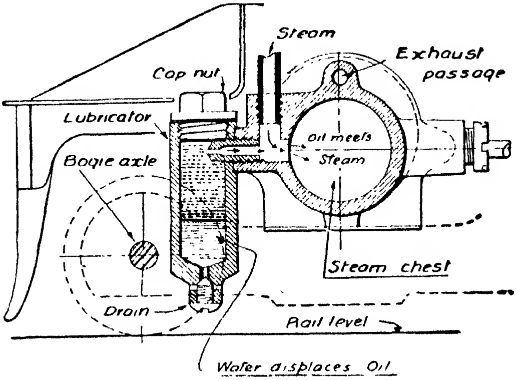


Fig. 373.—Small "Roscoe" Displacement Lubricator.

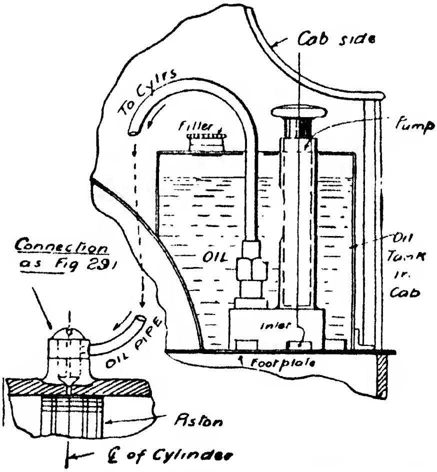


Fig. 374.—Simple Hand-operated Force-feed Lubricating Gear.

ing the locomotive, and caused it to act the same as when coupled to a heavy train. An adjustable brake may also be fitted to the roller spindles to allow the load on the locomotive to be varied.

Similar testing devices may be made to provide for engines of varying coupled wheel bases, the rollers other than those used under the driving axle being arranged on sliding bearing frames.

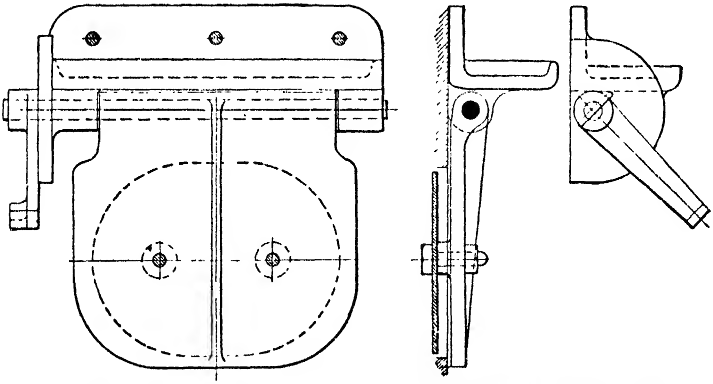


Fig. 375.—A Design for a Firedoor and Driver's Oil-can Tray.

Lubrication.—The lubrication of model locomotives is often fortuitous. The cylinders of all engines having a superheater should at least be provided with a "Roscoe" displacement lubricator (Fig. 373). Axle-boxes, etc., should have oil holes in any case, large models being fitted with trimming boxes above the footplate level. An oil-can tray over a firedoor is shown by Fig. 375.

Mechanical lubrication for slide valves and cylinders in its simplest form can be very easily rigged up by fitting in a convenient place in the cab an oil tank fitted with a small lever hand pump. This device will be found quite satisfactory for models up to 9½ in. gauge (see Fig. 374).

The oil pipes from either a Roscoe or a mechanical lubricator should fall all the way to the cylinder. This is absolutely important in the case of the displacement type, and advisable, to prevent air locks, in the other.

A Roscoe lubricator should be placed in a cool position, and at the same time its filling cap should be accessible. Where it is large enough a water drain is required at the bottom to get rid of the condensate which displaces the oil. The delivery hole at the top should not be too large. In a big model a needle valve may be added to regulate the size of this hole and consequently the flow of oil to the cylinder.

Fig. 376.—"The End of the Day": Tube Cleaning.

In his final paragraph the Author wishes to address a special observation to those readers who have been accustomed to using the ordinary methylated-spirit lamp for firing model water-tube boilers and who may consider that the solid-fuel loco-type boiler has been unduly favoured in this book. Prof. Simkinson has pointed out to the Author that the fumes emitted with the exhaust of an internally-fired spirit-burning engine are poisonous and form a compound known as "acetaldehyde." Discomfort, as well as expense, therefore, is present where this fuel is used indoors in such a way that it is not completely burnt, whereas there is little or no danger with the charcoal fire.

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