MODERN CHEMISTS
AND
THEIR WORK

PIONEERS OF PLENTY

MODERN CHEMISTS AND THEIR WORK

New Enlarged Edition

By CHRISTY BORTH

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To

EVANGELINE

FOREWORD

As THE first edition of *Pioneers of Plenty* rolled from the presses in September, 1939, the Old World raised the curtain for another grisly act of its ancient and interminable performance of the evil way of the plunderer. For two years Americans, preferring their uniquely American way of the peaceful producer, tried to avert their eyes from the disturbance which, beginning in Central Europe, spread steadily throughout the Old World.

Suddenly, as 1941 drew to a close, the evil leaped across the once vast but recently shrunken oceans and shook Americans awake. When that dreadful moment arrived, this book suddenly acquired new significance.

When the attack on Pearl Harbor occurred, the author was completing a series of investigations for the purpose of revising and expanding these stories of modern pioneering on the limitless horizons in the test tubes. For this new edition of a book which has retained its popularity despite the devastating torrent of current events, he had spent months on the trails of the pioneers, seeking to determine how far and how fast America's frontiers were being explored as, once again, Old World follies were forcing Americans to discover America.

His findings, set down as continuations of stories related before World War II began, provide hopeful answers for many of the questions which trouble the minds of Americans now that the hard facts of their involvement in war are making them sharply conscious of the destiny of their nation as a world leader.

THE PUBLISHERS

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Book Three

AMERICANS DISCOVER AMERICA

MODERN CHEMISTS
AND
THEIR WORK

Chapter I

CHEMURGY

1

Although the word that heads this chapter is not yet in your dictionary, it already affects your life far more than you realize. Because you are going to hear much more about it in the future, you should be introduced to it. However, because chemurgy touches your life at so many points and because it is less a new thing than a new way of looking at old things, it is not easy to introduce simply. Indeed, until only yesterday, I thought it could not be done simply at all. Then, visiting the office of Dr. Harry Everett Barnard, the fatherly and white-bearded but young-minded chemist who is technical director of the National Farm Chemurgic Council, I found on his desk a simple introduction to chemurgy:

Cheese—three one-pound heaps of it.

One pound was that familiar stuff called cottage cheese. If you are hungry, it is a finished product to you and the producer—a farm product with a ready market. If you already have all the cheese you want, that pound is a farm surplus. Unused, it becomes a loss to the producer and a waste to the community, a waste for which *you must pay*. You *must* pay for it because this pound of cheese, like everything that man produces, is merely a bundle of labor, and labor must be paid for either directly or indirectly. You cannot waste the cheese. If you bury it with the garbage you are merely returning it to the place from whence it came in the first place and from whence it will return again and again through the chemical processes of the earth and the sun and the wind and the rain. The only thing you can waste is the labor represented by the buried cheese. Fix this in your mind here and now: *The only thing you can waste is labor,* and *you can't dodge payment for that waste.* Plow the cheese under and you must pay for the wasted labor indirectly, through taxation or through increased costs of things you need or want. Export the cheese to a community whose people cannot afford to pay for the labor it represents, and you must pay the remainder of the cost whether you call the transaction charity or fool yourself by calling it export business.

Unless you want to go on paying for wasted labor disguised as cottage cheese that you cannot eat, you *must* consider that cheese not as finished product but as raw material that can be turned into something you *can* use; that is, you must add more labor to it to increase its value. By adding this labor, however, you do not add to the cost. On the contrary, you reduce the cost because you are now using the labor you would have wasted and paid for otherwise.

Now, what can you do with cottage cheese that you cannot eat?

Consider the second pound of cheese on Dr. Barnard's desk. You would never recognize it as cheese, for it's a blue and gray knitted winter sports suit composed of skirt, sweater and cap. It looks like wool, feels like wool, but is actually cottage cheese that has been put through a chemurgic process by dairy farmers, laboratory chemists and textile manufacturers who have co-operated to end the waste of labor.

That's chemurgy.

But that is by no means all of chemurgy's effect on your daily life. For, if you are not hungry for cheese and do not need clothing, the chemurgists offer a third sample. This one is cottage cheese disguised as a can of paint, a tube of glue, a stack of books and magazines of paper sized with casein, and a collection of things made of casein plastics, such as jewel cases, cigarette holders, bathroom tumblers, lamp shades, billiard balls, piano keys, buttons, etc., etc.

Consider the piano keys. Unless you were told that they came from the milk pail you would believe they were ivory and ebony. Basically, they *are* ivory and ebony. The sole difference lies in the manner in which they became piano keys. Ebony is the heartwood of a slow-growing jungle tree. Ivory is the tusk of the slow-growing jungle elephant. Nature intended neither of them for piano keys. Therefore both require years to produce and much labor to adapt to man's use. And, since they are found only in certain parts of the earth, all users of ebony and ivory are dependent upon the lucky people in whose back yards ebony and ivory happen to grow. Despite the fact that their ancestors signed a Declaration of Independence, the users of imported ebony and ivory are dependent until they can grow their own piano keys and everything else they need.

Grow their own piano keys? Exactly. Listen to Dr. Barnard. "What you see on this table," he says, "is not cheese at all—but grass. When a cow eats grass she converts it into beef and leather and cottage cheese. When a sheep eats grass one of the results is wool. An elephant turns the same mysterious stuff into ivory. So, when a chemist makes wool or ivory out of cottage cheese, he's merely processing grass."

From his desk the doctor pulled a toothbrush in a glasslike container and a wooden spool of silklike thread. "You might say these grew on trees," he said. "Or, you could say they're leaves of grass which, if you remember Walt Whitman's lines, can't be explained or defined."

I examined the doctor's "leaves of grass." The spool was wood. That was plain. The glasslike container was wood also. But that was not plain, for this thing had been made into its present form by chemical and mechanical processes that changed cellulose or wood-fiber into viscose or wood-syrup and hardened the stuff into something resembling glass. That glass is familiar to you as cellophane and photographic film. It also appears as rayon and celanese. Placed between two sheets of fused sand it makes safety glass out of the ordinary glass which it will one day replace. From this same stuff a German chemist recently made transparent cans for preserving and displaying fruits and vegetables in a nation seeking to end its dependence on foreign sources for tin and unable to afford the waste of labor in tinned iron cans rusting on rotting rubbish dumps.

The toothbrush was another plastic, resembling amber but probably cellulose. "Synthetic amber" neither defines nor describes it, for the word, *synthetic,* has come to mean *imitation* or *substitute* rather than *reconstruction of decomposed substances,* which it ought to mean. And, since amber is a yellowish fossilized vegetable resin, an accidental reconstruction of decomposed substances, and since this toothbrush is a deliberate reconstruction of decomposed vegetation, the description, "synthetic amber," is meaningless.

The bristles on the brush, like the silk on the spool, were made of that revolutionary "Fiber 66," which, perfected by du Pont chemists, is regarded as tremendously important to America. It means much to America's future independence because it is already replacing, as *Exton,* the hog bristles formerly imported from the Orient, and because it will undoubtedly replace, as *Nylon,* all imported natural silk to which it is superior in many ways. This fiber, I knew, could be made from many things, even from such unlikely things as cadaverine, the poison given off by putrefying flesh. But I knew also that it is now being made from coal, so I asked, "And these?"

Dr. Barnard was waiting for the question.

"Leaves of grass," he said. "Trees and grass and ferns that died millions of years ago, vegetation which decomposed, was buried and fossilized and is now being mined as coal for fuel, for dyes, for acids and alcohols, for aspirin tablets and fertilizer, for silk and hog bristles and horse hair, for millions of things. Should we run out of coal, we could use the same stuff now growing and rotting on the earth's surface. That's chemurgy."

That, essentially, is chemurgy, a program of correlated processes by which hitherto unused raw materials and wasted labor are put into productive and socially useful forms by the aid of those modern alchemists, the creative chemists who have lately been demonstrating that you *can* unscramble omelets, sink ducks and make silk purses out of sows' ears. (Scrambled eggs can be processed into plastic eggs sufficiently real to fool a hen. Chemist Arthur Dehon Little made a silk purse out of hog ears. Chemists Alphons Otto Jaeger and Coleman Caryl of American Cyanamid Company perfected Aerosol OT, a chemical which makes water so wet that ducks sink in it.)

Chemurgy is an organized attempt to create true wealth—that only *real* wealth which lies dormant and neglected in the powers of the soil and the air and the sun and the mighty minds of people—powers which, if directed intelligently, can be translated into "the more abundant life" for all the people (even "the forgotten man") in all the nations (even the "have-not" countries). It's a program progressing toward world peace down a pathway to permanent prosperity and economic independence. It is perhaps less a new thing than a new way of looking at old things.

2

Charles Franklin Kettering, who is General Motors Corporation's vice-president in charge of research and has been called "one of our most useful living scientists," likes to startle people by saying that we could know three times as much as we now know without learning one new thing. Ask him, "How?" and he explains that it could be done by looking at old and familiar things as if they were new and strange and by *using* the learning and experience we now have.

Dr. Barnard's reference to "leaves of grass" reminded me of a discussion in which "Boss Kett," as Mr. Kettering is known, demonstrated what happens when you look at old things in new ways. This famous "monkey-wrench scientist," who invented the automobile self-starter and perfected light-weight Diesel engines by looking at old facts as if they were new, was asked what we would do for motor fuel when the petroleum is all used up.

"I don't know," he said, "but I don't think we're going to sit around and twiddle our thumbs. I think maybe we'll run automobiles by radio by then."

Present was a practical person for whose common sense Boss Kett's remark was the occasion for the lifted eyebrow of doubt. Boss Kett caught the signal of unbelief, accepted it as a challenge and, fixing those sharply quizzical birdlike eyes of his on the skeptic, asked, "How do we run them now?"

"With gasoline," was the reply.

"Where do we get gasoline?"

"We distill it from petroleum."

"What is petroleum?"

"Oil that is in the earth."

"How did it get there?"

"Well," said the doubter, becoming uncomfortable now, "the chances are that it came from decaying plants and so forth."

"Where did the plants come from?"

"They grew."

"How did they grow?"

"The sun made them grow."

"So," said Boss Kett, "we're running them *now* by radio—by radiation of the sun, seasoned forty million years in the ground. Maybe we can learn how to pick up our sun-energy direct, instead of going along on that long-drawn-out process. I'm not worried about what we are going to do so long as the sun keeps on shining, because we can grow enough fuel. I'm sure we can grow all our fuel after a while because all of the fuel that we *have* has been grown."

That is an instance of how a familiar thing can look like a new thing when you batter it with questions. It's a demonstration of how a scientist weakens a tough problem, wearing it down to a size that mere man can tackle. Years ago, when Boss Kett, almost blinded by his studies at Ohio State University, had to rest his tired eyes and build up his body with a summer of digging postholes for a telephone company, he looked at a cornfield in a new way. Wondering why a corn plant could increase its weight three thousand times in less than a hundred days, he began to ask questions. Botanists told him that five per cent of the corn's increase came from the earth and that the other ninety-five per cent was "solidified solar energy." That, he said, was a definition, not an explanation, and he began to ask the question, "Why is grass green?"

He is still asking it. Because he has been asking it, scientists are now trying to discover why and how plants trap sun power and convert it into virtually everything on this earth, man included. Some of this research is being done at Harvard University under Chemist James Bryant Conant, Harvard's president. Some of it is being done by German-born Chemist Paul Wilhelm Karl Rothemund of the C. F. Kettering Foundation at Antioch College in Yellow Springs, Ohio. This attempt to find out how plants simply but mysteriously use sunshine to convert water and the carbon dioxide from our breath and our fires into the stuff of life is called chlorophyll and photosynthesis research, but the man who started it says it is nothing more nor less than the search for the answer to his old question: "Why is grass green?"

Though that question concerns the nature of one of the commonest things on this earth, nobody knows the answer. Perhaps nobody will ever know the answer, but that should not deter anyone from asking it. Nobody knows the answer to the simple questions Michael Faraday asked years ago; but, because that inquisitive man asked questions, we have been able to get millions of unexpected things out of coal tar and we have been able to make good use of electricity even though we don't know what electricity is. For that matter, cellulose, which we are using more widely every day, is a profound mystery to Dr. Wanda K. Farr, the William Boyce Thompson Research Institute chemist who is recognized as one of the world's foremost authorities on the subject.

Behind every phase of this thing called chemurgy is this baffling mystery of the leaves of grass—a mystery based on a trinity; the carbohydrates such as sugar and starch and cellulose that serve as the plants' building blocks; the lignins that cement the blocks together; and the proteins that direct the placement of the blocks. What are they? A chemist has said that "protein is a word which illy defines a large number of organic compounds containing nitrogen about which very little is known." Until recently, for instance, there was so little known about lignin that nobody knew what to do with this tough stuff in wood. Today, thanks to a chemurgist named William Horatio Mason, it is being used.

In Dr. Barnard's office I saw a box of tile squares in which lignin had been used. Hard as rock they were and brilliantly colored. Some were smooth as glass and some had satiny surfaces. Strangest of all of them was one that was tile on one end and a booklike arrangement of what resembled black blotting paper on the other end.

"What's this?" I asked.

"A new chemurgic product," said Dr. Barnard. "It's called *Benalite* and is made by the Masonite Corporation. Made of sawdust, bark, chips, twigs or anything woody, it may be used tomorrow as building material for houses."

"It looks like paper," I said, examining the unfinished section.

"You could call it paper," he said. "The sole difference between it and paper is that, in making paper, lignin is separated from cellulose and thrown away, and, in making this product, lignin is used to make paper into something as tough and hard as some metals."

Now this chemurgic product for which we have not yet found many uses touches the future of America in two ways that we should examine briefly here.

It is already raising the living standards in what was a poverty-stricken community before the process was developed. A few years ago, Laurel was a Mississippi ghost town in an area which had once been forest but which big lumbermen had turned into an ugly landscape of stumps and shacks, scrubby timber and beaten people. Today, as the Mason processes turn stumps and scrubby timber into useful things in the mills near Laurel, the shacks are being replaced by good homes and the people no longer look beaten.

Not long ago, Dr. Karl Taylor Compton, the chemurgist who is president of Massachusetts Institute of Technology, declared that one of the big jobs to be done before our country can become a permanent abode is the huge task of converting farm products to industrial use. He cited the plastic industry as one example of what may be done. Capable of indefinite expansion, the plastic industry, though growing rapidly, is still in the "gadget" era, with attention centered on use rather than source. While industrialists expand the use of plastics in the manufacture of small articles, a few organic chemists are delving into the chemistry of plastics, trying to remove the physical barriers which make costs of larger plastic articles prohibitive.

These difficulties are being removed. The Mason process in which whole wood is blasted by steam and squeezed by pressure into something having some qualities of metal lends weight to the prediction, recently made, that entire airplanes will be built of plastics. A few years ago, Henry Ford was ridiculed when he said the time would come when most of an automobile would be grown on the farm. Since then, Ford chemists have perfected processes whereby soy beans are converted into plastic substitutes for automobile parts formerly made of metal. Ford Chemist Russell Hudson McCarroll estimated that the use of plastics for interior window moldings alone would increase that company's use of farm-grown metal-substitutes twenty-five million pounds annually. This would decrease the annual requirement of sheet steel much more than the same amount.

So, it becomes plain that a process that has the immediate effect of raising living standards of farm people is putting us on the road toward organic substitutes for metals that man has been digging out of the earth and for the possession of which he has been bartering, battling and building empires.

That, too, is chemurgy—an attempt to put man on a pay-as-you-go basis in terms of raw materials by beginning *now,* before he *must,* the policy of living on his annual income of growing things and using less of the stored capital of mineral wealth that nature accumulated through millions of years.

As you should now be able to realize, chemurgy is not easily defined. Any attempt to introduce it simply and briefly is difficult—as difficult as trying to describe a rainbow to a man who has been blind from birth. Its potential effects are so vast that only a rash prophet would dare to predict the turns which history may take because of this recent acceptance of the fact that man is mastering at long last the art of converting base things into valuable things.

3

Chemurgy's first appearance in print was in 1934, in a book called *The Farm Chemurgic,* written by Dr. William Jay Hale, an organic chemist who is research consultant of the Dow Chemical Company of Midland, Michigan.

Dr. Hale explained that the word he had coined could be partly defined from its roots, "chemi" and "ergon."

"Ergon" was the Greek word for work. It gave us *erg,* the unit of work and energy used in physics. For "chemi" we are indebted to the ancients to whom Egypt was *Khem,* the Hebrew "Land of Ham." These names, according to Dr. John Read's *Prelude to Chemistry,* were derived from Egypt's hieroglyphic name, "Qemi" or "Chemi," meaning black, or black land, or country of the dark soil. As long ago as 3000 B. C., says Williams Haynes in *Men, Money and Molecules,* the Egyptians were skilled in arts based on chemical knowledge, such as metallurgy, dyeing, enameling, the making and tinting of glass and the extraction of plant oils. The chemical, ammonia, for instance, got its name from the Egyptian sun god, Ammon-Ra, the priests of whose temple in Libya had a chemical laboratory in which they turned the dung from the worshiping pilgrims' camels into "sacred" Salts of Ammon for the bleachers of Thebes. Chemurgist Haynes points out that mythologists might make something of the mystic link between a bleaching agent named for the sun god and the bleaching effect of the sun's rays. It was because of this Egyptian excellence in arts based on chemical knowledge that "the art of the dark country" came to be known as *chemistry* in English, *chimie* in French and *Chemie* in German. And, when the Egyptians' lore was carried into Islam as *al Khem,* the world got *alchemy,* that "black art" of the Middle Ages whereby man attempted, without success, the conversion of plentiful and base things into scarce and valuable things—an art which modern scientists are now mastering and applying to our daily lives as chemurgy. That word, *chemurgy,* was made by joining *chemi* and *ergon,* signifying "chemistry at work."

A scientist does not like to use an old word for a new thing or a new way of looking at an old thing. Old words are likely to be misleading because they suggest old habits. So Dr. Hale chose this new word to embrace *all* chemical manufacture. We were already using "metallurgy" for the chemical art of getting metals from ores. We were using "chemical manufacture" to specify operations in chemical synthesis. So, there being no word for the natural chemical operations by which soil, air, moisture, sunshine and micro-organisms become things which man can use, this new word was coined.

Dr. Hale is authority for the pronunciations: *Kem-urgy,* soft g, accent on the first syllable; and *kem-urgists* (similar to metallurgy and metallurgists). The adjective, chemurgic, he says, is *kem-urge-ic,* accent on *urge.*

The word began to appear in print fairly often after May, 1935, when some three hundred manufacturers, scientists and farmers met at Dearborn, Michigan, to try to act on Dr. Hale's suggestions.

Dr. Hale maintained that the American farm problem and the problem of unemployment in American cities are not *two* problems but two sides of *one* problem. One hundred years ago, he said, more than four-fifths of everything that man used came from farms. Then the Machine Age began, bringing ever greater demands for things which could stand great pressures and hard use, demands met by mining metals and minerals. The result was that farms gave way to mines to such an extent that now only one-third of everything man uses comes from farms. There, he said, you have the central clue to the farm problem. But, what of unemployment?

From the mines, he said, the same number of men could bring forth annually three to four times the tonnage they could produce from the farms. Now, since labor is the only thing which man can waste, the effect of this shift from farm to mine would seem to be desirable because it enabled man to produce more things with less labor. But labor is also wasted when it is available and not used. That variety of waste, called the problem of unemployment, has been increasing rapidly in industrialized nations in our time. This unique form of waste, said

Dr. Hale, was introduced by the shift from farm to mine. For, he said, although new machines created new industries and opened up new jobs, there were not enough new jobs for all the people released from work by the adjustment. And, he warned, unless we find new uses for the wasted labor of involuntarily idle hands, we need expect no release from the social unrest which manifests itself in explosive changes in government—which is merely the people's misdirected expression of dissatisfaction with the paradox of poverty amid plenty. Unless the problem of unemployment is solved, he said, society must face the increasing danger that troubled people shall become more and more willing to trade their dearly-bought liberty for a mere promise of security.

Well, what are you going to do about it? If it requires less labor to get more things from the mines than the farms, shall we seal up the mines and work harder for fewer things? Or shall we continue the process of providing more things with less work, destroy the surplus things, and tax the employed to pay the unemployed for not working? What *are* you going to do about it?

Such are the questions that politicians ask. And, because our vision is clouded by dust kicked up in the political arena, where conflicting ideologies and national ambitions clash, we *are* likely to believe that the problems can't be solved. But, unlike the politician, the scientist considers nothing impossible. "The secret of all who make discoveries is to look upon nothing as impossible," said that great German chemist, Justus von Liebig, who began to solve this very problem of ours as long ago as 1840, when he astonished his associates by turning his back on his nice clean laboratory to take up the dirty job of studying the action of manure on the growth of plants.

Because of von Liebig's odd behavior, this problem has been solved. Politicians may not know it, but chemists have long known that the greatest invention of modern times occurred in

1913, when Fritz Haber, the German chemist, perfected a simple process by which man could take from the air all the nitrogen required to produce an abundance of everything that grows.

It is typical of the politician's habits of thought that Fritz Haber's great gift was used first, not for human welfare, but for warfare. When the German politicians discovered that it was now possible to get endless supplies of nitrogen from the air, they thought first of nitrogen's use as an explosive for guns and ammunition. Ramming the great gift of this pioneer of plenty into their cannon, they launched the World War. The war destroyed more than forty million lives, wasted untold billions of dollars worth of *real* wealth—and ruined their own nation to such an extent that the unhappy German people finally sacrificed their liberty for the promises of security offered by another politician. The new politician ran true to form when he removed the great Fritz Haber from his university job because the chemist was said to be no "Aryan."

There you have an example of politicians' attempts to solve problems. Save for a few scientists, nobody seemed to realize the *real* meaning of Haber's discovery in 1913. And, although the Haber process has been in use now for more than twenty years all over the world, not many people realize even now that this process, providing unlimited means of making endless amounts of fertilizer for the soil, makes it possible for the farms to compete with the mines again and introduces the Chemical Age as the successor to the Machine Age.

From now on, says Dr. Hale, the things we need must be produced chemically because that is becoming the best way of producing them. With unlimited supplies of fertilizer, our acres of growing plants, trapping sunlight and turning it into chemicals, can give us everything we need. We do not have to go into the bowels of the earth for fossilized sunshine. We need not destroy one another with warfare because some nations happen to have fossilized sunlight and other nations have none. The stuff we need is being produced every day, right under our noses. It is produced in such huge amounts that it has given us that big problem which no human being would have dreamed of three hundred years ago—the farm surplus, or *too much food!*

Let's look at that farm surplus, not as food, but as chemicals, said Dr. Hale. Let's *use* it as food, clothing, shelter, transportation, communication, medicine and the thousand and one things we need and want and *must have.* Let's stop trying to grow less. Let's grow more and more until every acre is trapping sunshine and until every employable human being has a job and is adding the value of his labor to the things which nature provides so abundantly.

This, he said, is the *real* meaning of the Chemical Age that is upon us. The immediate mission of chemurgy, he added, is the education of man to search beyond the simple wonders already revealed and to explore the grandeur of Nature's intricate workmanship.

4

"It is surprisingly easy to persist . . . in overlooking the simply obvious," said the late Rev. Father Julius Arthur Nieuwland, the Notre Dame University chemist who perfected the method of making rubber out of coal, limestone and salt.

These words were spoken by him when the American Chemical Society awarded its William H. Nichols Medal to this unassuming, Belgian-born, Indiana-bred scientist-priest for his great gift to American independence. The words were uttered just a few days before those three hundred farmers, chemists and manufacturers assembled in Dearborn for the first chemurgic conference. It is typical of our habit of overlooking the obvious that our politicians and press either overlooked this conference entirely or dismissed it as merely another one of many wild schemes for "saving the farmer."

Out of that meeting grew the National Farm Chemurgic Council, an organization of farm leaders, scientists and industrialists, serving as a clearing house for chemurgic ideas. Working quietly, its influence has been great. Chemurgy is rapidly becoming a subject for study in an increasing number of schools, colleges, universities and among such study groups as are sponsored by the National Grange. Vast rural areas have been revitalized by new chemurgic industries, such as paper mills throughout the South, potato starch mills in New England, wood-waste recovery plants in Mississippi and the Pacific Northwest, and new factories for processing farm-derived food surpluses and crop wastes into the chemical bases of manufactured goods. Today there are more than thirty regional chemurgic councils devoted to study of problems peculiar to their areas. Their numbers increase rapidly. The movement has been studied and its methods have been applied in the Dominion of Canada. Famous British scientists, such as Sir Harold Hartley and Professor Lancelot Hogben, have studied its deeper implications; Sir Harold devoting the 1937 William Mather Lecture to a discussion of chemurgy, and Professor Hogben, the biologist and author of *Mathematics for the Million* and *Science for the Citizen,* referring to the significance of Dr. Hale's ideas in his famous Moncure Conway Memorial Lecture, "Retreat from Reason."

Chemurgy is obviously growing into a major force for plenty and peace in the world. It would seem then that the story of its origins should be worth telling. The telling would seem to be especially worth while right now, when so many of us daily cower under the nameless dread of what the next edition of the daily paper may hurl at us in bold-faced type. In such times we are likely to forget that the wise and kindly Louis Pasteur said, "What really leads us forward is a few scientific discoveries and their application." We are prone to overlook entirely the obvious significance of the encouraging fact that, when the children of France were recently polled for their selection of the greatest Frenchman of all times, they chose, not Napoleon Bonaparte, the probable choice of their fathers, but this humble, spotlight-shunning scientist, Louis Pasteur.

So, since there seem to be many good reasons for telling the story of chemurgy, I have attempted it. Because I am no scientist, I have had to ask many questions. Thus chemurgy's story became the stories of chemurgy's men-at-work, the pioneers of plenty, who, being questioners themselves, were infinitely patient when pestered with questions.

Some of their stories border on the fantastic. One such is the story of chemurgy's origin. It is the story of how an idea, bagged by a pair of organic chemists during a grouse hunt in Michigan's jack-pine plains, became a catalyst for concepts and changed the shape of events in scores of instances. That is largely the story of the mercurial-minded Dr. Billy Hale, the preacher's son, whose boyhood was so heavy with hints of his coming scientific career that adults referred to him as "that terrible Hale boy." His adult career as a prophet capable of calling his fantastic "shots" brought him the nickname, "Chemistry's Dizzy Dean." And, fantastic though it seems, his recent enthusiasm for chemurgy as a means to greater independence for all nations has caused some people to suspect him a Fascist and others to believe him a Socialist, name-calling substitutions for thinking which jovial Doctor Billy laughs off with his belly-bouncing chuckle.

It is also the story of Doctor Billy's crony, Dr. Charles Holmes Herty, soft-voiced Georgia gentleman who packed three great scientific careers into seventy years, and upon whose frail body Father Time, having had to wait while Doctor Charley finished his third career, dumped in ten brief days the life-corrosive effect of ten deferred years.

And it is the story of chemurgy's third pioneer, Francis Patrick Garvan, who should have been a politician but learned to think as a scientist thinks after the death of a pretty, blue-eyed child made a crusader of him. That is the most fantastic story of them all, for Garvan's career began and ended with a contest with those round-bodied microbic killers, the members of the coccus family. It began when the killers took his child, and it ended, just twenty years later, as the killers took him—took him at the very moment when the microbe-hunters whom he had helped were finding the weapon to fight the round-bodied microbes.

Chemurgy's story includes, also, the story of Dr. Leo Hendrik Baekeland, the pioneer of the plastic industry. And it takes in the story of Henry Ford, the self-educated tinker, who, confounding the super-educated thinkers, carried the Industrial Revolution to its peak with the greatest single unit of industrial centralization of all time, and who then set in motion the forces of industrial decentralization by fashioning with an Oriental bean some powerful new links between farm and factory.

Then there is the story of the scientist who was a slave, and of the nut that is not a nut, both of them coming to the United States through an interplay of forces set in motion by a Portuguese prince and a Peruvian plant-wizard—the story of peanuts and George Washington Carver, the Negro chemist, who was a chemurgist before Hale coined the word.

Chemurgy's story is the sum total of the stories of these men and others who, like them, have of late been bedeviled with the itch of curiosity. Just as, of old, it nettled those forgotten men, the red-skinned original Americans without whose magnificent plant-wizardry there would have been no *plenty* in which to *pioneer.*

Book One

CHEMURGY'S CRADLE-ROCKERS

Chapter II

CHEMURGY'S CROWDED STAGE

1

Swift is the current of events nowadays—so swirling swift that few current events have time to become events. In the competitive clash of ominous occasions and momentous moments, the obvious is often overlooked. In these desperately tangled times of ours, the official observers follow the easy course, fixing the focus on the gesturing and posturing in the political arena. So, entranced by the puppet-dance of egocentric saber-rattlers and bullheaded trouble-makers and money-muddlers and self-styled statesmen, we are likely to forget that political posturings are but belated and imperfect mirrorings of those significant simplicities which, though seldom spot-lighted, are the scorned commonplaces upon which history hinges.

Consider the crowded stage in that eventful week in May, 1935, when chemurgy climbed out of its cradle. Chief claimant for attention was the British Empire, mighty top-dog of the kennel that is Europe. Its power undisputed even in the then-potent League of Nations, Britain was dramatizing its might and majesty with a series of Royal Processions in London, celebrating the Silver Jubilee of King George V. Heading one procession was the popular heir to the throne, Edward, Prince of Wales, who was publicly lauded that week by the Archbishop of Canterbury. Heading another was popular Prime Minister Ramsay MacDonald, one of the foremost labor leaders of his time.

At that moment, Benito Mussolini was quietly moving fifty thousand black-shirted bully-boys into East Africa, a troop-movement that shortly shook Britain's might, shattered the League of Nations and changed the map of Europe. And, before many months had passed, King George was dead, the Archbishop of Canterbury hounded King Edward from the throne, and Ramsay MacDonald, jeered by British Labor, had gone into retirement to die, a disappointed man.

In the United States, infant chemurgy's small-voiced debut was drowned out by a cacophony in the political arena, a contrapuntal caterwauling by conservatives noisily confused about what they wanted to conserve and by liberals who were liberal mainly with their loud and low opinions of conservatives.

President Franklin D. Roosevelt had just received four billion dollars from Congress to spend as he pleased on relief and public works. Kicks came that week from such hitherto docile business groups as the National Association of Manufacturers and the United States Chamber of Commerce, and from the nation's press whose conservative organs clarioned, "Reform or recovery, which will you put first, Mr. President?"

Congress was wrangling over the payment of the bonus to World War veterans. The Supreme Court was pondering the fate of NRA. Roosevelt, opposed to the bonus payment, had just pleaded in his seventh radio fireside chat for the continuation of NRA. Within a month, the bonus payment was authorized and NRA was knocked out.

Automobile industry executives announced that their wages were at an "all-time peak." In Toledo, Edward F. McGrady, the United States Labor Department's trouble-shooter, was trying to mediate the first of the labor disputes which were shortly to rock that industry to its foundations.

Throughout the rural areas of the United States, hundreds of thousands of farmers were attending rallies and, dipping into the $742,000,000 received in benefits from AAA, were financing thousands of delegates who, a week later, began to pour into Washington to demand continuation of New Deal farm policies. In Michigan, Wisconsin and Minnesota, the American farmer's plight was highlighted by the beginning of the hegira of beaten farm families toward that "new frontier," the Matanuska Colony in Alaska.

Radio Corporation of America announced the creation of a million-dollar fund for television research. This, at a time when Americans, fishing in the crowded wave-bands for radio entertainment, were able to catch little save the microphone bellowings of such worthies as Senator Huey Pierce ("The Kingfish") Long and the Rev. Charles Edward Coughlin, a noisy pair who were then threatening to link their followers to those of Milo Reno, of the Farm Holiday Association, Dr. Francis E. Townsend, the bellwether of the indigent aged, and Upton Sinclair's EPIC movement. There was great alarm about the potential political power of this proposed union of "the lunatic fringe."

The general lunacy of the moment is measured by the fact that the chief activity of Americans that week was the attempt to acquire wealth by mailing dimes to one another. The Send-a-Dime chain-letter craze was sweeping the nation.

In Detroit, "Boss" Kettering stood before the members of the Michigan Patent Law Association and declared:

"The world is on the threshold of a mighty renaissance of invention. Inventive genius has been handicapped in the past by an almost total lack of knowledge of the properties of matter. As research develops a greater knowledge of fundamentals, we will be rewarded by inventions . . . beyond our wildest dreams."

And, in near-by Dearborn, on May 7, 1935, some three hundred men and a few women sat down to try to determine what "the inventive genius" of organic chemists, probing for "knowledge of the properties of matter," might be able to contribute here and now toward "the mighty renaissance of invention." Thus, chemurgy climbed out of the cradle.

2

That first Joint Conference of Agriculture, Industry and Science at Dearborn Inn produced none of the clamor and glamour that makes headlines. I know. I was there—hunting headlines. It was a conference without precedent. Present were no demagogic windbags, no wild-eyed visionaries, no fuglemen of the frustrated, no dragooners of discontent. There were no self-styled statesmen present, although the problems faced were exactly those which statesmen are usually called upon to face.

The conference was called by the late Francis Patrick Garvan, president of The Chemical Foundation, Inc. He had invited outstanding leaders of organic chemistry, research-minded industrialists, leaders of the nation's farm organizations and faculty members of colleges and universities to assemble and attempt to erase the shameful waste represented by America's idle acres and idle men.

That was the immediate aim. On the surface, it was not an occasion for drum-rumbles and bugle-shouts. Yet, considering how consistently business and political leaders had been fumbling all attempts to banish the waste of involuntarily idle labor on farms and in factories, it looked like a task for Titans.

The stated aims of the conferees were not grandiose. There was no talk of legislative panaceas. Nobody said, "There ought to be a law. . . ." The time for talk is past, they said. Now, let's see if we can *do* something about America's problem. They asked themselves what it would mean to America if the farm income could be restored to fifteen billion dollars annually, the former peak of farm prosperity. They decided that this would mean recovery, not only on farms, but in factories, for they had assembled statistics from the United States Departments of Agriculture and Labor proving conclusively that farm income and factory pay-roll totals rose and fell together. So here was statistical evidence that the problem of unemployment and the problem of farm surpluses were *one* problem—the problem of wasted labor. Therefore, when these totals fell to four billion dollars in 1932, it meant that Americans wasted at least eleven billion dollars' worth of labor in that year.

Now it was in 1932 that the people of the United States decided they had had enough of whatever it was that was causing them to waste the billions of dollars' worth of labor represented by millions of idle workers. And, thinking in political terms rather than scientifically, the people resorted to the time-worn political practice, "Turn the rascals out!" That political force rolled up Democratic majorities in all of the Farm Belt States, including normally Republican Iowa, the boyhood home of President Herbert Hoover, who was washed out of the White House by this flood tide.

Then when Franklin Delano Roosevelt became President of the United States, he picked Henry Agard Wallace, the Iowa farm-paper editor, as Secretary of Agriculture. This intelligent and warm-hearted man had devoted the major part of his life to helping farmers. He had inherited his devotion from his father, Henry Cantwell Wallace, who wore himself out trying to better the farmers' economic lot while *he* was Secretary of Agriculture in President Warren Gamaliel Harding's none-too-savory cabinet, and from his grandfather, the Rev. Henry Wallace, who advised President Theodore Roosevelt on agriculture and was beloved throughout Iowa as "Uncle Henry."

Henry A. Wallace was picked for this most difficult job in the New Deal administration because he was obviously the only living man capable of handling it. He was certain that the farm problem was the basic American problem. He felt that this problem arose from the fact that the United States is an industrial nation in which industrialists can keep prices up in bad times by cutting down their production, while farmers, who must buy the fixed-price products of the industrialists, are at the mercy of both climate and economic forces as far as *their* production and prices are concerned. So he set out to help farmers control their production by having the government pay them for not producing. It was a painful duty he assigned himself, for he was famous for having perfected one of the most prolific strains of corn ever developed, and now he was allotted the dirty job of reducing the abundance of corn for which he was largely responsible.

In 1933, Secretary Wallace sponsored the Agricultural Adjustment Act to help farmers keep the prices of their products up by cutting down their production. In that year, the people of the United States paid through the United States Treasury a total of $162,000,000 to the farmers of the United States for plowing under more than ten million acres of cotton and destroying more than six million hogs, and the farm income rose to $5,117,000,000. In the next year, the people paid the farmers $556,000,000 and farm income rose to $6,348,000,000. And, in 1935, the people's payments were $583,000,000 and the farm income was $7,090,000,000.

This sort of thing, said the conferees, might be good as an emergency measure, but it could not continue indefinitely, for, at bottom, it was an attempt to eliminate waste by increasing waste.

"In their attempts to rehabilitate the farmer," said Mr. Garvan, "politicians have proved again and again that their programs are based on the outworn economics of scarcity. This conference must try to solve, independently of governmental interference, the economic problems which government has demonstrated its inability to solve. Industry and agriculture, working together with science, must effect our economic salvation. There is no alternative."

What did the conference propose?

First of all, it planned to get Americans to stop thinking of farms as food factories. We must introduce Americans to chemurgy, said these men. We must tell them of the vast, but little known, progress of organic chemistry in recent years. We must show them why, because of this progress, the farms of America *must* become the source of more and more of the raw material used in industry.

To do that effectively, they added, we must survey the farm products which, through organic chemistry, can be turned into non-edible things that Americans want and need. We must find new frontiers for America in the chemist's test tubes. Then, as we begin to put idle acres to work profitably, we shall begin for America an orderly march toward permanent prosperity, a progression in which the increased buying power of the farmer will create increased demands for the things he buys from industry, and the increased demands on industry will create demands for labor.

That was the immediate aim. Beyond this vision of horizonless frontiers in test tubes was the broader vision of the conservation of America's natural resources which would result from the gradual shift of industry's raw-material dependence from the sub-surface *fixed* resources to the surface *flow* resources. Inherent in that broader vision, was the hope that the United States would thereby become an economically independent nation, making such a successful demonstration of economic self-dependence that other nations would strive to copy the pattern. The path to peace, said these planners, can be marked out by America. If Americans co-operate in the effort to translate America's potential plenty into "the more abundant life," the democratic principles for which America stands will not be endangered from within by the dissatisfaction of "the forgotten man." And, if America can thus perfect an attractive "design for living," the people of other nations will insist that their governments practice the policies of "live alone and like it" and "minding their own business."

3

Dearborn was selected as the conference site because it was the home of Henry Ford, an industrialist who had demonstrated his understanding of the meaning of the farm problem, and because there were, in near-by Edison Institute, working exhibits of the processing equipment which Ford researchers had developed to convert soy beans into some thirty industrial products. This industrial use of a food crop, which had then grown into a volume demanding increased crop production, was cited by Mr. Garvan as an example of how "agriculture may be wedded to industry with chemistry serving as the wedding ring."

Elected permanent chairman of the conference, Mr. Garvan pledged the full support and research facilities of the Chemical Foundation and the chemical industry, both of which he represented. He offered the assistance of chemical industry's research plants, its twenty thousand chemists and its eighteen years of experience in co-operative solution of problems.

Although, just a fortnight earlier, the American Chemical Society had celebrated the tercentenary of American chemistry, he pointed out that American leadership in chemical research and manufacture dated from the World War.

"The chemical industry," he said, "was all that the American people got out of the war. It was founded on the co-operation of *all* the American people and it comes here desirous to pay a part of its debt to the American people. It is determined to make itself worth the terrible expense of money and men that the war cost America."

Admitting that "we are a little bit nutty on the subject of co-operation," he described the causes of the co-operative spirit which, as many observers have pointed out, is the unique characteristic of chemical industry in the United States. Although, throughout the world, chemical manufacturers always have been a necessarily secretive lot, the American branch of the industry has ameliorated the fiercely competitive nature of the business by adopting a co-operative attitude which, he said, was directly attributable to its origins.

Before August, 1914, Germany held the key position in this industry, a position attained so quietly that its importance was not recognized by other nations until the opening of the World War shut off the world's supplies of dyes, drugs, fine chemicals, biological stains and other chemical necessities.

When Americans realized their dependence on Germany and tried to correct the condition, representatives of Germany reported to their government that Americans "could never establish the dye and pharmaceutical industry in this country" because Americans lacked "the moral power for the creation of such an industry," and because the "conflicting selfishness" of American business "would render impossible the solution of a problem that could only be solved through regard for all points of view."

Citing the German envoy's report to his government, Mr. Garvan added, "Under the leadership of President Woodrow Wilson and by his appeals to Congress and the people of the United States, the Chemical Foundation was set up as the forum of American ingenuity and character in the attempt to free us from that condition of servitude. We established that industry. But we did not do it ourselves. It was done by 120,000,000 American people. They made great sacrifices. They wore garments dyed with bad dyes. They accepted inferior drugs. They spent hundreds of millions of dollars in building up college laboratories to develop young men until today we have more than $300,000,000 of private and public funds invested in chemical laboratories.

"We met co-operation from the textile industry. We met co-operation from both parties in Congress as one administration was succeeded by another. It was co-operation that started us on our way. We come here as the beneficiaries of the type of co-operation which we are urging here as the keynote of the solution of the farm problem."

To prove that the chemurgic program was not a fantastic proposal, the conference discussions were confined to farm products already being used in industry. Among them were the following:

Soy Beans. The soy or soya is the only real bean developed by Eastern Hemisphere agriculture. Main crop in Manchuria and staple food and feed in China and Japan, it was brought to the United States about a hundred years ago and became an American farm crop largely through the efforts of a group of scientists at the University of Illinois. In 1934, some three million acres were devoted to the crop in the United States, mainly for forage and to a slight extent as human food. How this food staple may be converted into non-edible raw materials for industrial use was described by Ford Chemist Russell Hudson McCarroll. From the bean oil Ford chemists make a lacquer which is claimed to be superior to the pyroxylin paints usually used in coating metals. From the residue of meal after extraction of oil, Ford chemists make plastic parts for automobiles, these farm-derived parts being substitutes either for metals formerly mined or for rubber formerly imported.

Tung Trees. Tung oil, also known as Chinawood oil, is used extensively in paints and varnishes in the United States. Largely imported from China, it became a small item in American agriculture in 1907, when the plant-hunter, David Fairchild of the Department of Agriculture's Division of Foreign Plant Exploration and Introduction, distributed eight hundred Chinese tung trees to pioneer growers. B. F. Williamson of Gainesville, Florida, reported that an acre of tung trees produces four times as much oil as an acre of flax, that tung oil is preferable to linseed oil in paints and varnishes, that half of the linseed oil used in the United States is imported, and that, were American agriculture to attempt to replace this import, it would require 3,000,000 acres devoted to raising flax, or 750,000 acres of tung groves. He added that the United States already possessed 30,000 acres of tung trees, chiefly in Florida, and that all the growers needed to make the crop ready for market was efficient machinery for the extraction of the oil from the tung nuts.

CELLULOSE. In breaking down the structure of vegetation to derive cellulose, modern chemistry has virtually boxed the compass, coming around again to one of the fantastic goals of the alchemists—the transmutation of the base into the valuable. Since the World War, cellulose has found an increasingly widening circle of uses as raw material for film, rayon, celluloid, paints, explosives, leather substitutes, textile substitutes, etc., etc. This widening circle of uses was described as leading to the chemurgic possibility of using woody crops in their entirety as sources of cellulose supply, thus eliminating considerable waste. Cotton, for instance, which is almost pure cellulose, may ultimately be harvested and processed whole instead of being picked apart laboriously and expensively.

COTTON. In 1933, the final year of *real* prices for cotton, the United States exported 8,419,000 bales. In 1935, although world cotton consumption had *increased,* United States exports fell to 4,800,000 bales. There is no need to mourn the loss of our overseas cotton market, said Dr. Harry Everett Barnard, citing statistics which showed that, whereas America once furnished sixty per cent of the world's cotton, today we are growing less than forty per cent. "No sane man will buy cotton from us when he can supply his wants from a cheaper market," he said. As proof that new uses for cotton could be found in the United States, the chemurgists examined early reports of experiments in the use of cotton fabric in highway construction, and Mellon Institute's Dr. Edward Ray Weidlein's report on *Visking,* the cotton-derived substitute for imported casings for sausages.

SLASH PINE. The late Dr. Charles Holmes Herty of Savannah, Georgia, was undoubtedly the world's foremost authority on the chemical content of pine trees. To agriculture of the South he opened up the vista of profitable cultivation of the quick-growing southern pines, on cut-over land and abandoned cotton acreage, as raw material for the American paper industry and as a less laborious source of cellulose than cotton. These hitherto despised trees, he said, will ultimately furnish a domestic substitute for the sixty to seventy million dollars' worth of sulphite and sulphate pulp annually imported into the United States.

Sugars and Starches. New chemical uses for these products of vegetation were described and newer uses were predicted. Among the sugars discussed was levulose, the sweetest of them all, and most prolifically produced by the tuber of *Helianthus tuberosus,* the wild American sunroot which the American Indian cultivated as a staple food and the American farmer has long looked upon as a pestiferous weed. Containing no starch, this tuber is being grown increasingly widely in Nebraska and Kansas as food for diabetics and as a potentially prolific source of alcohol.

Power Alcohol. The introduction of this subject into the chemurgic program was the spark that produced its most stormy sessions. Described as "power sessions," they actually became struggles for power between two groups—the present suppliers of fossil power (petroleum), and the agricultural leaders who proposed that farms should again supply at least a part of the raw material that becomes artificial horse power in internal combustion engines. They were challenged at every step by representatives of the petroleum industry, but the conferees proved that, since blends of alcohol and gasoline are widely used in the United States and abroad, the sole remaining problem is production of power alcohol from farm products in sufficient volume to lower costs to a point where it can be used economically as fuel. Dr. Leo M. Christensen of Iowa State College, who devoted years to research in this field, pointed out that, though it may be deferred, the ultimate exhaustion of the world's petroleum resources must come. He recommended that the United States begin now on a program of conservation upon which it must embark eventually. "Alcohol," he said, "is not a substitute for gasoline. It is an ingredient of a superior fuel already in use. It competes with the several materials or processes employed to improve the qualities of gasoline. With this in mind, we can proceed to an economic analysis of the use of agricultural alcohol." If it were possible to produce sufficient alcohol from farm products to provide a ten-per-cent blend for the 17,000,000,000 gallons of gasoline used in 1934, he said, the farm surplus problem would be largely solved, for the 1,700,000,000 gallons of alcohol would take out of the market 700,000,000 bushels of corn, or 675,000,000 bushels of wheat, or 2,000,000,000 bushels of potatoes. "If agricultural alcohol becomes our future motor fuel," he said, "about 100,000,000 acres will be necessary to supply it."

At the close of that first conference, the foundations were laid for a continuing organization which would serve as a clearing house for suggestions and study of new American farm crops and new uses for old farm crops, an organization which later became the National Farm Chemurgic Council. Climbing out of its cradle onto a crowded world-stage in 1935, chemurgy grew lustily thereafter, attracting an increasing number of far-sighted men and women, and translating into action many of the plans which were little more than hopes when that first conference opened.

Today, a roll call of chemurgy's proponents would include thousands. Among them are men and women famous in such spheres of human activity as religion, agriculture, transportation, merchandising, medicine, manufacture, chemistry, physics, engineering, journalism, politics, insurance, etc., etc.

Although chemurgy is scarcely old enough to have made a dent in the plans of dictionary makers it has become a classroom subject in many schools in the United States. In 1937 a grant of a half million dollars was given by the Rackham Fund to Michigan State College for chemurgic research. In 1938, Congress, Secretary Wallace and President Roosevelt joined in endorsing the possibilities of such research when, in the reorganization of the Department of Agriculture, a new bureau, known as the Bureau of Agricultural Research and Technology, was set up as a clearing house for all projects devoted to finding new industrial uses for farm crops. In the same year there was included in the new Agricultural Adjustment Act a provision for four regional farm-industrial research laboratories, each staffed with about two hundred researchers and financed with a million dollars annually. These laboratories, supervised by Dr. Henry G. Knight, chief of the Bureau of Chemistry and Soils, were set up in Illinois, California, Louisiana and Pennsylvania to deal with crop-use problems.

In 1939, chemurgy had made such substantial progress that Roger Babson advised businessmen and investors to watch its development closely, and Ohio's Governor John William Bricker established a chemurgic commission as a part of the state's governmental machinery.

In that year also, construction began on the first newsprint mill designed to use the southern woods and the processes developed by Dr. Herty, and a foundation was set up to continue the Herty research program in Savannah, Georgia, after Dr. Herty's death.

It was the late Dr. Herty who revealed, on the night that the first conference closed, how chemurgy was fathered by the fertile imagination of his friend, Dr. William Jay Hale.

Chapter III

HALE—FATHER OF CHEMURGY

1

To scientists, Dr. William Jay Hale is one of the greatest living organic chemists. To more and more American farmers, Dr. Hale, "the greatest chemurgist of them all," is the embodiment of their hope that they, who are chiefly responsible for the abundance upon which "the more abundant life" directly rests, may themselves have a better share of that more abundant life in the future. To such British scholars as Professor Lancelot T. Hogben and Julian Huxley, Dr. Hale is one of the very few men capable of understanding why and how such recent technical changes as the replacement of traditional clothing and building materials by cellulose derivatives and synthetic plastics, and the vast increase in productivity of acres through the use of synthetic fertilizers, are making it possible for nations to live at home and not covet their neighbors' possessions.

By whatever yardstick you bring to the measurement, Dr. Hale is one of the world's great men. When you know the facts of his childhood, you realize that the world might have been robbed of this leader if his parents had been less tolerant.

Born in Ada, Ohio, on January 5, 1876, the son of the Reverend James Thomas Hale, Billy Hale was a scientist before he was dry behind the ears. The neighbors in the various Ohio towns in which the Reverend Mr. Hale "labored in the Lord's vineyard" did not call Billy a scientist. Unlike his parents, the neighbors did not understand that the thing they called "devil-try" was the surface expression of a young mind's curiosity about a thousand and one things. They didn't understand what Jesus meant when He said, "Unless ye become as little children . . ." or what the great Michael Faraday meant when he said, "I claim the privilege of speaking to juveniles as a juvenile myself." They did not realize that every great mind the human race has ever produced has been merely a normally inquisitive child-mind which resisted the attempt of adults to thwart its healthy curiosity. So these neighbors referred to young Billy as "that terrible Hale boy."

It was fortunate for Billy (and for the human race) that his parents did not share the neighbors' low opinion. But it must have been hard for these parents sometimes not to believe that the neighbors might be right after all; for, like the youthful Leonardo da Vinci, that fifteenth-century titan whose varied greatness man is just beginning to discover, this "terrible Hale boy" was curious about literally everything. He studied chemistry, physics, biology, anatomy, zoology, entomology, mathematics—and virtually memorized *Peck's Bad Boy.*

He and his brother experimented endlessly. Once they conducted a chemical experiment on the kitchen stove while their parents were in church. It was a success. It demolished the stove and blew a hole in the roof. Then there was an experiment in physics which, like the famous one of Galileo, had to be done at a height. The site selected was the highest point in town—the church steeple. To reach it, they had to crawl between the ceiling and the roof, and somehow or other a hole was punched in the ceiling. The debris was carefully swept up and the young physicists went away—hoping for the best. On the following Sunday they attended church services. They sat in the choir loft, lustily singing hymns, but concentrating on the laws of optics involved in the question, "Is that hole within range of Papa's eyes?" They learned the answer when Papa knelt down, saying, "Let us pray," and, casting his gaze toward

Heaven, began, "Oh, Lord . . ." paused—and repeated, "Oh Lord!" with a different tone of voice. When the prayer got under way, they went away from there—quietly but quickly.

And they learned about economics when they had to pay for the damages. That was where their knowledge of anatomy helped. It always helped when they had to pay for damage, which was pretty often.

The interest in anatomy began early, with mice. Billy discovered that a mouse skeleton, wired together and mounted on a pedestal, made a nice museum piece. The Hale zoo, containing a large collection of beasts and bugs, had always been a money-maker. So, reasoned Billy, since creatures die on occasion, why not add a museum? To get a skeleton, you boiled the dead creature until the flesh could be picked off the bones, which you then dried, polished, wired together and mounted. But you found that you couldn't keep the museum stocked because visitors were always buying the exhibits at a dollar each. So you established the Hale Skeleton Factory, Unincorporated and Unlimited. That "Unlimited" was an afterthought arising from the discovery that mouse skeletons were difficult things to assemble—much too difficult to be selling for a dollar. So the acquisition of anatomical knowledge broadened and deepened, and, in every town into which the Reverend Mr. Hale was "called" the cat population mysteriously declined and the bird population increased.

Then there was biology. It, too, was a sure-fire money-maker. The young biologists discovered that, after an owl devours and digests a mouse, the bird disgorges the mouse's fur coat. So the Hale owls went to work before audiences of other young scientists whose eagerness to acquire knowledge filled the Hale pockets with cash and things. To get the fur-disgorging business on a scientific basis, the young impresarios fastened strings to the owls' mouse-meals and thus helped them disgorge on demand.

From all of which it appears that the Hale attitude toward science was in accordance with the spirit of this modern age. It was practical science, the kind of science which the late great Thomas Henry Huxley praised when, at the opening of Mason College in Birmingham, England, he deplored the common habit of speaking of pure science and applied science as if they were two kinds of science.

Huxley pointed out that what people call "applied" science is nothing but the application of "pure" science to particular problems by putting into practice general principles established by reason and observation. It was "pure" science, for instance, when young Billy, the entomologist, discovered that bumble bees die when their stingers are yanked out but are not hurt in the least when the stinger-points are snipped off. It was "applied" science when, a bright May morning making school seem very unattractive, he filled his pocket with disarmed bees and quietly released them in a classroom which then became untenable.

It was a lesson in psychology that he received when he tried the experiment a second time. Because he was the sole undisturbed person in the room, the teacher became suspicious. Investigating, she found bees crawling from his pocket. "What's the meaning of this?" she demanded. "Oh, *these?*" said Billy, saucer-eyed with innocent astonishment. "These are my pets," he added, fondling a few of them. "That action," he recalls, "threw her off guard. For days afterward, she treated me as if she weren't quite sure whether I was a scamp or a young Saint Francis."

Chemistry finally won out over the other scientific interests, and his understanding parents sent him to Miami University in Oxford, Ohio. Graduating in 1897, he went to Harvard University for post-graduate study. After that he became a traveling fellow in chemistry at Berlin's Technische Hochschule and at the University of Göttingen, two of Germany's great scientific centers.

Back in the United States, he taught at the University of Chicago and then went to the University of Michigan in 1904 as instructor in chemistry, to rise to an associate professorship in 1915. Among the students who came into his orbit at the University of Michigan was young Russell Hudson McCarroll, who later became the chief chemical researcher in Henry Ford's soybean experiments of which we shall hear more later.

But the walls of his safe little associate professorship were too tight for him. At Göttingen, Professor-Doktor B. Tollens, whom the students affectionately called "der Kleiner Mann" ("the Little Man"), had planted in his mind that curiosity about the chemistry of growing plants which later became the driving force of his experiments and ideas. It was all very nice to be teaching chemistry, but did it mean anything? He wasn't sure that it did.

Originally, as we have seen, the scope of his scientific interest had been all-inclusive. As the boy grew older, the vastness of the scientific field became apparent and his interests had narrowed down, chemistry becoming the selected field of operations. But, just as he made that selection, the science of chemistry began to stretch. It burst its boundaries, refused to be held in the tight compartments called "inorganic" and "organic." The bulkhead separating mineral and metal from animal and vegetable wasn't as tight as it had been before Wöhler, the friend of von Liebig, had made urea from minerals without the aid of a kidney. It had become a screen, full of holes, as the great Germans bombarded it with a series of discoveries culminating in Fritz Haber's neat little trick of making air yield the fertilizer for which man had been combing the stables and pig-sties and outhouses for centuries.

Smart people, these Germans! But you could not say that out loud in 1915, for there was then growing in the United States a strong public feeling about the "right" side in the war in Europe.

That irked Billy Hale. He had acquired such a high regard for what German chemists were accomplishing that by following their work he had become one of the leading American authorities on organic chemistry. It seems preposterous today, but the field was then so devoid of specialists in the United States that, when he was invited to address the Rochester Section of the American Chemical Society on August 31, 1915, the program committee, having conducted a survey, notified him that he had better not speak after all because few of our chemists knew anything about organic chemistry.

It is not unlikely that the real reason for the canceled invitation was the fear that Hale might be indiscreet in his praise of German chemistry. Not that American chemists would object! They knew full well the price that America was paying for having allowed the Germans to dominate this field—a price we were paying in poor dyes and lack of vitally necessary drugs and medicines. No, the chemists were well aware that the Germans were great, but it was becoming unsafe to say so in public. You never can tell how newspapermen may turn a scientist's sober speech into a howling headline! So Hale's speech was canceled.

Six months later virtually every American knew what German chemistry had meant to him; knew it as dyed clothing faded under the sun and streaked in the rain; knew it as formerly cheap and easily obtainable drugs skyrocketed in price or disappeared entirely. And in July, 1916, doughty German Captain Paul L. Koenig became a hero in this country when he ducked under an iron band of patrolling Allied warships and popped up out of the sea off Norfolk with the super-submarine *Deutschland* carrying a million dollars' worth of sorely-needed chemicals. This gallant feat, which Koenig repeated in August with a ten-million-dollar cargo, illustrated both Germany's helplessness on the sea and America's helplessness in chemistry.

It was about this time that the late Dr. Herbert Henry Dow, founder of the Dow Chemical Company, visited his daughter, Helen, a student at the University of Michigan, and was introduced by her to Dr. Hale. In 1914, Dr. Dow, who had perfected an electrolytic process for extracting valuable chemicals from Midland's brine-wells, set up a plant to make chloroform by reacting sulphur chloride with carbon bisulphide and then treating the resultant carbon tetrachloride with iron in the presence of water. This is generally conceded to have been the first synthetic organic chemical process on a commercial scale in the United States. As the war wore on there arose a huge demand among the Allies for phenol (carbolic acid), chlorbenzene and other organic chemicals which the Germans had been making for the world, and the Dow plant's problems in organic chemistry increased. Dr. Dow discovered that this young professor's great curiosity had resulted in his having acquired some of the German chemists' secrets, and, before long, the drugs and chemicals once obtained only from the German cartel were being made in the United States. Hale's name will always be identified with American triumphs in the manufacture of phenol which, as we shall see later, played a potent part in the beginnings of the plastics industry.

In February, 1917, Helen Dow became Mrs. William J. Hale; and, on April 6, when President Woodrow Wilson issued a proclamation that "a state of war exists between the United States and the Imperial German Government," the career of Professor Hale ended as Dr. Hale became one of the co-operative chemists of Edgewood Arsenal, established at the Dow works to make war materials. Phenol production was stepped up to thirty tons a day. Magnesium metal, needed for the star shells that illuminated dirty death in the darkness of Western Front nights, was dragged out of the Midland brine. For more efficient murder in the mud, chlorine and alcohol and sulphur were combined to yield that dangerous liquid which chemists know and fear as di-chlor-di-ethyl-sulfide and which plain men call mustard gas, though it is not a gas and contains no mustard. The first American-made batch of this sinful stuff ready to reach the Western Front was made in the Dow plant. There's a scar on Dr. Hale's hand to remind him of how horribly it burns, and his memory is scarred with the remembrance of the companions it killed.

When, finally, the signing of the Armistice put an end to the apemen's misuse of the supermen's gifts, Billy Hale should have been jubilant. But there was no joy in that day for him, for he had just become a widower with a baby daughter. That daughter, Ruth Elizabeth, became the center of his world. Her picture hangs now just above his desk. Flanking it are the portraits of the late Dr. Charles Holmes Herty and the late Francis Patrick Garvan, the two men who, with Dr. Billy, were the cradle-rockers of chemurgy, which Hale fathered.

3

But, at the World War's end, chemurgy was not even a gleam in its father's eye. The time for its arrival had not come. Yet, though nobody knew it, the stage was being set for it. The forces, setting the stage and bringing Hale and Herty and Garvan together, were the arrival of the chemical industry in the United States during the war and the post-war emergence of that unique thing which has since acquired the name of the "American farm problem."

How chemurgy was born and named and provided with a driving force was revealed at the end of that first Dearborn conference, when the cradle-rockers, having launched their promising brain child on its career, confessed that it all began because of a grouse-hunting expedition.

"The actual beginning of this movement," said white-crested, soft-voiced Dr. Herty, "was in the sandhills of Michigan just above West Branch, where, ten years ago, Billy Hale and I were hunting. . . ."

In the fall of 1938, Michigan conservation officers were puzzled by photographs proving hunters' reports that certain ruffed grouse, considered the wariest of American game birds, had become so tame they allowed themselves to be handled. Remembering that these birds had once been so plentiful and so unafraid of man that early settlers had called them "fool hens," the conservation officers concluded that the photographed birds had reverted to type. People who knew about the grouse-hunting expeditions of holidaying chemists which sallied forth from Billy Hale's laboratory every fall after 1919 concluded that these birds had been tamed by contact with Hale's hunters who spent most of their time sitting around the campfire, listening to Dr. Billy.

That conclusion is not absurd if you know Hale. He's a disturbing fellow, disturbing to solidly fixed mental habit-patterns. Once, when I said I would interview him, a fellow reporter told me, "You don't interview Hale. He interviews *you!* He grabs your question, slaps a saddle on it and rides it hell-for-leather beyond your intellectual horizon, gaily kicking cosmic dust in your befuddled face. And, hours later, you get back to earth with your head full of visions and your note-pad empty."

To this roly-poly scientist with the merry eyes, time is not measured in seconds, minutes and hours, but in centuries, millennia and eons, and space encompasses a universe in which our solar system is a chemical brew bubbling in a retort. He has an uncanny flair for accurately predicting future events. He has called so many unlikely "shots" that a newspaperwoman, discovering his record for accurate prophecy and remembering George Herman ("Dizzy") Dean's record for "calling shots" in baseball, dubbed him "Chemistry's Dizzy Dean," a name which stuck.

The first of the fantastic grouse hunts occurred in 1919. The American chemical industry was then a feeble thing. America's top-flight chemists were a small band of men drawn together by the fact that most of them had been trained under the masters in the German universities. So, every fall, they had a reunion in the hills and swamps and jack-pine plains of mid-Michigan, where, completely outfitted as hunters, they sat around campfires and discussed chemistry.

"We took our relaxation in discussion of deeds of the outer workaday world," Dr. Hale says, but lets the truth out by adding, "particularly those exploits of the organic chemical synthesist in his rapidly expanding horizon. We chemists felt sincerely that the whole sphere of chemical activity had become distorted. What waste and destruction in the birth of coal tar! What frightful losses in breaking of seals to valuable hydrocarbon reservoirs! Surely an all-seeing Providence has provided man with better means of advancing chemically and in simpler fashion and with no depletion of resources."

From this you get an idea of the kind of hunting that was done. G. Lee Camp of Monsanto Chemical Company, St. Louis, Missouri, relates how he and Hale once sat on a log for at least an hour, talking with their guns stacked beside them, only to discover that a pair of grouse had been resting under the log during the conversation. No wonder the wary grouse grew bold! As guides and dogs snored beside silent guns the chemists gabbed about the penalty man must pay when, in the course of economic evolution, bottom is scraped in the reservoirs of mineral wealth from which the Machine Age draws its sustenance. But what can the chemists do about it? Nothing—at least not now, for they have their hands full of their own troubles at this moment.

Their chief problem at the time was the tough job of keeping the American organic chemical industry alive. It was a puny infant of an industry, a war-orphan born in 1917 when the United States Government seized the chemical formulas which the great Germans had cannily filed in the United States Patent Office for the protection of their tight monopoly—and had cannily garbled. Those formulas were being licensed through the Chemical Foundation for the benefit of the American chemical industry, but it was such a helpless weakling it could not stand the kind of kicking around it would get with the war over and the German chemical trust ready to rampage. The legislators in Washington were talking of lifting the embargo on German imports. The chemists knew that this meant the beginning of the end of American chemical independence. Having been trained in Germany, they knew all about the murderous tricks the German trust once employed to maintain the monopoly on what was called "the verboten industry."

Down in Washington, Francis P. Garvan, president of the Chemical Foundation, had just saved the young industry by turning his Irish oratory loose on Congress and getting a last-minute extension of the wartime embargo. But Garvan concluded from this experience with lawmakers that lobbying is not the way to get things done. It is no good talking to the public's servants, he said. You chemists will have to convince the public that your industry is the only thing the American people got out of the war. You must leave your laboratories, talk to plain people in plain language and ask them to help you make this industry worth the terrible expense of men and money which the war caused them to pay. You must make it clear to people that, with their co-operation, scientists can solve every problem of American life.

It was easy for Garvan to talk to the people. He was trained as a lawyer. He had an Irish gift of gab. But how was a chemist to approach the man-in-the-street and sell him on the value of chemical industry? What *is* chemical industry anyway? Can you put its meaning into plain language? Can you define it?

For the beginnings of chemistry you can go back to the myth-shrouded dawn of prehistory and point to the forgotten fire-finder. For the beginnings of industrial chemistry you can go to the Chinese gunpowder makers or to those Libyan priests who extracted bleaching salts out of camel-dung ashes. But for the beginnings of chemical industry, which is something vastly different from industrial chemistry, where do you start? It would have been hard in 1919 for even a chemist to decide where, for, at that time, the educational spade-work in this interesting field was yet to be done. That it was finally done, is a tribute to Garvan, as will appear later. Now that it has been done, it was possible for the editors of *Fortune* (December, 1937) to attribute the beginnings of chemical industry to Nicolas Leblanc, the French chemist who, wanting only to make money, made history. In 1791, he created in France a substitute for the alkali that French glassmakers had been getting from Spain until English armies cut off their supply. It was a significant event because it was the first deliberate transformation of one thing into another thing by scientific means for a practical end—the first chapter of the thrilling story of the modern alchemists who, having learned how to handle molecules as if they were toy building blocks, strive endlessly to abolish scarcity by turning useless things into useful things.

The story is fairly familiar today but it was virtually unknown in America in 1919. To make it known, Garvan launched an educational campaign, backed it with Chemical Foundation funds and by digging down into his own pocket. Dr. Edwin Emery Slosson had written some interesting articles about the industry in *The Independent* during the war. These were assembled and expanded into the book *Creative Chemis-*

try. The Foundation distributed 300,000 copies of this, the first of many post-war attempts to popularize science. And out of the laboratories of the new industry Garvan summoned the chemists who had been professors and could talk to the people. So Hale became a teacher again—a barn-storming teacher whose classes were civics clubs, chambers of commerce, luncheon clubs, women's clubs, farmers' societies, etc.

As a result a clause was inserted into the Fordney-McCumber Tariff Act to protect the American chemical industry from the growing German threat, and the act was passed by Congress.

This was the immediate effect of Garvan's attempt to save the industry which, he said, was all that America got out of participation in the World War. More far-reaching was its other effect—the bringing together of Hale, Herty and Garvan. For, in the friendship that developed between these three, the stage was set for chemurgy. That friendship began in the fall of 1921. You can orient the time in your mind if you recall that most of us were then concerned about such things as the growth of the Ku Klux Klan, the depletion of stocks of good liquor, the brevity of women's skirts, and the meaning of the Washington Conference for the Limitation of Armament. It was the year in which, on Armistice Day, some 150,000 persons in New York's Madison Square Garden and San Francisco's Plaza heard President Harding speak at Arlington National Cemetery over a device that came to be called "radio."

While these fleeting shadows brushed the horizons of ordinary folk, Hale and Herty talked beside the campfire near West Branch. Herty was then president of the American Chemical Society and had just completed a series of lectures in which he had warned against the economic folly of lending American money to bankrupt foreign nations to enable them to buy American goods. Hale was occupied on a process for getting phenol and aniline from chlorbenzene. He discussed his problems with Herty, the genial, silver-haired Georgian with the soft Dixie drawl, who, having begun his experiments in extracting alpha-cellulose from young southern pine, boldly claimed that the cellulose age would one day outstrip the coal-tar age in chemical prominence. Someday, Herty insisted, the secrets of the chemical structures of carbohydrates in vegetation will be revealed. Then the day of man's dependence on the hydrocarbons of the fixed natural resources will be done. The knowledge of these structures was beginning to unfold in Herty's mind. He was discovering the majestic mystery of the molecular architecture of trees, and, as discoverers must, he *had* to talk about it. Quiet talk it was, but persuasive. Like the talk of lovers and converts, it set minds on fire. And Hale, the younger man, listened and began to feel a deep affection for this soft-voiced little Georgian. Then and there, the two of them agreed that they would meet each autumn to hunt grouse. Herty called the birds *partridge,* but it wasn't important. Grouse or partridge, the birds were unmolested; for, when chemist meets chemist, they talk—about chemistry.

So, every fall, Hale and Herty met in Midland and, assembling guides and guns and dogs, sallied forth to discuss problems, exchange ideas and chart plans.

Chapter IV

HALE AND HERTY HUNT

1

The jack-pine plain was wet. The leaden sky, bellying down, was heavy with the promise of more rain. Beside a barn stood a combine, neglected, rain-streaked, rusting. Hale and Herty, hunting again, spied it.

"Why should a farmer own a combine?" asked Herty. "He uses it only a few days a year."

"Why shouldn't ten farmers own a hearse?" asked Hale. "That would be just as sound economically."

This conversation was the genesis of chemurgy.

It happened in the fall of 1924. Hale had embarked on research into methods for making simple aliphatic acid from fermentable carbohydrates. Herty was probing deeper into the mysteries of cellulose. Both now knew what they wanted. They were beginning to see that the kind of chemistry in which they were pioneering would create demands for increasingly vast amounts of vegetation. Herty wanted a prolific source of cellulose. His mind was toying with visions of Georgia's piny woods, wondering if the quick-growing pines were not a better source of cellulose than the cotton which was produced so laboriously on southern acres. In the back of Hale's mind was an idea of a method for getting the price of acetic acid down low enough to enable him to produce cheaply the chemical reagents which, now expensive, were needed in large quantities in the making of plastics.

So, here were these two dreamers, staring at a combine rusting in the rain, wondering where and how to get cheap alcohol and cheap cellulose—wondering until a pair of foolish questions began a conversation which became a discussion of American farming. The exact words of that conversation are lost, but its general trend is remembered. As Hale recalls it, the talk was about farming, past, present and future. The two men saw that the farm problem would soon emerge as the major American problem. "The time was ripe for some sort of presentation calling a halt to our illogical provisioning of the world with foods and cotton fiber," he says. "We knew that increased buying from abroad took its origin solely in easy money loaned to various nations by our banks. Sooner or later, we knew, these nations must regain their own capacity to produce, and our nation must suffer when this happened."

As a result of this conversation, Herty wrote magazine articles in scientific journals, warning of the farm debacle and the financial collapse that would come when Europe would stop borrowing our money to buy our goods. And Hale, a full-fledged after-dinner speaker, began to build a reputation as a prophet.

He sensed the fact that those cheap chemicals he needed would be abundantly available when, very soon now, Europe would stop taking our farm products, and farm surpluses would begin to pile up in the United States. He was trying to think of ways and means whereby these surpluses could be dovetailed into chemical industry's growing needs for cheap chemicals.

He was thinking about these things as he sat in a hotel lobby in Charlotte, North Carolina, the following April. He was also thinking about alcohol because he had just read a report of some European experiments in chemical synthesis. In Germany, Dr. Friedrich Bergius had squeezed a gasoline substitute out of coal by making hydrogen molecules perform like a regiment of guardsmen. In France, General Georges Patart's crew of chemists had just made "wood" alcohol without wood. The Frenchmen had applied heat and pressure to carbon monoxide and hydrogen until the component molecules behaved as the chemists ordered, and the result had been methanol.

A newspaper reporter, seeking advice on the Patart process and its significance, sought out Dr. Hale and asked him about this woodless "wood" alcohol. Is it true that the French intend to use this stuff in place of gasoline? It is possible, said Hale, explaining that the time would come when chemists would know enough about the structure of coal and wood to enable man to make all the motor fuel he might need. To help the reporter dramatize his story, he portrayed a future in which American farmers would feed their tractors and automobiles out of the corncrib and the oatbin.

The story was published and Hale's reputation as a prophet grew. Shortly thereafter, he faced that relatively novel thing, the microphone. It was in Washington's Station WCAP. He was then a member of the National Research Council, and, as "one of the great living organic chemists in America," he had been asked to provide the "Prophecy of a Chemist" for a series of "Radio Talks on Science," co-sponsored by the Council and Science Service.

Since the prophecies were later embalmed in print (*Scientific Monthly,* February, 1926), their accuracy can now be tested.

He predicted that highways and airways would soon become serious competitors of the railways; that motorbus and truck lines and automobiles would compete for the railroads' short-haul business; that air-transport lines, using all-metal planes, would become competitors for their long-haul business, and that steam locomotives would be replaced by electrified types. There were then only 31,146 miles of rural concrete highways in the United States. There are more than 3,000,000 now. Motorbuses, then virtually non-existent, carried 3,441,000,000 passengers in 1937. Interstate and intrastate trucking business, then unknown also, operated 188,809 vehicles in 1935. From 1925 to 1937, United States motor vehicle registration rose from 19,000,000 to 29,000,000. In 1925 airplanes were flimsy things. Later, Henry Ford produced Engineer William Bushnell Stout's all-metal, tri-motored "Tin Goose" in quantity, and the National Air Transport Corporation was formed in Detroit, thus beginning what became the world's greatest network of scheduled air transportation. In 1925, United States railroads carried 900,000,000 passengers and almost 2,500,000,000 tons of freight; in 1937 they carried 499,000,000 passengers and less than 2,000,000,000 tons of freight. And, fighting desperately to continue in business, the railroads are now turning to Diesel-electric and turbo-electric locomotives.

Commenting on the meaning of the Patart process of alcohol synthesis, Hale predicted that alcohol would be blended with gasoline to provide more efficient fuel for motors with higher compression. In the early 1920's, higher compression ratios in automobile engines produced a problem which was first called "spark knock." "Boss" Kettering and his associates, Thomas Midgley, Jr., and T. A. Boyd, discovered that it was a fuel knock, tried to eliminate it by adding hundreds of chemicals to gasoline, finally hitting upon tetraethyl lead. But the stuff cost $585 a pound and was so poisonous that it killed five Standard Oil employees. Then, through the addition of Dow-produced ethylene dibromide, the poisonous feature was brought under control. When Dow chemists perfected methods of extracting bromine inexpensively from sea water in 1933, ethyl gasoline became so common that about seventy per cent of all gasoline now sold contains tetraethyl lead.

He predicted that airplanes would become the strongest arm of military combat and that Germany would demonstrate it. This was thirteen years before the "Peace of Munich," when the world suddenly became aware of German might in the air.

And he stated clearly how and why America would shortly run head-on into its major problem—the surplus of farm crops. Until 1900, he said, American agriculture's commodities were largely exchanged for European industry's finished goods, an exchange that did not penalize our waste because the things we got from Europe were produced by cheap labor. Now, however, he said, we have become an industrial nation, with an increasing wage rate for labor and, therefore, an increasing need for waste-elimination in manufacturing processes. And, as industry is forced to cut manufacturing costs, he added, the blow falls first and most severely on the suppliers of raw material—the mines and the farms. Therefore, he concluded, farmers *must* adopt industry's methods of cutting production costs—*must* eliminate wasted labor by co-operative purchasing, marketing and storage, and by scientific management of large groups of farms.

Here was the first public statement of the ideas born on that day when Hale, prompted by the sight of a rusting combine, conceived a vision of American agriculture and industry serving each other through organic chemistry. The vision was beginning to take form now. He could see the trends shaping themselves. He observed that fifteen per cent of the 1924 crop of 3,000,000,000 bushels of corn had gone into factories instead of stomachs, and he predicted that the day would come when fifty per cent would go to industry, which would return the by-products to the farms for fattening stock. Moreover, he added, we shall raise oats for the hulls and use the kernel as a by-product in cereal manufacture.

It must have sounded ridiculous to his listeners that night. But, *was* it? Let's check it.

We now know how the World War changed the interdependence of America and Europe. Before 1914, the interdependence was decreasing, although Europe still took nearly two-thirds of United States exports. When Europe's millions of hands were suddenly switched from production to destruction, our dependence on Europe ended and Europe's dependence on America increased. Our exports to Europe expanded three hundred per cent in 1915 and 1916. Then millions of American hands were switched from production to destruction and the United States productive structure was rapidly shifted onto a labor-saving basis. During these years Europe's wartime demands for America's carbohydrate and cellulose crops was as abnormal as it had been a century before during the Napoleonic Wars. In 1819, American farmers faced huge surpluses of food, wool and cotton when the Napoleonic destruction ended and Europe's hands began to produce. But *that* farm problem was not serious, for the interdependence of Europe and America was still increasing.

In the intervening hundred years, however, the relation of America and Europe changed, slowly until 1914, rapidly thereafter. By 1919, we needed little from Europe but Europe needed much from us. But Europe was bankrupt. So, as Hale and Herty were trying to tell us in lectures and magazine articles in the 1920's, America *gave* its surplus products to Europe, financiers disguising the gift as a *sale* by loaning the bankrupt *buyers* American credit to enable them to obtain American goods.

The result of this, Hale predicted in 1925, would be a depression that would be a cataclysm to agriculture.

We now know that America's fictitious export business ended when foreign nations recovered their ability to fill their needs. The day of reckoning for United States farming and finance approached as French bakeries no longer needed the Dakotas' wheat, and Iowa's pigs were no longer needed to grease German skillets. Simultaneously, the finance fiction collapsed and surpluses piled up. Today Europe takes only forty per cent of United States exports; and, says Hale, the interdependence *must* continue to decrease save during time of war, which adds destruction to nonproduction.

Now, what of his other predictions? In recent years the co-operative idea has seized the imagination of increasing numbers of American farmers, and farm management from centralized control offices has become fact in the upper Mississippi and Missouri River valleys and, in its most efficient form, in California.

How about that prediction regarding corn in industry?

According to Morris Sayre, vice-president of Corn Products Refining Co., the annual corn-grind of more than 80,000,000 bushels between 1926 and 1929 went mainly into starch, syrup and sugar, with oil and feed as by-products. Of these, the major product was starch, destined not for food but for cotton textiles, paper boxes, soap, perfumes, fireworks, asbestos, coal briquettes, yeast manufacture, window shades, twine and cordage, wood-veneer glue, dry-cell batteries, etc.

And what about the oat hulls?

A compound known as furfural was accidentally prepared from oat hulls when chemists were trying to increase the digestibility of oats as cattle feed. After they found furfural, they didn't know what to do with it. They tried to keep it in wooden containers but it got out—through the wood. In 1922 it was a laboratory curiosity worth six dollars and fifty cents a pound but useless. By 1926 the price had dropped to fifteen cents and it was still a curiosity. Today it is bought in tank car lots and used as a germicide, a fungicide, a wood preservative, an improver of tobacco flavor, a solvent for dyes and leather dressings, plastics and nitrocellulose, and an important chemical in the refining of lubricating oil. The Quaker Oats Company, of Cedar Rapids, Iowa, is now at times forced to operate primarily for oat hulls as raw material for furfural, leaving the production of oatmeal as of secondary consideration. Only yesterday, Dr.

Hans F. Winterkorn, research associate in soils at Missouri State College of Agriculture, discovered that this peculiar oil-like non-oil provides a durable and waterproof road-base when it is blended with soap, salt, lime, farm wastes and native soil. Dr. Winterkorn believes that his experiments, designed to improve Missouri's side roads where native stone and gravel are not available, may lead to vast changes in the base construction of the more expensive paved highways.

Setting Dr. Hale's predictions beside a list of events that have occurred since they were uttered, it is easy to understand why that newspaperwoman's sobriquet, "Chemistry's Dizzy Dean," stuck to him.

2

But this was midseason in that decade, the Turbulent 'Twenties, when profits spoke louder than prophets. As a voice crying in the wilderness, Hale had an attentive audience—in the wilderness near West Branch. The holidaying chemists heeded, but the workaday world had ears only for the sweet music of the big "boom-boom" of Big Business drumming for bigger business.

As the first half of that decade slipped off the calendar of current events into the wastebasket of history, Hale was hunting—a publisher. He had written an article defining farming as "simply organic chemical manufacture." He submitted it to every national magazine he could think of. The title of the article was "Farming Must Become a Chemical Industry." Apparently the editors didn't think so, for the manuscript bounced back to his desk in Midland.

Perhaps the editors thought that plain readers wouldn't be interested in the significance of the shift of chemical emphasis from coal tar to cellulose. Perhaps they suspected the sanity of a man who dared say that organic chemists are tearing open the door to nature's secrets and will soon excel nature in the production of molecular complexities. Or perhaps it was Hale's flair for prophecy that caused them to reach for the rejection slips. Indeed, it *must* have been a severe test on an editor's credulity to read, in 1926, an author's deduction that organic chemistry holds the only promise of a solution for that hardy political perennial, the farm problem. It *must* have seemed far-fetched then to read Hale's scornful dismissal of all attempts to solve this problem by marketing exports abroad; for this was the time when Secretary of the Treasury Andrew Mellon was justifying foreign debt adjustments with the remark: "Europe cannot continue to be a great consumer unless it be restored to health," and Congress was creating the Foreign Trade Service to help Secretary of Commerce Herbert Hoover sell American goods abroad.

But what probably made that manuscript bounce back to Midland was Hale's bold declaration that "we shall be importing large quantities of grain in ten years."

Even now, when America's major problem hinges so obviously on huge grain surpluses, this prophecy seems fantastic. That is, it seems fantastic until you remember that, between 1932 and 1937, when we were destroying 6,000,000 hogs, 2,000,000 sheep, 1,000,000 cattle and the productive potential of more than 36,000,000 acres, our annual imports of corn rose from 347,000 to 88,000,000 bushels and our annual corn-on-the-hoof imports rose from 48,000,000 to 191,000,000 pounds.

Finally, after Hale had about abandoned hope of ever finding a publisher, someone suggested that Henry Ford might be interested in reading the article. So off to Dearborn it went. Back came a reply—by telegram! May we publish this immediately in *The Dearborn Independent?* Would two hundred dollars be satisfactory payment? Yes and yes, Hale replied to these queries from Editor William John Cameron, the man who has since become famous for his Ford Sunday Evening

Hour radio talks. And, on October 2, 1926, the first organized presentation of the idea that became chemurgy appeared in print.

Then things began to happen. Within a week, readers' requests for additional copies began to arrive in Cameron's office. Within a fortnight the requests had become a flood. Extra copies were printed in leaflet form, but the flood mounted. Then the Chemical Foundation took over the job of complying with the requests and quickly exhausted a press-run of 500,000 copies.

"That was the beginning of this movement," said Dr. Herty on the May night in 1935. "What the outcome will be, perhaps only the great vision of Billy Hale can comprehend."

Concluding his generous tribute to his young colleague, Dr. Herty said:

"I remember well how Billy was derided when he first put forward his views. It is interesting to note that his ideas were accepted and published first in this very community where we are now meeting; that the four of us who were in on the start of this matter should all be present now; and that the first man to give the idea editorial endorsement was the man at the head of this table."

It is a matter of historic interest that Dr. Herty's "man at the head of this table" was Wheeler McMillen, an editor who would have leaped at the opportunity to publish Hale's article in 1926 because he was then reaching conclusions similiar to those of Hale. It is an odd fact that McMillen, who neither knew nor was known by Hale, was born and reared on a farm just outside Ada, Ohio, Hale's birthplace.

In 1926, McMillen was associate editor of *Farm and Fireside*. He had tackled farm journalism after a career of journalism in Cincinnati, Ohio, and Covington, Indiana, and four years of farming in Hardin County, Ohio. In his four years as associate editor, the suspicion had grown in his mind that the need for a new kind of farm journalism was arising in the United States. Heretofore, big farm journals had made a success of the formula of telling the farmer how to grow bigger and better crops. McMillen deemed that old formula silly. It was obvious to him that the American farmer's problem was now arising out of the unique fact of plenty. The trouble, as he saw it, was that farmers were growing things too well and too abundantly for the markets open to them.

Here, he said, is a new problem, a problem without precedent in human history, the astounding problem of too many mouthfuls and too few mouths! He suspected that the solution of this strange problem would not be easy, but he tackled it. He traveled extensively, talking to farmers, interviewing farm leaders and legislators, analyzing the many panaceas for "farm relief." But the solution eluded him until he heard a businessman sum up a discussion of the wheat surplus with the remark, "Unfortunately, the human stomach isn't elastic."

He was thinking about that remark when he came across a report of an Iowa chemist's efforts to make paper out of straw and cornstalks. Then a startling idea struck him. Maybe, he said, the scientist is a better Santa Claus for the farmer than the politician is. Maybe the answer to this problem is the development of non-food uses for farm products. Yes, that looks like the solution; for, though the consumption of food is definitely limited by the easily satisfied appetite for it, the non-food appetites of man are limited only by purchasing power. Yes, *that* looks like the answer, said McMillen, reaching for paper and pencil and putting the ideas together for an editorial for the issue of October, 1926.

Thus, simultaneously, the chemurgic idea appeared in print in two places. The sole difference between the two treatments was that of approach: Hale thought of raw materials for industry, and McMillen thought of non-food uses for farm products.

The result was that McMillen met Hale in Washington and was introduced to Herty. Herty told him of his experiments in cellulose chemistry and fired him with an enthusiasm that sent him into the laboratory of every scientist who might have something to contribute to the idea. In the January, 1927, issue of *Farm and Fireside,* he assembled the scientists' suggestions into an article, "Wanted: Machines to Eat Up Our Crop Surpluses," which also produced such an astonishing reader demand for extra copies that the Crowell Publishing Company had to reprint it in leaflet form.

Subsequently, McMillen incorporated these ideas in the book, *Too Many Farmers,* which did not receive the attention it deserved because it was published in that very dark October, 1929, when the Turbulent 'Twenties ended in a world-shaking crash. Promoted to full editorship in 1934, after *Farm and Fireside* had become *The Country Home,* McMillen contributed much to the final acceptance of the ideas of Hale and Herty.

To understand the value of McMillen's contribution, you have to know something about the average American farmer's individualism. *Rugged* individualism, it's called—even when *ragged* would seem to be the better description. When Hale and Herty first spoke of their idea in the presence of the late Dr. Dow, that wise and paternal chemist told them, "You're day-dreaming. No chemical plant could hope to operate on raw materials based on political prices." And, when the two men replied that they would educate the farmer and show him the folly of political control, Dr. Dow retorted:

"You don't know farmers!"

Dr. Dow knew farmers, for he had been reared among farmers in New England, Ontario and Ohio. When he tossed a wet blanket on Hale's proposal, he did not know that McMillen, the ex-farmer who also knew farmers, was launching a program destined to change farmers' attitudes. Through the McMillen editorials, millions of farmers began to learn that they need not be primarily food producers. They were told how milk becomes buttons and combs. They learned that corn becomes about one hundred and fifty non-edible things. They were informed about the transformation of bagasse, the refuse stalks at the sugar-cane mills, into lumber substitutes. They were told that the day would come when the wasted straw and chaff of cereal crops would be as valuable as the grain. But what really made them sit up and take notice was the suggestion that their acres might be required to provide horse power again. That was something they could understand easily. They had no occasion to doubt Dr. Hale's estimate that something like 30,000,000 acres, formerly required for the production of horse power, were released for other uses when the internal combustion engine changed the meaning of ***horse power***. They could see the significance of this change from muscle to machine on their own acres. They needed no statistics to tell them that horses and mules in the United States were decreasing and that this decrease was taking them out of the business of horse-power production.

So, when it was suggested that farmers might again become horse-power providers via the alcohol still, these farmers began to think along the lines that Billy Hale had laid down, for it was cheap alcohol Hale wanted most of all. He wanted it because he needed a plentiful source of acetic acid for cellulose acetate. He wanted it also for the ethyl chloride used in ethyl cellulose (*Ethocel*).

3

In 1932, Dr. Hale wrote a book for the Century of Progress Science Series. Titled *Chemistry Triumphant,* it was the second best seller in this series issued for the Chicago Exposition. It was history without so much as a nod of recognition for the political parcheesi-players and military hell-raisers who usually hog history's pages. This was history told in terms of the pale dreamers who sit in laboratories and quietly light the fuses which detonate historic events. It was history with the emphasis on chemical achievements—Wöhler's transformation of ammonium cyanate into urea in 1828, Adolf von Baeyer's conversion of coal tar into indigo in 1878, Hilaire de Chardonnet's revelation of the silkworm's secret in 1889, and Haber's fixation of atmospheric nitrogen in 1913.

In writing this book, Hale took the plain reader by the hand and said, "See how these test-tube termites are nibbling the insides out of all the nicely arranged and seemingly solid timbers upon which *all* the economic theories of the Machine Age rest! Isn't it high time for us to overhaul our concepts and build new ones out of a better understanding of the meanings of these chemical processes?"

And for those new concepts, he designed the name, "chemeconomics."

That book is still stimulating reading—if you can get your hands on it.

Now he had the auctorial itch. There was another book in his system somewhere—a book about the meaning of his alcohol research to agriculture. Then, out in Iowa State College, Drs. Leo M. Christensen, Ralph M. Hixon and Ellis J. Fulmer prepared a report on "Power Alcohol and Farm Relief." The researchers delegated Christensen to take the report to Hale. Hale took Christensen and the manuscript to Garvan. Garvan saw the significance immediately, and the Chemical Foundation published the Christensen-Hixon-Fulmer book in March, 1934. The petroleum industry trained its guns on the proposal, and Hale replied with *The Farm Chemurgic* in the fall of 1934. The movement now had a name. It also had an aim which farmers of the Middle West could understand. After the Chemical Foundation took over the publication of his book and distributed 50,000 copies, Hale was swamped with invitations to address farmers' groups, businessmen's clubs and legislators throughout the Middle West.

Naturally, interest was greatest in the Plains States—South Dakota, Iowa, Illinois, Nebraska, Kansas—where grain surpluses were most annoying. D. B. Gurney, of Yankton, S. D., who had been experimenting with the sale of gasoline-alcohol blends in his chain of about five hundred filling stations in five states, had found it difficult to get alcohol for blending. He had read about Dr. Hale in McMillen's columns, and, when *The Farm Chemurgic* fell into his hands, he wrote to Hale, explaining his problem.

Early in 1935, Hale, Christensen and William W. Buffum, manager of the Chemical Foundation, went to Yankton and conferred with Gurney. His problem, they found, was far from simple. Though his customers wanted blends for motor fuel, he was unable to meet the demand. There were many reasons, he said. First, he needed an unfailing source of farm-derived alcohol. Second, this alcohol would have to be completely anhydrous (water free) to make a perfect blend with gasoline. Third, it would have to be adulterated to remove it from the highly-taxed category of beverage alcohol. Fourth, it would have to be cheap enough to compete with premium gasoline. And, fifth and finally, there would have to be found an unfailing source of gasoline, the producers of which would not be opposed to the blending of their product with alcohol.

While they were pondering Gurney's problem, Hale and Christensen received an invitation to address the last joint session of the Nebraska legislature. At Lincoln, they found the lawmakers considering a proposal to beat down the petroleum industry's opposition with a tax that would favor alcohol-gasoline blends. The chemists cautioned the politicians against the use of such methods of compulsion, pointing out that it tends to erect tariff barriers between the states. The counsel was heeded on this occasion, but, subsequent attempts to market blended fuels having failed, legislators are again toying with the idea of preferential taxation as a means of fighting the opposition. On June 3, 1939, the Nebraskans, angered by the opposition of the petroleum interests, enacted a law which exempts from the four-cent state tax all fuel containing ten percent farm-derived alcohol and used on the farm.

A few days after Dr. Hale addressed the Nebraska lawmakers, he was invited to talk to a group of farmers at Bloomington, Illinois. That invitation resulted from the reading of his book by E. D. Funk, of Funk Brothers Seed Company, which had played a major role in popularizing soy-bean agriculture in the Middle West.

From that Bloomington rally, on Lincoln's Birthday, Hale and Christensen were summoned to Washington, D. C., by Carl B. Fritsche, a Detroit industrial engineer who had read Hale's book and concluded that something should be done to fuse the widespread interest it had aroused into a forum for the discussion of all chemurgic possibilities. Fritsche felt that he could organize such a forum. His ability as an organizer had been proved by his success in handling America's pioneer air transport company with Howard E. Coffin, the automotive industrialist who had later retired to his Georgia estate to become chairman of the board of Southeastern Cottons, Inc. In Detroit, Fritsche was then associated with William B. Mayo, former Ford executive, Ralph H. Upson, aviation engineer, and Edward J. Hill, balloonist and engineer, in the Detroit Aircraft Corporation which had built and sold to the United States Navy the metal-clad airship ZMC-2.

A few days later, Fritsche invited Hale and Christensen to Detroit and introduced them to John Haggerty, former manufacturer and state official who had retired to devote his time to scientific farming. Next day, the four men conferred with William Cameron and Henry Ford, and the first chemurgic conference began to take shape. Late in March, Fritsche was discussing the plans for the conference with McMillen and Clifford Gregory, then editor of *Prairie Farmer,* in Chicago, when Fred W. Sargent, president of the Chicago & North Western Railroad Co., and Col. Frank Knox, publisher of the Chicago *Daily News,* joined the discussion and supported the plan for a chemurgic forum.

More and more minds were now taking fire from this "fantastic" idea; and, on April 4, the conference plans were drawn up in Washington's Mayflower Hotel by Hale, McMillen, Buffum and Watson Davis, editor of *Science Service.* Five days later, the plans were completed in Garvan's office, with Coffin attending and requesting that the plight of the cotton-growers be considered in the sessions.

A month later, chemurgy climbed out of its cradle. But, although the power-alcohol sessions got the spotlight at this and subsequent conferences, chemurgy's first great triumphs were fulfillments, not of Hale's dreams, but of Herty's. Within a year after that first conference there were under construction in the South seven new paper plants, representing an investment of more than $40,000,000 and designed to use the processes developed by Dr. Herty.

4

Before we proceed to Herty's story, however, it is necessary to investigate the reasons for Dr. Hale's concentration on alcohol as the key-log in the jam which, in his opinion, prevents human attainment of the potential plenty that is dammed up behind a barrier of interlocked and antiquated concepts.

As we have seen, he had already started on the hunt for cheap alcohol in those days when he and Herty sat by the campfires and talked about the molecular architecture of vegetation. He wanted cheap alcohol primarily, not for motor fuel, but as a plentiful source of acetic acid which, as every amateur winemaker knows, is the vinegar that results so very easily and so often when fermentation has set in. Hale's interest in this common stuff centered on direct oxidation of ethyl alcohol by means of water. Several patents were issued to him for perfecting processes utilizing dilute alcohol direct from beer slops and thus producing acetic acid at ridiculously low prices.

"Eventually," he says, "we hope to make an acetic anhydride by a slight shift in the process and thus come to a chemical reagent at so low a price that cellulose acetate will cost no more than regenerated cellulose (rayon) today." Far more spectacular is Hale's claim that isoprene and butadiene, resulting directly through dehydrogenation and condensation of alcohol molecules, will afford the cheapest possible source of synthetic rubber, even at lower price than natural rubber.

To understand what the perfection of low-priced chemical reagents may mean to man's future, you have to think of man's past as a narrative of chemical progress; that is, progress in the use of three materials—inorganic stone, inorganic metal and organic plastics.

In his use of inorganic materials, man employed unfashioned stones for hammering and cutting for hundreds of thousands of years before he learned to shape stones into tools. Then, about 4,000 years ago, he began to use metals. Until about 2,000 years ago, bronze was the principal metal used. Then the use of iron increased until 1856, when steel began to replace iron. The Steel Age, says Dr. Hale, is now giving way to what he calls the Magal Age, an age in which man will decrease his use of the coal-refined and unevenly distributed heavy metals and will increase his use of the electrically produced and widely distributed lighter metals, magnesium and aluminum.

Since these light metals are among the most common elements of the earth's crust and since their fabrication depends on electricity, which is fairly equally distributed among the nations of the earth, Dr. Hale predicts that the Magal Age will bring about entirely new relations between nations.

But more significant than this shift from heavy-metal to light-metal economy, he says, is man's recent progress in the use of organic instruments, utensils and building material; for, although man has been using such things as horn, bone, ebony, ivory, bitumen, etc., since prehistoric times, it was not until the beginning of this century that man began to attempt to *make* these things. The first successful attempts to make plastics from liquids under pressure, he says, introduced the Neoplastic Age, an age which, he predicts, will be superseded within fifty years by the Silico-Plastic Age, when man, having perfected the processes for making horn, bone and ivory, etc., will improve these processes by introducing silica into the synthetic structures. In other words, man will make stone as he now makes ivory and ebony. Then, probably before the Twentieth Century ends, Dr. Hale predicts, man will find a way to introduce metal atoms into the molecular latticework of plastic structures, and will *make* metal, thus introducing the Metallo-Plastic Age.

At present, plastic progress is impeded by a number of things, an important one of which is the high cost of the chemical reagents used in the processes. The removal of that impediment is the aim of Dr. Hale's extensive researches in ethyl alcohol and acetic acid.

To grasp the meaning of the Hale research, let us examine one small segment of the plastic industry. On May 15, 1929, the explosion of stored X-ray films in a vault at the Cleveland Clinic of Dr. George Washington Crile released poisonous chemical fumes which killed one hundred and twenty-four persons. Those films were transparent plastics in which the chemical reagent had been nitric acid, the kind of photographic film then commonly used. Subsequently, film manufacturers switched to acetic acid as the chemical reagent for the cellulose and produced the harmless cellulose acetate film which we call "safety film." Although cellulose acetate film is more expensive than cellulose nitrate, the safety factor outweighs the cost advantage; but, until the cost advantage is removed by some such research as Dr. Hale has been doing, the use of cellulose acetate film will be limited by this high cost. At the third conference of the chemurgists he revealed how the cheapening of cellulose acetate film may alter the pattern of agriculture. He prophesied that, once the stuff becomes as cheap as rayon, it will be used to protect truck-garden and orchard crops from the vagaries of the climate. Truck gardens, he said, will become huge greenhouses, and precious fruit trees will be protected with transparent hoods or capes. As a binder and with wood flour or hemp flour as a filler, he added, acetate will be used to make huge plastic panels for the mass-production of houses.

So it was the hope of attaining these and similar boons for humanity which caused Hale to concentrate on the chemistry of alcohol. Because he considered alcohol the key to the riddle of nature's chemical processes of organic transformation, he became, willy-nilly, the chief target for the fire of those who feared that the introduction of power-alcohol would interfere with the business of the petroleum industry. In him, the industry recognized a dangerous foe. How dangerous he could be was illustrated at one of the first power-alcohol sessions when, a petroleum chemist having dismissed alcohol-gasoline blends as technically impractical motor fuel, Hale arose and, tracing the steps by which liquid fuel is turned into power in internal combustion engines, said:

"When the apologists for the petroleum industry try to tell us that alcohol-gasoline blends are not satisfactory, they seem not to recognize what the organic chemist knows, namely, that in feeding gasoline into a motor we are already using alcohol for fuel." Then, describing how the aliphatic hydrocarbon, gasoline, begins combustion (under high pressure and by blending with oxygen) by the production of a hydroxylated compound of the same chemical order as alcohol, he added that, to the organic chemist, gasoline *is* alcohol in that split second when the electric spark detonates the vaporized gasoline-oxygen mixture into horse power.

So, whether he wanted to or not, he became the pioneer of the power-alcohol proponents and the man upon whom the opposition concentrated its attack. When the attack became furious, he replied with another book, *Prosperity Beckons,* which, published in 1936, was sub-titled "The Dawn of the Alcohol Era." In this book he examined all the arguments in the power-alcohol controversy and restated his conviction that ethyl alcohol is the chemical with which man will banish the waste of idle hands and idle acres, or the chemical key with which man will unlock the door to the secrets of transmutation which the alchemists sought without success.

With an unprecedented abundance of alcohol, he said, man would be able to free himself from his dependence on the fixed natural resources for the possession of which civilized nations have been threatening to destroy one another. Now, he said, all nations may be self-contained, independent. And, he added, the greatest progress hereafter will be made by those nations whose leaders recognize the significance of chemical synthesis.

5

"That exchange of goods which we call foreign trade is merely the international exchange of bundles of warm, moist air," said Dr. Hale at the conclusion of an address he delivered in Omaha in April, 1938, when he accepted, as "the Pioneer Chemurgist," the National Farm Chemurgic Council's Pioneer Cup "for distinguished service to the American people."

This, an organic chemist's appraisal of foreign trade, exemplifies the dangerously controversial ground which Dr. Hale now occupies as an advocate of scientific nationalism. Because he insists that the nations of the world are becoming *less* interdependent and because this point of view is anathema to the so-called "liberals" who still think in terms of the decadent Machine Age, Hale has been identified erroneously as a friend of Fascism.

In the summer of 1938, he visited Europe and discovered that, while the world press was again focusing attention on the posturing and gesturing in the political arena, the scientists of Germany and Italy were quietly pushing their nations into the van of chemurgic progress. In Germany he found a remarkable aviation industry growing out of the expanding use of magnesium alloys for which chemists were "mining" a trapped ocean; an automobile industry utilizing plastics instead of sheet steel for automobile bodies; and an industrial research program of unprecedented magnitude and diversity being pressed forward by some 220,000 technologists striving to make their nation self-dependent and crisis-resistant. Similarly striking advances, especially in textiles, are being made in Italy, he learned. And, when he returned to the United States and began to talk enthusiastically about these laboratory triumphs, he found he was again facing the kind of situation which confronted him in 1915 and 1916, when it was impossible to tell the truth about German accomplishments. So today it is not unusual to hear Hale's critics assail him as a proponent of Fascism, the critics conveniently neglecting to observe the obvious fact that Hale's enthusiasm about German achievement cannot include enthusiasm for the political leaders who banished his hero, Fritz Haber, into the exile that ended when Haber died in 1934.

Unfortunately for Hale, name-calling is again rampant as a substitute for thinking in this year 1939. It is much easier to yell "Fascist!" or "Communist!" than to define either epithet. Those who scream "Fascist!" for instance, seem to overlook the significant fact that the Soviet Union, though supposedly dedicated to the propagation of the Marxian tenets of internationalism and interdependence, is quietly pushing forward toward an economy of self-dependence. And, on the other hand, those who profess to fear communism because of its potential menace to nationalism and religion seem to overlook the huge fact that the rulers of Germany, though loudly anti-communistic, are ruthlessly stamping out religion and nationalism in Europe. Because the name-calling does not make sense to a scientist, Dr. Hale ignores it. He laughs at his critics.

"Call it anything you like," he says. "The fact is that Americans have been chumps to the rest of the world for years. We've been told and told that we couldn't get along without the rest of the world. But we can. Chemistry has taught us that we can. There is no problem that we can't solve. Reactionaries have been telling us how impossible it is for us to be self-sufficient. They don't know what they're talking about. Why is the rest of the world so important? We have all that we need right here in America! Other nations are striving to attain self-sufficiency which is difficult for them but which would be easy for us. This nation is the laughingstock of the world because its leaders do not recognize the meaning of recent discoveries in scientific laboratories.

"You can call my insistence on the significance of these discoveries 'Hale's lunacy' if you like. You can call it anything you will. But name-calling will not help you understand the meaning of the fact that scientists are tearing apart the complex bundles into which nature has tied up energy and are reassembling those bundles into things that fill our needs. The test tube tells the truth. It doesn't talk theory. It deals in facts. Recognize those facts and you recognize that we live in the most amazing country in the world, a country of unlimited richness."

These broad tenets have been expounded in Hale's latest book, *Farmward March,* published in June, 1939. He now maintains that *agricrude* alcohol (farm-derived ethyl alcohol) holds the greatest power over human civilization because it is the one chemical entity endowed with the widest range of chemical activity and versatility. The development of an *agricrude* alcohol industry, he declares, will end all unemployment, provide unlimited extension of mechanical power and end all international trade in organic chemical material (farm produce). He predicts that, as man discovers the latent plenty-potential in *agricrude* alcohol, the sunlight streaming down upon tropical lands will come to be considered the greatest natural resource. Therefore, he says, each great national group will strive for "a place in the sun." He believes that the political turbulence in Europe and Asia is directly attributable to the fact that Germans, Italians and Japanese are dimly aware of their growing need for sun-soaked acres. These great national groups, he adds, *must* have free access to superabundance of organic raw material in continuous supply. "When they obtain it," he says, "national security will rest upon national self-sufficiency in ever increasing degree."

So, until sanity is again enthroned in a world that now seems to be churning itself into a lather of ideological hates, Billy Hale will probably be a prophet without honor in his own country. At this writing, a letter lies before me, containing his bitter complaint about the difficulty of telling "the truth about Germany, Italy and Japan and what the future must be." But, though Hale, the prophet, may be silenced, Hale, the scientist, continues to function. Not long ago he discovered that furfuryl mercaptan, an alcohol in which oxygen is replaced by sulphur, can be converted into a perfect coffee flavor. In plain English, mercaptans are the acrid and choking chemicals that are the skunk's weapon of defense. That skunk-oil should yield a substitute for coffee is not half so odd as the fact that the identification of the particular furfuryl compound should have been made by Hale, who not only drinks no coffee but never misses an opportunity to regale his coffee-drinking breakfast-table companions with a scientific discourse on the superiority of beer to coffee as a beverage.

On the occasion when he was honored as "the pioneer chemurgist," he delivered his speech of acceptance and, flanked by a few friends, retired to the hotel taproom. There, foam-crested stein in hand, he gazed a long time at the Pioneer Cup which he had just been awarded, and, opining that he was the lesser of the two chemurgic dreamers, ordered a toast to Doctor Herty.

Chapter V

HERTY—PIONEER OF THE PINES

1

Dr. Charles Holmes Herty did not attend the fourth national conference of the chemurgists in April, 1938, at Omaha, Nebraska. There were two reasons for his absence: His project had become accomplishment; and he had informed his fellow chemurgists that he was "a tired man."

How tired he was became apparent three months later. On July 17, he went to the hospital in Savannah for "observation and rest." Ten days later, his seventy-year-old heart stopped.

If you search the newspaper files for his obituary you will be astonished by the brevity with which the major organs of the press dismissed the passing of this chemist who, for more than two decades, had been recognized by cellulose chemists as one of the greatest in their profession. Astonishment becomes amazement when you realize that he had devoted the last ten years of his life to the task of freeing the press of the United States from dependence upon foreign sources of newsprint. Indeed, future historians, searching among time-yellowed newspapers of the 1930's for information about him, may conclude that *he* was "the forgotten man" about whom there was much hullabaloo in that decade. They may wonder why, in an era in which there was so much editorial screaming about "freedom of the press," the man who was implementing economic freedom of its press was virtually ignored by the major newspapers of the United States.

Herty's development of methods for converting cheap and abundant slash-pine into newsprint was but one of several great accomplishments of this modern alchemist. As long ago as 1916, he was world-famous among chemists for his development of revolutionary technics in the turpentine industry. To the list of his contributions to the welfare of the United States must be added the fact that, largely through his efforts, the Federal government embarked on a program of forest conservation. Posterity may honor him for his pioneering in the field of alpha-cellulose research, an activity whose ultimate ramifications may dwarf everything else that Herty did in his lifetime.

For, in the unpredictable future, the Hale-Herty cellulose-acetate experiments may play as potent a part in the revolutionizing of publishing technics as did the laboratory tinkerings of Michael Faraday in the ultimate conquests of distance and substances.

It is extremely hazardous to attempt to chart the probable effect of these Hale and Herty experiments. But despite the hazards, the attempt can be made by fitting into the background of the past a few of the revolutionary ideas that have already come upon the stage of the present.

To make such an attempt, it is necessary to shatter some solidified concepts, divorce some time-welded associations, and rearrange the separated parts into new associations. That this is not impossible has been demonstrated by an incident which I observed in Edison Institute Museum, the central unit of Henry Ford's far-reaching and revolutionary educational system.

Edison Institute Museum is a super-museum of history-in-the-making, an enormous building housing the tools and implements with which mankind has waged the long uphill battle of existence. The exhibits are grouped in such a way that the story of the ordeal of civilization may be read, in terms of tools, from mankind's beginnings down to yesterday morning.

The story is divided into three "books" (arrangements of implements), in three sections of the building.

The agricultural section's story begins with the crude artifacts of the primitive seed-savers and earth-scratchers. It comes down to date with tools and implements which, devised for agriculture and the home arts of food-preservation and clothing-manufacture, etc., developed into modern mechanized farming and such modern industries as canning factories, textile mills, garment factories, etc.

In the section devoted to the story of Manufacture, the history of man's attempts to harness power is unfolded with a display of engines and motors, all capable of functioning as planned by their creators.

The third section is devoted to the story of Transportation. A visit to this section provides the kind of idea-association that seems to be needed by most adult minds today.

Once I visited the museum with a magazine editor. Our guide was a seventeen-year-old student from the Edison Institute High School, which is also housed in the building. When we entered the Transportation section, the editor stopped in his tracks and expressed amazement. The first exhibit he saw was a display of business office machinery, ranging from such primitive tools as the stylus and the abacus to modern typewriters and accounting machinery. Beyond it was a display of lighting equipment, from rush lamps to modern sodium-vapor lights. Farther along were displays of refrigerating devices, laundering machinery, cooking and heating equipment, and displays portraying the development of the graphic arts, the telephone, telegraph, radio, cinema, etc. And, beyond were carriages and ships, railroad engines and trains, automobiles and airplanes.

"What," said the editor, waving his hand in the direction of the refrigerators and typewriters, etc., "have these to do with transportation?"

"They are transportation tools," said the boy matter-of-factly.

"As an editor, you're a transportation worker, transporting ideas and intelligence and information from mind to mind with such transportation tools as the telephone, the telegraph, the typewriter, the linotype, the printing press and paper-making machinery."

After thinking it over, the editor admitted that, although it had not occurred to him in that light before, "the idea makes sense."

Now, if you cling to that idea-association, the historic background against which the Hale-Herty cellulose-acetate experiments must be placed provides some clues to the probable ramifications of those experiments. For, contemplating that background in that new way, the nineteenth-century revolution in transportation acquires new meanings. It is no longer a mere parade of steam-powered land-vehicles and ships, electric trains and cars, automobiles and airplanes. The mind's picture of that revolutionary century is no longer confined to the tools with which man annihilated distance for the movement of himself and his goods. The picture expands. It includes, also, *all* of the tools with which man conquered time and space in the transportation of information, ideas, intelligence, heat, light, water, refrigeration, etc. (To the Edison Institute students, for instance, money is a transportation medium.)

Thus when you look at this idea of transportation in a new way, it becomes plain that this book is a vehicle. Now when you think of a book as a vehicle, you suddenly realize that it is one vehicle which has not been changed much since the Middle Ages. True, there have been technological advances in printing, paper-making, type-making, binding, etc., but, by and large, books have changed so little that, were a man of the Middle Ages resurrected, he would recognize our books though virtually everything else would have to be explained to him.

That this vehicle will be altered as drastically in the future as the oxcart was in the past is no longer doubtful. Some changes are already in force. Magazines and newspapers have been influenced by technical upheavals wrought by radio-broadcasting and cinema. Newspaper publishing technics are now changing rapidly as transportation of information is revolutionized by teletypewriters and wired and wireless transmission of photographs and printed pages. The recently developed teletypesetter, a tool that enables an operator at a central keyboard to set type in any number of distant cities, will make further changes. An attachment for radio receiving sets, capable of printing news-dispatches and photographs silently in the home of the set-owner, has been developed and will undoubtedly alter the fortunes of those who deal in the transportation of spot-news. The publishers of the St. Louis *Post-Dispatch,* for instance, recognized the meaning of this development early in 1939 and installed broadcasting equipment that "prints" a tabloid newspaper in the set-owner's home between midnight and 6:00 A.M.

But the most meaningful new thing on the horizon of this kind of transportation is the present experimental use of microfilm. In Washington, the pages of thousands of rare books are being recorded on motion-picture film. Hereafter, these books may be read by anyone possessing a projector.

Consider some of the potential effects of that idea: Books on film! In the future, private libraries of thousands of volumes, the pages microphotographically printed on strips of cellulose acetate, may be housed in small filing cabinets. The mechanics of reading may be drastically changed. Type-size will be controlled by the reader where film and light replace paper and ink. Perhaps the "printed page" may be projected on a screen. Perhaps "reading" may be done with the eyes or the ears or with both simultaneously, for Radio Engineer James Arthur Miller has already perfected sound-on-film recordings for radio-broadcasts and is working on an application of his idea which will invade the phonograph field.

Now, with these developments on the immediate horizon, who dares to predict how the possible combinations of cinema, radio, television, facsimile news transmission, micro-film, Miller-tape, etc., may shape the future of *all* thought-transportation?

As we have already discovered, one huge barrier that stands in the way is the price of cellulose acetate, which Dr. Hale predicts he will one day make as cheap as rayon.

2

When Dr. Billy Hale received the Pioneer Cup in Omaha, he said, "The honor should have gone to Charley Herty." That was more than a friendly gesture. It was a great chemist's tribute to a great chemist, a student's acknowledgement of his debt to his teacher.

Herty was Hale's senior by only eight years, but, seeing them together, one invariably thought of them as a father-and-son team, with the younger man constantly trying to break into an intellectual gallop in pursuit of some idea and the older, white-haired and soft-spoken Herty holding to the plodding policy of the persistent but unhurried push.

As Hale has admitted, the idea that became chemurgy, though first fostered by the two of them during those fantastic "grouse hunts," was nurtured by Herty's ability to plot and plod.

Herty's specialty was arboreal alchemy. He probably knew more about the molecular architecture of trees than any other two chemists who ever lived. Indeed, his knowledge of his specialty was so vast and deep that it had come around the circle to that point where the possessor of thorough knowledge of any subject inevitably arrives—the mind's recognition that even thorough knowledge is but the recognition of ignorance.

Poet Joyce Kilmer looked at trees and saw God-wrought poems. Philosopher Henry Thoreau looked at trees and saw God-wrought art. Chemist Charles Herty looked at trees and saw God-wrought wealth. The views are not conflicting. Take

Thoreau's poetic interpretations of the changing colors of autumnal foliage, for instance. The chemist has recently found the key to the picture of colorful autumn. The change from green to the brighter hues is merely an unmasking of colors that were there all the time. The disintegration of chlorophyll permits the true colors of the chemical components to appear; anthocyanin producing the reds and purples, and xanthophyll and carotin producing the yellows. Anthocyanin forms in the presence of sugar under a condition of low temperature and bright light and is dissolved in the plant-cell fluid. Xanthophyll and carotin are solids whose function in the food cycle is not yet understood; but carotin, as was discovered in 1937, has therapeutic value in the relief of eyestrain because of its ability to become Vitamin A in the digestive tract and thus regenerate visual purple, the light-sensitive substance of the eye.

Herty's attempts to probe the mysteries of trees made him humble. Trees also taught him that patience coupled with persistence constitutes a force that enables a fragile wraith of mind-stuff to move a mountain of inertia as easily as a hairlike root splits a boulder.

On that occasion when he told of the beginnings of chemurgy, he gracefully side-stepped Hale's praise with this little speech.

"I'm glad to see how strongly the leaders of agriculture have taken Billy's words to heart. He has proved a sound leader, though I remember well how he was derided when he first put forward his views. So, too, was he derided when he predicted a great lowering of costs of phenol and aniline oil; but today, largely through his work, those two great developments in organic chemical industry are accomplished facts. I do not hesitate to predict that from plans he now has in mind, coupled with work we are doing in the South, still greater developments may be expected."

In praising Hale, Herty did not deem it necessary to refer to his own accomplishments save by the vague phrase, "work we are doing in the South."

To get the full story of the "work we are doing in the South," you have to dig for the facts in the files of such technical publications as the *Journal of Industrial and Engineering Chemistry,* which he edited from 1917 to 1921 and to which he was a frequent contributor. Scattered, also, are the facts of the Herty biography.

He was born on December 4, 1867, in Milledgeville, Georgia. Orphaned when but a small child, he and his infant sister were taken into the home of an aunt. To this foster mother he accorded full credit for his scientific career. Recalling that he was a backward child in school, he said that the turning point in his life was a day when his aunt took him to his mother's grave and unfolded to him the glorious possibilities open to him if he would resolve to devote himself to worth-while objectives. Thereafter, he said, he believed himself to be a man, though he was still a child. At the age of thirteen, he was enrolled as a student in the Georgia Military and Agricultural College, a school whose title was a two-way mirror for the blasted glory of the South's past and the frail hope for the South's future. In 1886, the University of Georgia having accorded him the degree of Bachelor of Philosophy, he went to Johns Hopkins to study chemistry. In those days chemistry was considered almost entirely an adjunct of medicine in the United States; the word "chemist" conjured up a vision of a pill-roller in an apothecary shop.

Herty's concept of the chemist's role was unorthodox. When Johns Hopkins gave him his doctorate of philosophy in 1890, he moved on to the Georgia State Experimental Station as assistant chemist. After a year of that, he returned to the University of Georgia as an instructor in chemistry. In 1894 he was moved up to the professor's chair, and, a year later, he married

Sophie Schaller, who bore him two sons and one daughter.

But the professor of chemistry was dissatisfied with the elementary stuff being dished out to chemistry students in the United States. In Germany, he knew, the master minds of the rapidly unfolding science were doing big things, doing them with the active encouragement and financial backing of the state and individual industries. So, off to Charlottenberg, Berlin, he went, to sit at the feet of Professor O. N. Witt, one of the most celebrated teachers of industrial chemistry in Europe.

One day the gentle Georgian mustered up enough courage to ask Herr Doktor Witt what he thought of the turpentine industry in the United States.

"You have no turpentine industry in America," was the reply. "You have a butchery. I speak from personal knowledge, for I have been in Florida. You are wasting your natural resources and getting nothing like an adequate return for them."

Herty came home, investigated the thing that he had thought to be an industry until he had heard it called "butchery," and found Witt's criticism justified.

To get naval stores, turpentine operators hacked a deep pocket into the base of a pine tree. In each pocket or "box," as it was called, about a quart of turpentine collected as the wounded tree died. He had a hunch that the pine tree is not a turpentine storehouse, but a turpentine factory. Credit for the hunch goes to an unidentified, left-handed Negro whose pine-tree gashing produced a slightly different cut because his axe was ground for a right-handed worker. Examining that unorthodox gash, Herty discovered that turpentine is not present in a healthy pine tree, but that it is a secretion manufactured by the tree when the inner bark is wounded. After extensive testing with the shallow cut, he announced that if the tree is cut no deeper than the inner bark, the turpentine yield is approximately twenty-five per cent greater than when the tree is mortally hurt. He went before a trade convention of turpentine operators, told them of his findings, and was paid for his trouble with ridicule. "Just another of those meddlesome professors! Why can't they stay in the classroom with their crazy theories instead of trying to tell businessmen how to conduct their business?"

But the professor didn't go back to his classroom. He went into the workshop and invented a turpentine cup that could be nailed to a tree. It revolutionized the industry and is now universally used. Shortly afterward it was estimated that the "meddlesome professor" had cut and cupped an additional million dollars' worth of turpentine for the businessmen who thought they knew their business. They took the profit. The "meddlesome professor" returned to his chair in the University of Georgia. His reward? In 1932, more than a quarter of a century later, he received a medal from the American Institute of Chemists.

After that turpentine triumph, the chair of a chemistry professorship was a hot-seat for the Pioneer of the Pines. Herty's chief interest now became trees.

He had developed some "crazy" notions that there was entirely too much useless tree-butchery going on in the United States and that, if it continued, posterity would have to pay for it—through the nose. He talked to Gifford Pinchot about these notions of his. Pinchot listened sympathetically and got him a post as collaborator in the Bureau of Forestry, United States Department of Agriculture. That was in 1901, after he had attended chemistry lectures in the University of Zurich.

In Washington he instituted a persistent campaign that helped bring about the Federal government's survey of national forest resources, a survey which, though still in progress, has produced volumes of published findings.

Such accomplishments should have been enough for one man, even a superior man; but, in 1902, the professor became an expert in the Bureau of Forestry. Then, in 1905, the Chattanooga Pottery Company had a problem that required the attention of a chemist and Herty left the Bureau. At the end of the year, the University of North Carolina called him to its chair of chemistry.

The following eleven years were quiet ones for Professor Herty. Classroom work during the school year may have been monotonous for such a restless spirit, but vacations in Europe were adventures. His circle of acquaintances among the great European chemists was expanding. Acquaintances became friends and friends became confidants. In Europe, big things were afoot in chemistry, and Herty was allowed an occasional peep behind curtains. The big things that were bubbling in the crucibles and retorts were planned by their creators as contributions to the welfare of the world. But, while the close-mouthed tinkers were implementing welfare, the loud-mouthed "thinkers" were blatting and bungling toward warfare.

In England, a bearded Jew from Minsk, who had found a haven from persecution in the University of Manchester's chair of chemistry, was happily busy in his spare time with what his students called "stinks." That was Dr. Chaim Weizmann, trying to produce synthetic rubber. He didn't produce rubber, but he found a hitherto unknown miscroscopic bug which was subsequently loaded down with the sesquipedalian tag, *clostridium acetobutylicum Weizmann*. Nicknamed B-Y (B for bacteria and Y for Weizmann), the bug was a perfect glutton for corn. After a B-Y banquet on a batch of corn soup the brew became water, butanol, acetone and ethyl alcohol, which could then be separated by fairly simple distilling. Weizmann wanted butanol for his synthetic rubber experiments. Acetone and ethyl alcohol were just bothersome by-products. When the World War began, acetone became desperately needed in the manufacture of explosives. Ultimately, as results of this bug-hunt in Weizmann's laboratory, the world got a new assortment of valuable solvents, the automobile industry got a quick drying enamel that facilitated automobile production, aviation got "dope" to coat fabric wings of the early planes, and Great Britain got the "Palestine Problem." (For an exceedingly interesting account of the fantastic ramifications of the Weizmann research, you are enthusiastically referred to Fred C. Kelly's little book, *One Thing Leads to Another*—the biography of Commercial Solvents Corporation.)

In Germany, where Herty had many friends, Fritz Haber was busy with his famous experiment. Since 1656, when Dr. Johann Rudolf Glauber provided a scientific basis for the peasant adage, "Corruption is the mother of vegetation," by identifying the role of saltpeter in fertilizer, the world's stables, bird-cotes, sheep-pens, pig-sties and outhouses had been assiduously mined for the stuff. Doubly valuable because, as fertilizer-source, it could increase total mouthfuls of food and, as gunpowder-source, it could decrease the total of hungry mouths, it remained so scarce that hunger-dodging man remained always just one precarious jump ahead of famine. There was a brief respite when it was discovered that there were veritable mountains of the stuff in Chile. There was enough for a long time, had the supply been devoted mainly to man's welfare. But warfare drained the supply, and, early in the Twentieth Century, Sir William Crookes, the famous British chemist, estimated the Chilean supply of fixed nitrogen and the increasing rate of its use, and predicted, as Thomas Robert Malthus had done before him, that the human race would shortly starve to death. Then, in 1914, began the World War which, to the chemist, was a series of explosions that liberated nitrogen. Prior to 1914 Germany and England had been the best customers of the Chilean nitrate monopoly. When war broke out, the two nations blockaded each other, the British fleet closing the German ports and the German Pacific fleet blockading the Chilean ports. Until a British fleet smashed the German cruisers off the Falklands on December 8, the Allies faced certain defeat because they lacked nitrogen compounds for their guns. Then

Germany was shut off from the Chilean source of supply and the Allies believed that lack of nitrogen would result in German defeat in a year. But they reckoned wrong, for Germany had Haber; and Haber had wrested from nature the secret of nitrogen's manufacture. Haber's process, perfected by Professor Carl Bosch of Badische Anilin und Soda Fabrik, resulted in large-scale production of the precious chemical from atmosphere. Other results: The war was extended until the United States became involved; American participation in the war started the United States on the road to world leadership in chemical industry; and Herty was dumped out of his snug professor's chair into wartime activities that carried him to new achievements.

In these pre-war years, Herty also learned much about the many experiments that European chemists were conducting in following up the clues that Hilaire de Chardonnet uncovered in 1884, when that French nobleman-chemist learned something about the manner in which the silkworm's gastric juices convert mulberry leaves into hairlike fiber. It developed ultimately into the commercial production of rayon, the greatest textile revolution since the invention of the cotton gin.

In Switzerland, the Chardonnet-pioneered research into the mysteries of cellulose resulted, in 1908, in the production of the first sheet of what has come to be known as cellophane, now so commonplace that even the poor discard it thoughtlessly, but then a chemical marvel. Having studied under the masters at Zurich, Herty had learned enough about this marvel to deem it significant.

The first sheet of cellophane was not, as is generally believed, the result of accident, but of sound scientific research by many chemists in England, France and Switzerland. In 1892, British Chemists Charles Frederick Cross and Edward J. Bevan found that cellulose, when treated with caustic soda and then with a solvent, became a syrup which they called "viscose." This syrup, they discovered, could be "regenerated" (restored to pure cellulose) by subjection to another acid. This was part of the vast amount of cellulose experimentation then going on in Europe, the spade-work which produced the thousands of cellulose-derived things we now use twenty-four hours a day. In 1898, another Englishman, Chorley, transformed viscose into a transparent sheet. Thus, the fundamental chemistry of rayon revealed the possibility of cellophane, a possibility which aroused the interest of the Swiss textile chemist, Dr. Jacques Edwin Brandenberger. Employed by Blanchisserie et Tenturerie de Thaon, Dr. Brandenberger thought he could make his company's fine tablecloths impervious to dirt by dipping them in viscose. They sparkled beautifully but they couldn't be folded. Next he tried to produce a sheet of viscose as a tablecloth cover. But the sheet was thick and hard, too stiff to be folded.

In 1908 Brandenberger knew he was on the threshold of a significant development, and he began to design machines and processes for making the transparent sheets. The process he developed was not unlike the process for making rayon. Whereas rayon is made by forcing the cellulose syrup through tiny holes, cellophane is made by flowing it through a narrow slit. In the process he developed and patented in 1912, wood is pulped, steeped in caustic soda, pressed, ground and mixed with carbon disulfide. Converted to jelly by addition of more caustic soda, the stuff is aged, filtered and, subjected to vacuum which removes bubbles, is forced through the slit into an acid bath, after which it is washed, bleached and treated with glycerine.

But, in these pre-war days, when Herty spent his holidays in Europe with his eyes and ears open, Dr. Brandenberger's product was still a laboratory curiosity. Chemists saw its possibilities, but "practical" men were busy with other things. And when, in 1914, practical men devoted their best efforts to the ancient practice of wholesale destruction, the Swiss chemist quietly improved his machinery and processes. In 1920, Alfred Bernheim, head of France's largest rayon-producing company, the Comptoir des Textiles Artificiels, organized a company called "La Cellophane" and tried to market the curiosity. It was too expensive save for wrapping the most costly luxury goods. Bernheim then thought of the successful arrangement that his company had made with the du Pont company for the use of viscose rayon processes in North America, and, in 1923, he organized a mission to sell it the North American rights to cellophane production. It is said that the Frenchmen laughed heartily when the Americans rose to the bait—for of what earthly use was a wrapping material that cost two dollars and sixty-five cents a pound? But the Frenchmen overlooked the fact that, while Europe was at war, the missionary work of such men as Herty had produced a chemical industry in the United States. Thus, a year after the du Ponts began to make cellophane, the price was pushed down to one dollar and seventy-five cents. Then, a year later, American chemists had perfected a moisture-proof product. And, in 1937, when cellophane was being produced for thirty-five cents a pound, the Franklin Institute of Pennsylvania bestowed its prized Elliott Cresson Medal upon Dr. Brandenberger.

Dr. Herty's familiarity with these and other European advances in chemistry resulted in his election as president of the American Chemical Society in 1915. In the years prior to 1914, he had preached and proselytized for better co-operation among American chemical manufacturers as means for combating European dominance of the industry. "Abandon your secretiveness and co-operate," he had repeated and repeated whenever he faced a group of American chemists. But nobody heeded until a Serbian assassin met an Austrian archduke in Sarajevo and the course of history changed. Europe's 1914 stampede into homicidal madness shaped the next chapter in Herty's career.

3

In 1917, Herty took over the editorship of the *Journal of Industrial and Engineering Chemistry.* But, as we now know, chemical industry was then little more than pharmaceutical pill-rolling in the United States. When the United States entered the war and the Federal government seized the German chemical patents, Herty's value to the nation was inestimably great. There were then few American chemists capable of deciphering the deliberately garbled formulas that the German cartel had filed in the United States archives. As the editor of the technical journal, Herty did much to get the industry established in this country. His European jaunts had provided him the necessary background of information that was then sorely needed, and he became rapidly famous, even in Europe, as a talented writer on scientific subjects.

It was his lively awareness of the social consequences of chemistry that made him insist on the general public's sharing the "mysteries" of the science. He wanted no scientific priesthood. So he made his science plain to ordinary minds, and he will undoubtedly have to be credited for much of the public interest that made the writing of books popularizing science a profitable enterprise in the post-war years.

After the war, when the Chemical Foundation was set up as a clearing house for the seized patents, and Garvan was placed in charge of the organization, Herty became his assistant. As such, he continued his campaign of sharing the news of scientific developments with the public. Largely because of his attitude, the Foundation launched the educational activities which, following the publication and distribution of Dr. Slosson's book, made Americans aware of the significance of scientific research. Behind the growth of American interest in science lies the solid fact that the Foundation distributed more than thirty million pieces of scientific literature in sixteen years.

And behind that fact is Herty and Herty's conviction that science should leave the lock off the laboratory door.

"Abandon your secretiveness," he said, and practiced what he preached. Famous is the bent spike that served as the only lock on the riverside door of his barnlike laboratory in Savannah. Once, when a friend noticed the spike and asked, "Doctor, why don't you put a lock on this door so you can fasten the barn at night?" he replied:

"You rascal! Don't be calling this a barn. This is a workshop and no place for fancy doorknobs."

So, in 1921, when he was president of the Synthetic Organic Chemical Manufacturers Association, he was exactly the kind of scientist Garvan needed most when he launched the campaign of public education which got the tariff protection required by the infant American chemical industry. It was this activity that threw him into frequent contact with Hale and resulted in the Hale-Herty-Garvan friendship.

In 1926, when he was nearing his sixtieth birthday, he was able to look back on his life and feel no small amount of satisfaction. He was not rich as men measure wealth; but he did not aspire to great riches. His wealth consisted of honors, degrees, fellowships, awards and world-wide respect among the men of his profession. He was an elder statesman of science. He had revolutionized the turpentine industry. He had helped to launch the forest conservation movement in the United States. He had helped the United States acquire a chemical industry that was becoming the world's greatest. He had been successful in arousing public interest in science. He was considered to be the greatest living authority on cellulose chemistry. And, he thought, he was ready to retire. So he accepted the post of adviser to the Chemical Foundation.

As he looked back on his career then, he considered his chief service to have been as educator of the public. In that year, he said:

"The greatest contribution of chemistry—greater in my judgment than any of its contributions to human progress—is what it has done in the past ten years to create a new attitude toward all problems of life; that is, the attitude of research.

"It would be difficult to say that any particular chemical discovery was of greater importance than another, but the new spirit that has come into social, industrial, political and educational activities of the American people in the last ten years marks a wonderful and unprecedented step in progress.

"The dogged method of the chemist, forever prying into nature to get fundamental facts about all processes which result in the world of things and people—that has been the spirit so fervently developed by scientists that the flame has of necessity passed on and spread, and it is making a new people and a new spirit of progress."

Not long ago Dr. Ernest B. Benger, chemical director of the du Pont Company, pointed out that research laboratories have so multiplied in the United States in recent years that research itself has become a major industry, employing more than 23,000 workers and financed with more than $250,000,000 annually. He added that this industry, non-existent before the World War, has made jobs for one out of every four persons gainfully employed in the nation, and has reduced manual labor, increased wages, conserved natural resources, enriched human life, increased the economic independence of America, contributed to human comfort and safety and lengthened the average life.

What was Herty's contribution to this? You cannot evaluate it. It is as intangible as the contributions of parents and teachers to whom the great benefactors of the race have often admitted indebtedness. But the popularization of science undoubtedly played a powerful part in the creation of many research departments in American industries.

We shall never know very much about the end effects of the educational activities of this frail, tireless little man. But it is not quite so difficult to determine our indebtedness to him when we examine the activities of the last ten years of his life.

4

At the age of sixty, when most men prefer the slippered ease of retrospection, Herty began a new career. Scorning clocks and calendars, ordering Father Time to mark time, he tackled a tough job which would have tested the strength of a young man. It began on a hot summer day in 1927, when he was sitting in his New York office, fretting about the heat. From his desk he picked a bulletin of the United States Department of Agriculture. Idly glancing through it, he suddenly snapped into alertness and snorted. The thing that pulled the cork for the snort was a statement that pine trees are "probably too resinous for consideration" in the manufacture of white paper. Didn't this fellow know what Herty had discovered all of a quarter of a century ago—that resin and turpentine are not natural components of healthy pine trees, but are produced only when trees are wounded?

If he didn't know it, he should be told. But, wait a moment, suppose we recheck this before we sound off! Recheck it? That means a trip to Georgia. Good idea. New York is unmitigated hell on a hot day and Georgia's piny woods are cool even in summer.

So, off to Georgia went Herty, revisiting home after a long absence. There an old friend, who had shared Herty's early enthusiasm for forest conservation, drove him out to the piny woods, showed him a stand of trees which needed thinning. "It costs money to thin woods," said Herty's friend, "and the timber you cut out is too small for saw-logs."

What can you do with trees too small for saw-logs? The question began to nibble at Herty's mind. And the Herty mind began to toy with the idea that had sent him down here from New York.

"When you thin these trees, keep the sawdust from each tree separate and save it for me," he said. "I've got an idea."

The idea was sired by the Herty attitude toward forest conservation and gestated by the Herty love of the South, a love saddened by the realization that the South's natural beauties were the setting for abject human misery. The idea resolved itself into the question: What if these quick-growing pines of the South, misnamed yellow pines, should be found white enough to be fed into the roaring presses which have devoured virtually all of the slow-growing spruces of the United States and are now gulping the slower-growing spruce forests of Canada and the Scandinavian countries? What would that do for forest conservation? What would that do for the poor, miserable southern farmers who, caught in the snarl of the one-crop system, have degenerated into a condition worse than slavery? Are you daydreaming, Herty?

Back in New York, the question continued to nibble. Herty *was* daydreaming—deliberately.

Out of the back of his mind came the remembrance of an experiment in which the Federal government had produced newsprint pulp at its Forest Products Laboratory on a suggestion from the University of Wisconsin. He was sure the experiment had been a success, but . . . better be doubly sure!

The samples of sawdust from forty trees were sent to one of the country's largest testing laboratories. Back came the report. What's this? *The analysis shows that pine trees contain only one per cent of resin.* Why, that's better than Herty had hoped for! Those southern pines are no more resinous than the spruce for which newspaper-hungry Americans pay some $170,000,000 annually to Canada, Sweden and Norway!

Here was something for a man to get his teeth into! It was

1927, and Herty was successful and honored by scientists, but Herty was also sixty and going stale. Here was something to make the threatening years roll back!

Thus began the odyssey, ten long years of grueling research, heart-breaking failures, and heart-bouncing triumphs, heart-warming promises of assistance, and heart-chilling breaches of promises, rebuffs, encouragement, ridicule, and, at long last, achievement. It is small wonder the aging heart collapsed suddenly when the excitement of those ten tumultuous years were crowned with a success that dwarfed the Herty imagining; small wonder that the ten years, held off by the excitement, rumbled down on the frail and snowy-crested Herty and did their deferred job in ten days.

In 1927, Herty needed money and a laboratory. He begged and borrowed, but he got little help. He pestered the operators of Canadian and American mills for a chance to test his southern pine in their paper-making machinery.

"Hell, no, Herty!" they told him. "Everybody knows that yellow pine won't bleach white enough for newsprint!"

And he explained that "yellow" pine is a misnomer, a relic of early lumbering practice, in which lumbermen used only the yellow, hard and strong heartwood, discarding and burning the sapwood. "There's no yellow heartwood in young, healthy trees," he said. "Their wood is white—maybe not as white as spruce but white enough, and cheaper."

But Herty had to prove that the wood of the pine is white. People saw turpentine gum on the trees and said, "Trees with all that gum are not fit for paper-making." Even Herty's friend, Tom Gamble, editor of the *Naval Stores Review,* called him aside after a lecture and said, "Doc, you're the biggest liar that ever walked. I can take you out in the woods and prove it to you."

"It took him a year to be convinced to the contrary," said

Dr. Herty. The trouble with the skeptics was that they trusted their eyes, the little doctor added, exhibiting a cross-section of a pine log and pointing to the growth rings which, he explained, merely appeared to be alternately light and dark because of differences in their cellular structure. But even when he proved he was right, he was still far from achievement.

"Why should we test your pine that grows so fast in the southern swamps?" the paper-makers demanded. "Suppose it pulps in the sulphite process as you claim it will. Where would that put us, with our money invested in spruce holdings?"

"But," Herty argued, "it takes fifty to sixty years for a Canadian spruce to grow to a size that a southern pine reaches in from twelve to fifteen years, and, at the rate we are gobbling up newsprint, the available spruce will soon be all cleaned off. Even at the increasing price, you can't afford to destroy forests as you are doing without dumping the final cost upon generations still to be born."

Sound arguments, Herty, but when has history recorded that a sound argument, based on the *long-range* view of profits, impressed "practical" people?

But, what's this? Here's George Spence of the Castanea mills in Johnsonburg, Pennsylvania, who not only listens to the pleadings of the gentle Georgian but says, "All right, all right; bring a sample."

Off to Georgia scampered Herty and back he came with a sample. What a sample! It was so small it would have been lost in the machinery; so it was chipped with a hatchet, and the chips, when cooked, were put into a milk-shaker.

This was funny to Spence and his associates, so funny that Spence began to feel warm-hearted toward the odd little man, so determined to test an idea that he remained serious even as his tiny sample was being handled like a soda-fountain milk shake.

"All right so far, Doc," said George Spence as the stuff in the shaker curdled into the sludgy pulp which is the beginning of paper. "Wonder if it will bleach."

It bleached, became whiter than the blanched face of Herty who was frightened for fear it wouldn't.

George Spence deserves a monument; but perhaps there was sufficient reward in the happy face of the man he had affectionately called "Doc" and who thanked him so profusely when he left.

Herty now needed money and a laboratory, needed them more than he had ever needed them before. He, the man who had put additional millions into the pockets of the turpentine operators, needed $50,000—and couldn't find a backer even in the lush, easy-money 1920's.

Friends offered to finance a paper mill, but Herty insisted that more research and a laboratory were the immediate needs.

He took his troubles to his old boss, Garvan. Yes, said Garvan, the Chemical Foundation would put up the $50,000—if someone else would furnish the $20,000 annually for the operation of the laboratory.

Where turn now? Someone suggested his home state. Herty became a fixture at the capitol in Atlanta, button-holing legislators, talking to them, pleading with them, making a nuisance of himself, hearing people call him a lobbyist. But he got his story into the right ears by pouring it into any and every ear within range of his soft voice. Some of the rural legislators had woodlots, and, the depression having set in, they were killing time by cutting firewood. In 1931, an appropriation was made by the state, the laboratory was established in an old brick warehouse on the Savannah waterfront, and Herty went to work. The City of Savannah helped. Equipment manufacturers supplied machinery at cost, and operations began in Herty's Pulp & Paper Laboratories in 1932.

5

The early experiments were disheartening. Everything went wrong. It was a full year before the laboratory's miniature paper mill turned out a successful run of newsprint. Six years had gone into the experiment now, but Herty, holding back the years, wasn't satisfied with the result. He knew the processes now, but would they work under large-scale, commercial conditions?

To make a test under such conditions, Herty needed help—a lot of help. Fortunately, that help came from many directions. The messianic itch that had driven him to talk ceaselessly about his beloved project had subtly infected other men. The result: A Canadian paper mill's offer to make a test which, in retrospect, may be termed a significant event in the course of history. The dramatic story of that test has been told by Herty, as follows:

"Five sections of a circus train were arriving in Savannah at half-hour intervals on Sunday afternoon, October 22, 1933, en route to Jacksonville. The purpose of the stop was to feed and exercise the animals. The news spread abroad and soon the railroad yards were filled with excited children accompanied gladly by their equally eager parents. Ropes and police were required to restrain the overeager sightseers.

"In the midst of these gay surroundings three phlegmatic refrigerator cars stood on a sidetrack waiting to be made a part of the fast northbound fruit and vegetable express of the Seaboard Air Line Railway, and destined for Canada.

"Little did the happy multitude realize with what infinite potentialities for the whole South were these cars laden. The bills of lading showed only three words, 'Pulp of wood.' To a newspaperman these words would have fully met Mr. Dana's definition of what is news. For the first time in history Georgia pine pulp for newsprint was being shipped to Canada. Why? To answer the question, submitted often almost as a dare, 'Could this pulp produce on a fast commercial paper machine as good grade of standard newsprint as had been produced on our small and slow laboratory equipment?' If so, the case was made up, for all the economics favor the South as the seat of a future great newsprint industry.

"The small staff of the laboratory, augmented by additional common labor, had been divided into two shifts and had been at work continuously for several weeks producing the twenty-five tons of chemical and mechanical pulp required for the test. This pulp, mixed with seventy-five tons of water, constituted the precious load. Temporary storage of the ground sapwood, as manufactured, in a room generously placed at disposal by the Colonial Ice Company insured against deterioration during the prevailing hot weather.

"At 6:40 P.M. the three cars left Savannah and on the following Saturday morning they reached Thorold, Canada, about twenty miles distant from Niagara Falls, and were promptly shifted to the unloading sidetrack of the Beaver Wood Fibre Company, Limited. I had ridden the switch engine in the Savannah yards when they were being lined up at the start of the trip, and couldn't help stepping apart from the two 'Bills,' McNaughton and Allen, and patting these bearers of such a historic load in congratulation upon the successful end of their long journey.

"But why Thorold? Because after months of search there had been found a group of men who were willing to co-operate, to give the pulp a fair test, to contribute their machinery and men without charge and who would give us the paper manufactured. With this latter asset in prospect there had been no difficulty in financing the freight costs through the daily newspapers of Georgia who were promised pro rata shares of whatever paper was produced for use in special editions on all-Georgia-pine newsprint.

"The officers of the company were frankly interested in the outcome, for the Beaver Wood Fibre Company, Limited, is a subsidiary of the Certainteed Products Corporation which had already shown its faith in the South by the erection of two roofing plants in the South—one in Texas, the other in Georgia, at Savannah. John Ball, the manager of the Thorold plant, was well known throughout the industry as an excellent papermaker.

"A rush order from a near-by city for a supply of paper caused a postponement of the experimental run. Finally, Wednesday, November 1, was set as the day for the test. Preliminary tests of the pulp had already been made. All morning the beater mixers had been busy preparing the proper mixture of sulphite pulp and ground wood and filling the great stock chest in order to keep ahead of the fast paper machine. All day men with water hose had been engaged in washing out every trace of spruce pulp from every piece of the equipment. At 5 P.M. all was in readiness.

"There was drama in everything. A great hall, two hundred by five hundred feet, down the center of which extended the paper machine; in a balcony stood John Ball overseeing the whole; here and there darted Henry Zieman, the superintendent giving instructions. Every man of the machine crew was at his post. We were seated atop bales of old paper, for our part was done. Water was being sprayed on the rapidly traveling wire, the steam-heated drying rolls were revolving; so, too, were the calender rolls.

"Suddenly the wire began to look milky—the pulp was on its way to paper. Back it went to the stock chest, thicker and thicker grew the wet sheet. The vacuum gauge on the suction-couch showed 13. At 15 the sheet would have the right thickness and be ready to go.

"The four o'clock shift had hurriedly returned and were crowding the doors. Everything was a-tingle. Then the gauge began to fall, the sheet thinned and again the wire was free of pulp. Henry Zieman was not satisfied with all of the adjustments. He had told me earlier that he was not going to let the experiment begin until he was sure everything was right. A wait of fifteen minutes seemed like a year.

"Again came the milkiness on the wire, the vacuum gauge mounted steadily, thicker and thicker grew the wet sheet. Suddenly, with catlike spring, a machine attendant threw a streamer of pulp toward the second press. It held—and soon a sheet one hundred and fifty-five inches wide was going through those press rolls—but still back to the stock chest.

"Now was the crucial moment. Would the sheet have sufficient wet strength to stand the tension as it passed to the drying rolls? How clever would this Canadian boy prove himself in throwing the streamer of pulp to the ropes which would guide the sheet over the long succession of steam-heated drying rolls? My heart almost stood still. Another catlike movement and over it went.

"I jumped from my perch and with two workmen followed its rapid progress over the rolls. There at the end was a wide sheet of white paper going down to the basement. Another workman with a dexterous slit with a knife and a blast of compressed air lifted the sheet to the top of the calender stack. A crackling sound told the story that it had been grabbed. Down it came, in and out, from one roll to another, spreading wider and wider across the rolls, then on to the reel where the winding of the roll began.

"There was the first sheet of commercial newsprint from young Georgia pine, pure white and smooth surfaced. John Ball seized a piece to inspect the formation. He was abundantly satisfied. He turned to me, his face all aglow, and exclaimed, 'We are going to lick it, Doctor.' 'Give me that first piece,' I replied, and wrote his words upon it.

"Soon the thirty-two-inch roll was removed to the re-winder, where it was slit and the edges trimmed, and out on to the storeroom floor rolled the first two rolls of Georgia newsprint, waiting only to be wrapped, weighed, marked and stored in the Canadian National car waiting for the shipment home.

"But we all waited for a break in the paper—a not uncommon experience in any newsprint mill. We wanted to see the repair crew do its skillful work. Hour after hour we waited, munching crackers and chocolate for supper. And still no break.

"About midnight, Henry Zieman said to me, 'The sulphite is going to run short. Shall I begin mixing in some of our sulphite and so be able to fill all of your newsprint orders?' It was an awful temptation for a moment; then common sense came to the rescue. 'No,' I replied. 'I have never yet faked my folks. They will have to stand a cutting down of their shares, for I want them to be able to say truthfully that every fiber in the sheets of their special issues were grown on Georgia soil."

"At 1:30 A.M. we were nearing the end of the run. The pulp supply was almost exhausted. As the last tailing of the sheet came over the reel at 1:45 A.M. I jumped for it, for I wanted that souvenir. Up came Henry, the superintendent, exclaiming, 'Not a break in a carload.' 'Write that down on this last piece of paper,' I replied. He did so. Then he tore off from the recording machine the permanent record showing that not a break had occurred during the entire run, saying I should have it so that my word would never be questioned on that point.

"What a load was lifted now that it was all over. Henry proceeded to inspect the entire machine and a little later came back to me saying, 'No sign of pitch anywhere.' 'Write that down on the same paper,' I replied. He did so. I was not surprised, for we had made our analyses before we left Savannah, but I wanted my friends throughout the paper industry to have the word of the man who made the run. It is difficult for them to believe, but it is true. And this fact assures a paper industry eventually for the South.

"On the following day all rolls were covered, labelled for the respective newspapers in Georgia, packed in the car, started on the return journey, which was quickly made in five days, and distributed for use on November 20—a day which I believe will mark the beginning of a new period of industrial and agricultural life in Georgia."

This account was printed on November 20, 1933, in the Savannah *Morning News,* one of the nine Georgia newspapers whose owners had assisted Herty by contracting for that run of paper and whose newspapers for that date were printed on Herty's stock.

Now Herty had his answers for the "newsprint experts" who had insisted that American chemists could not make from southern pine a sulphite pulp that would stand the speeds (750-plus feet per minute) with which northern spruce runs through modern paper-making machines. The answers were three small, ragged-edged fragments of paper, bearing the penciled notes of John Ball and Henry Zieman.

Interest in what was being done in that little waterfront laboratory was now fanned to fever-heat, not only in the South, where Herty began to be called "The Savior of the South," but among conservationists everywhere. For, in many parts of the world, conservationists had been developing alarm at the accelerated rate with which the United States press was becoming the great devourer of forests. In the previous five years four thousand square miles of Canadian spruce forest had, as Garvan put it, "gone down the sewers in the United States." It was estimated that the New York *Times* alone gulped two hundred and twenty-five acres every Sunday, and that the New York *Daily News* cleaned off sixty square miles a year.

Here, said the conservationists, was the answer: Southern pines whose growth in a year equals the five-year growth of the northern spruce! Here, said the southern editors, is new life for the South! There was a lot of enthusiasm in many places.

In the face of all that, you would think that Herty would have been throwing his hat in the air. Actually, he was doing nothing of the sort. He was dissatisfied!

Back he went to his unimpressive little laboratory, back down the waterfront street paved with rough cobblestones that Europe's ships brought to America as ballast in Colonial times. Back went Herty over the cobbles, muttering, "It'll do, but it's a bit flimsy, and I can do it better."

And he virtually buried himself until, in 1936, he turned out a kind of newsprint which he considered flawless. Those three years of wearisome experiments provided him with an even greater triumph. He had developed technics that could produce his paper much cheaper than the imported stuff.

To Herty's helpers outside his laboratory, this was big news indeed. In January, 1934, it was disturbing news to the established newsprint industry when A. A. MacDiarmid, chief engineer of Price Brothers and Company, Ltd., told convening members of the Canadian Pulp and Paper Association that Herty's research "appears to indicate that the undisputed position which northern wood has held in the newsprint field may soon be seriously challenged."

This Canadian engineer, having studied Herty's project closely, predicted that the cost-differential would constitute the most potent factor in the challenge. He showed that the maintenance of a perpetual supply for a five hundred-ton newsprint mill in Canada required about two thousand square miles of forest, and that a similar mill in the South could operate in three hundred square miles; that the climatic conditions favoring the growth of southern pines were favorable also to reforestation facilities and ease and continuity of logging operations; and he estimated that these factors alone would enable southern mills to obtain wood for from three dollars to four dollars less per ton than the lowest cost for Canadian mills. The sulphur requirements for southern mills, he said, would be filled from

Texas and Louisiana, which are also the sources of supply for the Canadian industry. Consequently, he added, the cost of southern newsprint paper would be less owing to the shorter transportation distances. His estimates that power-costs would be equal were made before TVA began to loom as a power-source and before a Texas group proposed that wasted natural gas from the oil fields be used as fuel. Other factors favoring the South, he added, would be lower labor costs and lower transportation charges for shipping paper to New York, Washington, Boston and Philadelphia from the mills in the coastal plain states of the South.

Summing up, the Canadian expert predicted that the United States could be expected to make its own newsprint paper in perpetuity and at lower cost than had been paid for the imported article. And he ended his forecast by pointing out that Herty's experiments had already doubled the United States production of kraft paper in the South and that this development had lopped off sixty per cent of the Canadian kraft exports to the United States.

If this were fiction, it would be nice to end Herty's story at this point with a verbal fanfare signaling triumph. But it is not fiction. It is cold and hard fact that a fanfare at this point would have to be the signal for the beginning of a battle. It may not make sense when you think about it superficially, but it is fact nonetheless that Herty was now resisted by the very people whom he had set out to help.

In May, 1935, when he addressed the first national conference of the chemurgists, he had to confine himself to discussion of his hopes that paper-making would become an industry in the cut-over pine lands and swamps of the southeastern States. But the realization of his hopes seemed as far away as joy. He had proof that southern pines—slash, loblolly, old field, longleaf and Virginia—could be grown as field crops, harvested when five years old and converted into paper. He had proof, certified by impartial authorities, that the South could furnish the nation's paper in perpetuity and at prices far below current rates for paper made from the slower-growing northern spruce. But, he admitted sadly, the millions necessary for the building of paper mills were hard to raise. Moreover, he had assembled more than a little evidence that northern newsprint interests were blocking the flow of capital.

"The paper industry," he said, "has not received these results with any warmth of enthusiasm. As a matter of fact, there are people who wish I were thrown into the Savannah River.

"The opposition has not come from Canadian sources. True, we have had trouble and misrepresentation, but it has come from our own people in the United States who have money invested in Canada. Do you realize that $403,000,000 of United States money was taken over into Canada to build their great mills and that over fifty per cent of the capital of Canadian mills to-day is United States money?"

Years before, the powerful newspaper publishers of the United States, watching mounting paper prices gulp their profits, invested heavily in the more profitable newsprint industry. Now, it was only human nature that made them wish to protect their private investments.

So, quietly and subtly, these vested interests put on the pressure. And, at that point, Herty's friend Garvan decided that this was a fighting Irishman's finest opportunity—a free-for-all fight with no holds barred. Garvan's telling wallops have been preserved for posterity in a group of pamphlets issued by the Chemical Foundation, containing letters he wrote to President Roosevelt and other government officials. One series of letters, published in pamphlet Number Four of *The Deserted Village* series, reads as if the fighting Irishman had used angrily flailing fists on the typewriter.

Garvan's letter to President Roosevelt proposed Federal investigation of Herty's project and Federal aid in developing the industry. But the letter was passed on to a minor bureaucrat who replied with a lesson in economics—the outmoded scarcity-economics confected of the cobwebby concepts of the decadent Machine Age. This wraith of brain-fog from a mind unfamiliar with the meanings of organic chemical synthesis threw Garvan into a purple rage; and Garvan, tossing off a lesson in what Billy Hale calls chemeconomics, decided that the appeal would again have to be made directly to the people of the United States rather than the people's servants in Washington. Thus it came about that, when Hale and Christensen approached Garvan with the proposal for a chemurgic forum, the Celtic blood was just hot enough in the Garvan veins to make him steam full speed into the planning of the first Conference of Agriculture, Industry and Science.

As a result, Herty's project got the support it needed, first from the kraft paper producers who were quick to see the benefits of moving south.

Herty's horizon began to brighten when Union Bag & Paper Corporation approved plans for a $4,000,000 plant in Savannah in June, 1935. The site selected for this mill was historic Hermitage Plantation which, founded in 1782, had served as setting in 1915 for David Wark Griffith's famous motion picture, *The Birth of a Nation.* From this site, Henry Ford removed Hermitage Mansion and the plantation buildings which he restored and placed on his estate on the Ogeechee River, fifteen miles south of Savannah.

Though this mill, designed to turn out dark and coarse kraft paper for bags and wrapping, did not represent the fruition of Herty's hope, it was a symbol of a coming change in agriculture in the southeastern states. Thereafter, paper became a hot subject in the South. Southerners were saying, "Prince Pine is sharing King Cotton's throne,"—saying it joyfully. And within two years the kraft paper industry was growing so rapidly that the National Farm Chemurgic Council was able to boast that the dozen mills built or started in the South were new chemurgic industries representing an investment of some $75,000,000 with an additional $40,000,000 going into harbor improvements, housing for mill-workers and purchase of forest acreage.

Not since the textile industry had begun its slow migration southward from New England had there been such a burst of industrial advancement in the South. Unlike the textile migration, this expansion was explosive. Within eighteen months after it began, the South's paper production doubled. Because of Dr. Herty, the forests of the South were being rediscovered at such a rapid rate that, in 1937, it was estimated the year's output of southern paper would fill four hundred and fifteen miles of box cars.

Some idea of the economic effects may be gleaned from a consideration of how the move to Savannah affected Union Bag. When the company's president, Alexander Calder, announced the move, the sixty-eight-year-old company's shares had sunk to five dollars because of annual deficits which had piled up even through the boom years of the late 1920's. One year after operations started in Savannah, the share values had increased fifteen hundred per cent and stockholders voted to split their holdings four-for-one.

Yet Herty's dreams for the South hinged on newsprint mills, which gulp a forest for every tree used by kraft mills. He was pleased because something was being done about the 440,000 tons of sulphate paper which the United States had been importing annually. But he was still concerned about those annual imports of 2,500,000 tons of newsprint and 1,000,000 tons of sulphite pulp. In his opinion, these were unnecessary imports representing a huge waste of labor, a flagrant destruction of Canadian natural resources and an enormous loss of southern buying power.

Two years later, Herty's dreams began to shape into reality. A group of newspaper publishers from Texas, Oklahoma, Arkansas and Louisiana assembled in Dallas and ordered the entire output of the South's first newsprint mill, for the construction of which a group of Texans proposed to raise $5,000,000.

Vice-President Ted Dealey of the Dallas *News and Journal* led the revolt of the smaller publishers by calling a meeting of southern newspaper executives in his home town. There Publisher James Geddes Stahlman of the Nashville *Banner,* who had been appointed chairman of the Southern Newspaper Publishers' newsprint committee, notified the assembled executives that, if they could raise the $5,000,000 required to build a mill, construction could be started immediately in East Texas. This proposed mill, he said, would be able to produce 45,000 tons of paper annually at around twenty-seven dollars a ton. The price of northern spruce paper was then forty-five dollars a ton and the producers were threatening to heave it up to around sixty dollars.

This was sweet music to the assembled publishers; but, though they agreed to take the proposed mill's output, they feared that $5,000,000 would be hard to raise in the South. Their fears proved correct.

The man who kept hope alive was Wirt Davis, chairman of Dallas' Republic National Bank. Davis had been Garvan's classmate at Yale University. After Garvan had tried in vain to interest eastern financial groups in the possibilities of Herty's discoveries, he remembered that his former classmate was now a banker in Texas and wrote him a letter. The letter was properly timed. It arrived on Davis' desk just after the Texas banker had listened to the Georgia chemist unfold his vision of a rejuvenated South at a meeting of businessmen in Beaumont.

Davis knew that the kraft paper mills were rapidly becoming the South's biggest industrial baby. Listening to Herty at Beaumont he had been fired by the vision of a renaissance in the South. And, when Garvan's letter arrived, he dropped everything to pursue the vision. Before long he was joined by Ernest Lynn Kurth, a land-owner and lumberman, and the two of them became Herty's missionaries in Texas. But the necessary capital for the mill was hard to raise. Promises of financial assistance from northern capitalists were no help at all. In fact, they were poison; for, when they came, Southerners who had been interested became suspicious. There was too much evidence that "damnyankee capitalists" were opposed to southern newsprint mills, they told Davis and Kurth.

Thus it came about that Herty did not live to see the fruition of his great dream; for not until December, 1938, did the Texans find the necessary $5,000,000. Of the funds required, $3,425,000 was put up by RFC which is headed by that Texan, Jesse Jones; $429,000 was contributed by southern publishers who contracted for the mill's production, and the rest was raised by stock sales. Then, early in 1939, in the little city of Lufkin, Texas, the rivet hammers began to chatter as the buildings and the huge paper-making machines were assembled for the Southland Paper Mills, Inc.

At the third chemurgic conference, held in Detroit, the Pioneer Cup was presented to these "Men of Texas, American Pioneers of the Twentieth Century." Eastern Texas was selected for the new industry's first unit because the area provided, besides sixty thousand acres of pineland, abundant water supplies (both spring-fed rivers and artesian supplies obtainable at from five hundred to fifteen hundred feet) and access to the cheap fuel supply represented by the millions of cubic feet of natural gas being wasted daily in the great Texas oil field.

7

What motivated the little Georgian? Profits? He had no pecuniary interest in any of the projects launched because of his efforts. Fame? He had made a name for himself as long ago as 1916, when the American Chemical Society elected him president, the greatest honor American chemistry has to offer.

To anyone acquainted with Herty, there was no mystery about his motive. When he spoke about his project (which was most of the time), facts and figures tumbled over one another in that soft, pleasantly persuasive speech of his. The facts and figures were all about the millions of United States dollars that the world's greatest consumers of paper were spending abroad, and the potential boons that would arise were those millions spent at home. Herty's motive was patriotism, not the easy flag-waving variety which Dr. Johnson associated with scoundrels, but the difficult, quiet kind which grows from a man's deep-rooted love for the country of his birth and a deep-rooted hatred for unnecessary evils which blight the homeland. Herty loved the South, loved it enough to be saddened by the squalor that was its distinguishing characteristic.

He knew that the nation's economic life could not be healthy so long as the South was backward. He wanted industry to discover the South, but he disliked the reasons for which many industrialists moved to the South. If he deplored the lower wage standards that attracted industry, he was, however, realist enough to know that, in the long run, the industrialization process would result in the rise of those standards.

While he was on his death-bed in the Savannah hospital, eight southern governors were telling an Interstate Commerce Commission examiner in Buffalo that the chief barriers to the South's economic improvement were the railroads' freight-rate disparities that favored the North. These disparities had grown naturally out of the fact that the railroads, fixing rates on the time-honored-basis of traffic density, had set higher rates for the relatively small amount of freight carried in the agricultural South, and had made no changes after the southern states began to become industrial.

The ICC hearing developed into a factional fight when a group of northern governors objected to the proposal of the southern group. Basis of the objections was the National Industrial Conference Board's report that wage scales in the South are substantially below the East and West even with lower living costs taken into consideration. In the battle of words that followed, a note of sanity came to the surface when Connecticut's scholarly governor, Wilbur Cross said:

"The South has God-given aids which even the ICC cannot match."

And, as that was being said, the flags on Savannah's city hall and courthouse dropped to half-staff as death claimed Dr. Herty, one of the South's most valuable "God-given aids."

Earlier in 1937, he had been denominated as "the man of the year for Georgia and the South." The honor came after January 15, when the first unit of a $9,000,000 pulp mill was dedicated in Fernandina, Florida, and Secretary of Commerce Daniel C. Roper congratulated the "Pioneer of the Pines" for his vision and leadership in the development of an industry which, though expected to reach billion-dollar proportions, was created out of material that had been considered worthless.

When that honor came to him, Herty revealed the real motives that had driven him to the point of exhaustion.

"I don't think of this thing in terms of dollars and cents," he said. "The development of this industry is going to mean the elimination of one-room houses for families, better food for those who are living on corn bread, better clothes for those who are in rags today. On the great coastal plain, a great mass of the population in the midst of the finest paper material have for generations endured the bitterest sort of poverty. The use of southern pine will change this."

On a May morning in 1939 a bronze plaque was ceremonially unveiled on the site of the South's first commercial newsprint mill near Lufkin. It bore the legend: ". . . this institution is the fruit of the genius and devotion of two great Americans, Francis Patrick Garvan and Charles Holmes Herty." At the conclusion of the ceremonies, Victor H. Schoffelmayer, the Dallas *News* agricultural editor who had done much to publicize Herty's ideals in Texas, filed his story under a new dateline. From Schoffelmayer's typewriter rolled five columns of copy headed:

HERTY, Angelina Co., Texas, May 27.—

CHAPTER VI

THE HERTY HERITAGE

1

To Dr. Herty a tree was much more than just so many pounds of wood. In his laboratory he laid down sets of rules which, if followed, will guarantee forests in perpetuity in the South despite America's increasing paper-hunger. It is a tribute to the man that the rules are being followed. Three months before he died, fears were expressed that the South's new paper mills would scour off the timberlands, repeating the wasteful destruction that had deforested the North. Herty replied to the critics with a report of another experiment. He had perfected a process for the conversion of black-gum wood into newsprint, a process which opened the way to the use of other semihardwoods and added an estimated 225,000,000 cords to the available timber supply. Later an Italian chemist discovered that chestnut wood could be used for newsprint. The discovery was not significant for Italy, where reforestation is a major problem, but for the United States it meant that vast stands of chestnut trees, killed by the blight, may now be used.

When Herty looked at a tree, he saw economic betterment. His little laboratory cost and spent about $500,000 in a little more than five years. From it came an industry from which the South gained a hundred million dollars in one year, an industrial renaissance which is expected to reach billion-dollar proportions. It is already lifting the living standards of the South to such a degree that President Roosevelt's statement: "The

South is the Nation's Number 1 Economic Problem," has been changed by Governor Hugh L. White to: "The South is the Nation's Number 1 Economic Opportunity." The President's statement was made in August, 1938. The Mississippi Governor's statement was made in March, 1939. Between those dates the South awoke. Generations hence, historians may decide that this awakening was the greatest heritage that Herty passed on to posterity.

In the southeastern states, where men's fears hinged yesterday on such problems of the cotton-economy as mechanical pickers, the movement of King Cotton's realm toward the Southwest and the unfair competition of foreign cotton, you will now hear Herty described as "the South's modern Eli Whitney." The common greeting in this area is changing from the old familiar "How's your cotton?" to "How's your timber?" The encouraging aspect of the new greeting is that it involves concern about conservation. The concern was not involved in the old greeting, for it is notorious that the South's one-crop economy was responsible for some of America's worst soil-starvation and erosion.

Herty saw to it that the new economy would be based on conservation. Under his direction, experiments were conducted in tree-farming, and the findings were publicized. It was shown that a return of $4.60 net profit per acre per year could be expected by transplanting slash-pine over 73.5 acres for operations based on a twenty-six-year rotation program. The report is significant when you remember that American agriculture has been traditionally short-sighted and that this experiment introduces a quarter-century plan in which the enemies of profit are shown to be erosion and forest fire. It acquires additional meaning when you recall that American paper-making has had a turbulent economic history because the industry's great mills invariably drowned in the red ink of deficits after their horizons were denuded of timber.

In March, 1939, the *Mississippi Forest and Park News* announced that "Herty Demonstration Forests," planned by Herty's former associates, are to be established throughout the South as Herty memorials and to provide forestry training and demonstrations to the public.

Herty's concept of a tree was unique. When he thought of trees, he thought of *all* forms of vegetation. His was the organic chemist's concept of trees as producers of organic entities concerned in what is called the carbon cycle of life. That cycle, in which plants and animals are mutually dependent for their sustenance and the very purity of the atmosphere they breathe, produces everything that man needs. In the plants' part of the cycle, the end products are carbohydrates—cellulose, starch, sugars, inulins, gums, etc. Progressing through the cycle, these end products degrade into vegetable oils, proteins and alkaloids. In the semidecomposition step, the cycle yields chiefly ethyl alcohol. (These three entities—carbohydrates, oils and alcohol—are called "Nature's Three Chemical Musketeers" by Hale in his book, *Farmward March.*) Final decomposition results in carbon dioxide and water which, uniting again, continue the life cycle.

In that first step in the cycle, the organic chemist deals with alpha cellulose, or high-grade cotton, and with starch and sugar. Since cotton is almost pure cellulose and a tree is mostly cellulose, the difference between the two dissimilar plants is virtually no difference to the chemist, in whose eyes cotton must not only compete with cotton but with trees.

In the second step, the chemist sees a fine future for American agriculture in the production of vegetable oils of which we now import huge quantities. And, in the third step, the cycle produces via fermentation the vast potential of ethyl alcohol upon which Dr. Hale centered his attention.

To grasp the meaning of the Hale and Herty aims you have to re-examine such common words as *wood* and *sugar* and *paper* and *cotton*. You must think of such words as having meanings that overlap. Then only does it become plain why more attention is now given to wood-chemistry than is given to the chemistry of metals.

"Wood," says Dr. Charles M. A. Stine, of the du Pont Company, "has become more valuable than gold."

That statement looks like an overstatement unless you can think easily of wood as the common source of such a miscellany as a Cape Cod cottage and its surrounding vegetation, a cotton shirt and the starch in its collar, five pounds of sugar and the paperboard of its container, the tobacco and paper and cellophane in a package of cigarettes, the olive and the alcohol in a Dry Martini, a rayon chemise and a strip of photographic film, the powder on the dressing table and the powder in a shotgun shell, the oil in a facial cream and the cleansing tissues that remove the oil, etc. When you think of wood in this manner, the lists of its uses seem fantastic.

The accomplishments of wood-chemistry become significant only when you begin to think about the modern American's use of wood. Take paper, for instance. When you think of how completely paper pervades your daily life it is something of a shock to realize that people are still alive who can remember when paper was a luxury. Man was making this stuff as early as 123 B. C. in China. Almost nine centuries elapsed before Arabs, capturing Chinese paper-makers in Samarkand, brought knowledge of the art to the West via Bagdad, Damascus, Morocco, Toledo and Venice. That Westward movement began in A. D., 750, but almost eleven more centuries passed before machines replaced hands in paper-making. The increased ability to produce paper caused the great shortage of cotton and linen rags which drove man into a search for substitutes that led to the woody fibers of trees. Only fifty years ago Americans saved paper—every scrap of paper that might be of additional use. Today, every man and women and child in the United States uses more than two hundred pounds of paper every year—uses it once and discards it. We use twice as much paper as meat—more paper than any other substance with the exceptions of water and milk.

Though paper is old, there is no substitute for it. On the contrary, the need for it increases because it is constantly being substituted for other things. It was chemistry that made possible both the plenitude of paper and the ability to substitute it for other things. Chemistry gave us the soda and sulphite processes that make paper cheaply from wood; and chemistry later gave us sulphate and kraft processes that make cheap paper strong. Because paper is cheap, it is now discarded by paupers. Every American uses annually more than fifty pounds of newspaper, one hundred and twenty postage stamps, more than eight pounds of fine papers and twenty-one pounds of books and magazines. The kraft process, toughening cheap paper, made possible the present annual use of four million tons of waste paper for tough paper. That ended the practice of marketing merchandise in bulk out of barrels and boxes, and provided every American with more than eighty pounds of paperboard and twenty-three pounds of wrapping paper.

The chemical research which produced the tough papers led into that currently expanding field of research which, turning out an endless succession of fiberboards, is producing from wood-wastes and straw and cornstalks, etc., new types of "synthetic" lumber which challenge lumber in its natural form as building material.

A half-century ago, the forests began to compete with the fields in supplying man with paper. Today, the forests, long the source of man's building material, are meeting the competition of the fields, as composition boards, fabricated on modified paper-making machines, use such woody fibers as wheat straw, cornstalks, flax and bagasse. Out of such materials man makes "boards" that are designed to serve special ends, such as insulation against heat and cold and sound, resistance to weather and abrasion, etc.

This new industry, though still in its infancy, is already indicating that it is capable of infinite expansion. Though it started to produce simple wall coverings in large and lightweight panels, its products are already entering hundreds of fields which the originators of fiberboards never foresaw.

The nature and degree of this industry's possibilities are best told, I think, in the story of William Horatio Mason, the inventor of Masonite.

In the spring of 1939, when the chemurgists met in Jackson, Mississippi, for their fifth annual conference, they were invited to visit Laurel, Mississippi, "America's one-hundred-per-cent Chemurgic City." What they saw was an old southern community humming with industrial activity. What they were told was that Laurel was a ghost town which had resurrected itself with chemurgy.

Not so long ago, Laurel was typical of the municipal derelicts left behind in America when the big timber operators scoured off the surrounding trees and moved on to other forests. Situated in an area denuded of its forests, Laurel's fine brick and stone buildings were the ironic reminders of a lush era of lumber profits that had passed. Laurel tried to keep up a fine front, but its only economic mainstay was the scrawny second-growth timber—the source of nothing better than a scrawny second-growth income.

About eighteen years ago, Mason, who had worked seventeen years as a research associate of Thomas Alva Edison, went to Laurel. Like Herty, his original interest was turpentine chemistry. Trying to develop methods of extracting turpentine from lumber while it was drying, he studied the physical properties of wood thoroughly. Just after he perfected his process, the price of turpentine fell. "I had to do something to keep the wolf from the door," he said, recalling his failure.

Mason noticed that sawmills used wood-wastes for fuel and wondered if this might not be expensive fuel. Those fibers and chemicals should have a greater value than mere fuel. But, he asked himself, how can the values be recovered?

He thought about it long and hard, putting into the thinking all the mental steam he could. He *had* to! Turpentine's price had tumbled from a dollar and a quarter a gallon to eighteen cents, and Mason was desperate. He thought about the great forests being ground through the whining sawmills for building material, of the insatiable wood-hunger that devoured in minutes the trees which required centuries to produce. *There* is the need, he said to himself, wondering if there might be some way to convert the scrawny second-growth trees, the stumps, the slabs, the chips and the sawdust into building material. If I can do that, he thought, there'll be no end of raw material for the building industry. The second-growth stuff shoots up like weeds, and small trees can be treated as farm crops while the forest giants grow slowly.

He discussed his idea with Laurel's businessmen. They decided they had nothing to lose by helping him. With their backing, he launched the research which perfected the method of tearing woody fibers apart by explosion of high-pressure steam. The discovery was not without an element of accident. Mason, pulping wood by exploding it instead of grinding it as the paper-makers do, retained in the fibers that mysterious chemical, lignin, which the paper-makers remove chemically and wash down into the sewers. In trying to get a cheap short cut from lumber to pulp, Mason discovered that the lignin became a tough self-bonding cement when the wood fibers were steamed and subjected to heat and pressure.

The result was Masonite, the tough building material which now goes all over the world. It replaces raw wood in many places because its interlocked and lignin-bonded fibers make it superior to the raw slabs of forest wood which, their fibers lying all one way, have a tendency to split.

There are more than a score of wood chemists in the Laurel laboratories of the Masonite Company now. They are finding hundreds of new uses for the chemicals in the stumps that big lumbermen left behind. They have recently perfected processes whereby the sawdust and the chips are steam-exploded and pressed into great slabs of plastic material having the feel of marble and some of the strength of metal. It is called Benalite, and it may be the forerunner of that plastic automobile body which Henry Ford predicted many years ago. Only the other day, a Swedish engineer, visiting the United States, revealed that German plans for the government-built *"Volkswagen"* (the proposed automobile for the German masses) call for a body built entirely of plastics.

Recently, Mason's research associates turned their attention to the chemicals which are normally washed out of wood in the regulation pulping processes. These chemicals, a great source of stream-pollution where paper mills operate, are being recovered by Mason's men who have made them yield such wood sugars as pentose and hexose, and considerable amounts of acetic and formic acid, besides a large number of chemicals not yet clearly defined.

"It's impossible to say just what products will be made from these solubles," said Mason, "but we have made furfural from the pentosans, and butyl alcohol, glycerine, citric acid, etc., from the hexoses. . . . I realize that we have probably not scratched the surface."

Mason refuses to hazard a prediction of what the future may bring to the South. He doesn't need to. All that is necessary is a look at Laurel, the chemurgic city that was a ghost town yesterday. Talk to the folks in Laurel about "the European situation" and you get about the same reaction as you would if you tried to discuss the spiral nebulae of Andromeda. Europe is as remote as Arcturus to Laurel's inhabitants. They're thinking about America, and the fine future for America burgeoning in the South because of such dreamers as Herty and Mason. They'll talk to you about pine oil which Mason's men are sucking out of the Mississippi stumps. They even carry bottles of the magic stuff around just to illustrate the discussion. They'll tell you to an ounce how much Asiatic starch the United States imports every year because it has special qualities which American industries demand. If you're willing, they'll take you out to the site of their newest chemurgic industry, the mill producing from Mississippi's sweet potatoes a starch superior to the imported stuff. And they'll tell you that it wasn't a chemist who discovered the superiority of sweet-potato starch. No, the old Negro laundresses of the South knew it first. Long before the chemists investigated, the Negro mammies mashed the potatoes that they called "nigger-chokers" and soaked them in water which they then drew off and boiled for a starch whose fineness you can feel with your fingers.

And, before you get away, these men of Mississippi—their Governor White has invited chemurgists to use the state as a laboratory—will tell you about the tung-oil boom. It has electrified southern Mississippi—a Gulf Coast chemurgic project. It roared into high gear when the Mikado's slit-eyed ruffians bottled up the source of the valuable industrial oil which Marco Polo spoke about, the marvelous Chinawood oil from which the artisans of Cathay produced their remarkable enamels. With the Oriental supply cut off, the industries of the North are having to turn to the South for tung oil. And the South's hundred thousand acres of tung groves are bringing a hundred million needed dollars to a part of the nation which needs desperately the things those dollars can buy. Beyond the horizon of this chemurgic frontier there is the beckoning hope that the new tung-processing machinery will bring to the Gulf States the $20,000,000 that Americans have been paying annually for 176,000,000 pounds of imported tung oil.

Truly, as the Laurel folks will tell you, the South is discovering the wealth in trees, capturing the vision of Charles Holmes Herty.

What about cotton? As the chemurgists met in Jackson, Mississippi, a strange thing was happening in the surrounding countryside. All over the South, old habits, stronger than chains, were pulling men and women into the fields to plant another crop of a plant whose white-bolled fruit nobody needs. More cotton! Bulging in the warehouses, eating up $123,000 a day in rentals paid out of the United States Treasury, were more than 11,000,000 bales, about twice as much as the nation can use in a prosperous year. In Washington, while the South's planters patiently prepared to increase this hoard of excess cotton, legislators racked their brains for a solution of the problem. The legislators were thinking of cotton as *cotton,* the stuff of which textiles and garments are woven. The chemists, on the other hand, think of cotton as pure cellulose—another tree, containing the wealth that lurks in all trees.

As an immediate solution, the chemists and the chemurgists look, not to the legislators, but to the experimenters in the textile-school laboratories of North Carolina State College of Agriculture and Engineering. From those laboratories came the brain sweat that is putting cotton fabric into highways. In 1937 and 1938 more than 10,000,000 yards of such fabric, which highway engineers call "lace curtains," went into more than one hundred miles of experimental "cotton roads" in North Carolina alone. The fabric is now being used experimentally on about a thousand miles of highway in more than twenty-five states. The experiments, conducted over a five-year period, already indicate that the expansion of this use of surplus cotton will have a number of good effects on the nation's economy. Its immediate aim is the reduction of the huge accumulation of surplus cotton in the world's markets. Its secondary aim is the improvement of farm-to-market roads. Though the experimenters point out that it is not an attempt to supplant the use of cement on highways carrying main streams of heavy traffic, they have demonstrated that the use of fabric as a binder of bituminous road-surface to crushed-rock base eliminates the water-seepage which causes "raveling" at the edges of side roads and necessitates the re-surfacing of some forty thousand miles of highway every year. Highway engineers are interested because the additional first cost—from $800 to $1,000 a mile—may eliminate high maintenance costs. Cotton-growers and textile manufacturers are interested because each road-mile requires from five to eight bales of cotton. Here is a possible new use for about a third of a million bales of cotton annually. But, though the merits of this proposal have been proved in a number of states, there is opposition. Clinton T. Revere, who has devoted years to the study of cotton roads, sadly admits that there is powerful opposition, an opposition hinted at by the southern cotton planter who asked Revere, "Don't you know that the most coveted political job in the South is not the governorship but the post of state highway commissioner?"

The cotton road is one of chemurgy's proposed solutions for the problem of surplus cotton. There are others. There is, for instance, the trick of putting cotton shirts on wieners, the cellulose-derived synthetic sausage skin called Visking which the Mellon Institute researchers developed. The average American eats about twelve pounds of sausage a year. Putting that sausage in a cotton-derived "skin" may not make a large dent in the cotton surplus, but it puts into the American market the nickels and dimes which formerly went into hiding in European peasants' socks and mattresses.

But with chemists tackling the cotton that has become a pestiferous problem to legislators, the very nature of the cotton plant may shortly change. Originally its seed carried soft tufts so that the wind could scatter them. When man learned to value these tufts as the source of textiles, cotton was subjected to selective breeding which increased the tiny tufts to long fibers. Now, there being too many of these long fibers on hand, the selective breeding may move in the opposite direction. Recently plant scientists at the Texas Agricultural and Mechanical College announced that they had perfected a cotton plant whose bolls contain many seeds but no fiber. "Bald-headed cotton," they call it. Cotton seed yields the valuable oil which Americans use in enormous quantities in shortening, oleomargerine and soap, etc., but which is largely imported. While the Texas scientists were working on tuftless cotton, a group of engineers were perfecting revolutionary cottonseed-oil processing equipment in the University of Tennessee in co-operation with the Tennessee Valley Authority. This mechanical research, backed by the Engineering Foundation of New York, is expected to increase by 45,000,000 pounds the South's present annual cottonseed-oil production. It is also expected that the processes, adapted to other oil-seed crops, will increase the American production of oils from soy beans, peanuts and flaxseed.

America's supply of vegetable oils has been inadequate for many years. As American use of the oils expanded into dozens of industries, our imports from Brazil, the Netherlands, India, China, Manchuria and Egypt increased. With the simultaneous perfection of vegetable-oil processing equipment and seed-prolific cotton plants, the South and the nation move another pair of steps closer to the realization of the Herty dream of self-containment.

4

"Wood," says Dr. Stine, "is more than wood to the chemist. It is cellulose, and veritably cellulose is a magic material. Wood was wood in the old days not so long gone, and cotton was cotton, but it is a clever chemist who can recognize them in all of their forms today."

And, he might have added, the chemist does not exist who can honestly say that he knows what cellulose is. Dr. Wanda K. Farr, of William Boyce Thompson Research Institute, is one of the world's greatest cellulose chemists. At the 1936 conference of the chemurgists she admitted there is so little definitely known about this mysterious stuff that the best the chemist can do in the way of defining it is to compile a long list of uncertainties about its basic properties. It has no known fusion point. It will not dissolve in ordinary solvents. Its molecular weight is undetermined. Even its chemical formula is uncertain. Of the little known about it, the most significant fact for man is that it forms the cell walls of all plants, being most readily available in trees and cotton.

Thus, as cellulose and its derivatives, trees and cotton plants enter into literally thousands of remote fields in infinite variety of forms. The possibilities of its use seem to be limitless. Chemurgists recognize this. Politicians are slow to realize it.

Looming larger and larger as a factor affecting farm-derived textiles is the fact that man has made drastic and rapid changes in his method of clothing himself. Formerly the demand was for natural qualities in the fibers from which clothes and furnishings were made. Man wanted expensive broadcloth and durable laces, pure silk and real leather. He scorned shoddy and common prints.

Today the emphasis is on surface appearance. Few buyers care whether the original of a textile was sheep, silkworm, cotton boll, cottage cheese or a pine tree, or whether it was a blending of chemicals and cellulose or chemicals and protein. Man now buys fabrics to delight the eyes or the skin, buys them at a price that enables him to enjoy variety and permits him to discard without pain whatever ceases to delight. He is leaving behind the expensive crudities of the nineteenth century textile and garment industries. And, catering to man's changing wants and needs, chemical research is upsetting age-old practices in the business and industrial worlds.

To the non-chemist, cotton is still cotton. Some time ago, when automobile tire-makers announced that rayon would soon replace the cotton threads of which 280,000,000 pounds went into tires in 1937, editorial writers in daily newspapers announced that this would cut off one of the biggest customers of cotton farmers. They forgot that rayon is very often disguised cotton, as truly a cotton fabric as calico.

It is easy to forget such facts which are obvious to the chemist—easy because we have not yet become acquainted with rayon and its sister "synthetics." These man-made fibers have not been with us long. Only forty years ago Chemist Arthur Dehon Little returned from a tour of European laboratories and, his imagination fired by the possibilities he saw in a new fiber called rayon, tried to raise the $55,000 necessary to buy the American production rights—and was given the frozen stare by financiers.

Today, the world production of these synthetic fibers, the blood children of field and forest, is valued at more than half a billion dollars. In the last ten years, perfected production methods have cut prices from three dollars to less than one dollar a pound. In twenty-five years production grew from 320,000 pounds to 250,000,000 pounds. The rayon industry alone now uses annually the cottonseed linters grown on 6,600,000 acres.

Despite the present superabundance of cotton, the uses of cellulose are expanding daily. It goes into photographic film, fingernail polish and toothbrush handles. Fully half of all women's shoes, and a growing percentage of men's shoes, are no longer sewed, nailed nor pegged, but are fastened together with a cellulose cement. The lumber camp and the cotton patch contribute to modern shoe buckles, eyelets, lace tips, and the scuffless coating on women's high heels. The cotton linters from 300,000 acres go into smokeless powder annually. Plastics in automobile safety glass, fountain pens, buttons and toiletware, take the linters of a million acres a year. For lacquers and varnishes an additional million acres are required.

Only yesterday Dixie's cotton became just thread and garments, and wood was used primarily to build and furnish and warm man's shelter. Today, largely due to such men as Dr. Herty, wood and cotton are being adapted more closely to man's growing needs. Shortly before he died, Dr. Herty extracted from pine a kind of fat resembling that obtained from animals. What may come of it? Who knows? Pine oil was found in old dead stumps when men turned to them for turpentine. It wasn't present in live pine trees. And, after they found it, chemists didn't know what to do with it. Then someone discovered that it had a valuable function in the flotation process for recovery of rare metals from low-grade ores. The United States Public Health Service found it was a good and cheap disinfectant. Then, for a time, changes in naval stores plants removed pine oil from the field of importance. The textile industry, turning to synthetic fibers, introduced a new need for pine oil; and, becoming plentiful again, pine oil was reexamined and found to contain the terpene alcohol, terpineol, which had heretofore been synthesized from turpentine. They are still dragging chemicals out of pine oil and turpentine. Only a few years ago, Americans were entirely dependent on the Orient for camphor. Today, American chemists *make* camphor from turpentine and pine oil, make it at costs far below those that prevailed when Oriental camphor's price included the miserable slave-wage of coolie labor. Because of that accomplishment, the medicinal uses of camphor are now overshadowed by the industrial uses.

In the face of such facts, who dares say that self-dependence of a nation is a daffy dream? Who dares say it? It is being said every day. Being said over and over by the self-styled "expert commentators" who profess to know the hidden meanings of the mad maneuvers of Europe's plundering and blundering "statesmen." For instance, when Hitler, threatening the peace of Europe, declares that Germany no longer fears starvation as a result of an embargo, few "expert commentators" observe the meaning of the declaration. Dr. Herty would not have missed the significance, for he knew that the lack of sugars and fats was the principal factor that wrecked Imperial Germany in 1918, and he was well aware of the economic meanings of the discovery which his friend, Dr. Bergius of Heidelberg, announced on Christmas Day in 1933. Bergius reported his success in the perfection of a process by which sugar can be derived from wood. You will remember him as the chemist who shared the 1931 Nobel Prize with Carl Bosch for the development of the hydrogenation process which makes cheap coal yield gasoline.

The meaning of his later discovery is this: Germany will not starve, because Germans can now eat German forests. The Bergius wood-sugars, extracted from any and all forms of wood-waste, can be neutralized, used as carbohydrate cattle feed and for fattening pigs. The nutritive value, he says, is about the same as that of barley. Subjected to inversion, it can be fermented and will thus yield alcohol, lactic acid, yeast and glucose. Its alcohol yield is slightly less than that of normal cane sugar.

For the overpopulated and industrialized nations of Europe, therefore, wood may become an important factor toward independence of food supply as the coal hydrogenation process moves these populations toward independence of foreign oil supplies.

Out of wood, Bergius gets foods. Out of the same wood, another German chemist recently produced the transparent cellulose food containers of which the German canning industry, lacking cheap tinplate, used 133,000,000 in 1938.

And, out of this same wood, thanks to Dr. Herty, the United States is now deriving new sources of wealth as a basis for a "more abundant life" in the South he loved.

The little doctor did not live to see the flowering of the dream that he and Hale nurtured on a rainy day in Michigan, but he saw to it that he would continue to participate in the fruition of the dream, even after his death. For, as the riveting hammers began to chatter on the girders of the South's first newsprint mill in Lufkin, Dr. Charles H. Carpenter and Herty's former associates announced that the Herty heritage would be a continuation of his experiments in the little West River Street laboratory with the bent-nail lock on the door. The researches will be continued by the Charles Holmes Herty Foundation, devised by the little doctor, created by Georgia's State Assembly and financed by several states. The objectives will be the demonstration of new uses of southern woods for pulp and paper and the publicizing of the social and economic potentialities of such wider utilization of the South's flowing resources. In addition, his conservation program is being carried on by Donald R. Brewster, the forestry specialist who was his friend.

"Surely he still lives," said Dr. Herty when death took his friend, Francis Garvan. The remark may stand as the epitaph of the Pioneer of the Pines.

CHAPTER VII

GARVAN—A CAREER OF CONTRASTS

1

FRANCIS PATRICK GARVAN's mind was the catalyst that transformed vagrant and undisciplined ideas into the potent reality of chemurgic action. Herty admitted it. Hale admits it. So does McMillen.

Yet, on the face of it, there's no reason why Garvan, most urbanized of verbalists—a Manhattan lawyer—should have converted chemurgy from concept into crusade. "Although I was born on a farm," he said, "I do not dare to talk to a farmer in his language. I know little of chemistry. I had a classical education, and therefore I always stand in fright when I face chemists. Successful businessmen to me are the marvel of the world. I know nothing about their mental capacity to achieve the great results which they do."

Yet this man, whose education stressed verbal rather than operational excellence, became the fusing element for a movement confected by and for and of such thoroughgoing operators as farmers, chemists and manufacturers!

Scarcely anything in the amazing career of Garvan makes sense. It's a protean career in which successive personalities, all of them Garvan, emerge one from another and present queer and astonishing contrasts. It is a confusing catalog of contradictions—until you discover the clue to his vocation. And when the clue is found, his career unfolds amazingly in the perfect pattern of fiction. The perfect pattern of fiction? If an author were to build a fictional narrative on the facts of the last twenty years of Garvan's life he would be criticized for trying to make readers swallow an incredible sequence of improbabilities!

Consider the facts.

In November, 1917, Garvan, a deserving but undistinguished member of the Democratic Party, was rewarded with the political job of managing the New York office of the Alien Property Custodian. "The luck of the Irish!" said his friends. They recalled that this same "Irish luck" had lifted him into the glare of publicity as one of the brilliant forensic performers whom the great District Attorney William Travers Jerome had assembled during the trial of Harry Kendall Thaw for the murder of Architect Stanford White. "The luck of the Irish!" said others, remembering his marriage in 1910 to Mabel Brady, whose father, Anthony Nicholas Brady, had amassed an $80,000,000 fortune as an organizer of public utilities. "The luck of the Irish!" said the envious, coveting the fat opportunities for nest-feathering in this political job, with its possibilities for mismanaging the precious chemical patents which the people of the United States had confiscated from the German cartel.

Two months later, "Irish luck" had become an unsmiling thing. In January, 1918, there were already abroad in the land a few scattered cases of the influenza which, in the ensuing twelvemonth, was to become a more devastating destroyer of human life than all the implements of warfare then concentrated on the business of mass-murder in Europe. In a hospital in Washington, D. C., lay five-year-old Patricia, the Garvans' first-born, a pretty blue-eyed child whose attack had developed into a streptococcus infection and then into that deadly scourge of children, rheumatic fever. The best medical minds in the nation were assembled at her bedside. "We're helpless," they said. For seventeen horrible days, a small heart, its valves and muscles ravaged by the round-bodied microbic killers, struggled to keep the spark of life in the pain-tortured little body. "Helpless," said America's best medical scientists. Helpless, despite the Brady wealth and the Garvan power. Helpless, because that tiny heart was struggling with microscopic murderers about which the best minds knew less than nothing. Death alone was not helpless. Death ended the ordeal.

Now skip down the years to the morning of May 25, 1937. The third annual conference of the chemurgists has just been opened in Dearborn Inn by William J. Cameron, the man who provided Billy Hale with his first editorial recognition. He has just told the chemurgists that they are surpassing the dreams of the alchemists who, centuries ago, sought futilely the gold in common things and the priceless treasure of good health. This council of yours, he has told them, combines the actual and the prophetic, confirms prophecy by practical demonstration. "Not only have you surveyed the course that progress is to take, but you have already begun to build the highway."

As Cameron sits down and the crash of applause smothers the bird song beyond the Inn's Georgian windows, you look about you and spot the chemurgic highway-builders. There's Henry Ford, cupping his ear to catch the conversation of his table companion, Dr. Heber J. Grant, the tall and grizzled patriarch who is president of the Latter Day Saints, and whose eighty years stretch back to a time when, he remembers, it was usual for him to have to remove his hat to prove Mormons are not horned devils. There is boyish Edsel Bryant Ford, president of the Ford Motor Company, chatting with Dr. Karl Taylor Compton, one of the four famous Comptons for whose shaping into greatness Mother Otelia Compton acquired fame as "the Grand Old Lady of Wooster, Ohio." There are the inseparable Hale and Herty, together again and radiantly happy about it. There is that silver-crested symbol of the National Grange, Louis J. Taber, whose friendliness has done wonders in convincing the members of the nation's oldest farm organization that chemurgy can weld agriculture, industry and science into an invincible economic trinity. Beside Taber is D. Howard Doane, president of the American Society of Farm Managers, who manages thousands of farms from his St. Louis headquarters. You catch sight of the wind-chiseled features of General Robert E. Wood, the plain-speaking ex-cavalryman who, as head of Sears, Roebuck and Co., knows full well how inextricably interwoven are the destinies of farm, factory and finance, and who likes to crack the tough shells of economic problems and exhibit some such kernel as: "A married man drawing twenty dollars a week is no asset in a capitalistic economy." And, near the door, you catch just a glimpse of a jet-black face and a white woolly poll—Dr. George Washington Carver, the world-famous Negro chemist, listening to the after-luncheon oratory from the hallway because, as he quaintly puts its, "Some folks might object to my presence at the table."

There is Dr. Howard W. Odum, the eminent sociologist of the University of North Carolina. There is Dr. John A. Widtsoe, the fatherly little man with the white-tufted chin, who directed the Utah Experimental Station, headed the School of Agriculture in Brigham Young University, presided over the Utah Agricultural College and the University of Utah, sits on the Council of Twelve of the Mormon Church, and carries the chemurgic torch in the West. There are Dr. Henry A. Barton, director of the American Institute of Physics; Dr. Paul F. Cadman, San Francisco consulting economist; John Shannon, a share-cropping farmer from Jonesboro, Arkansas; Charles D. Reed, government meteorologist; Harry H. Straus, New York manufacturer of fine papers, who loves his adopted America enough to want to back the chemurgic research which, he believes, will enable our farmers to raise the flax and hemp which he now has to import for our Bibles, our cigarettes and our carbon paper. There are several hundred men and a few women, drawn together from all parts of America and from every stratum of life, waiting to hear more about chemurgy and the progress it has made, and . . .

The applause thins and dies. Carl B. Fritsche has introduced "the original organizer of this council—the man who has lived his life for his fellowmen . . ." Garvan, "the original organizer," is on his feet, grinding his cigarette into an ash tray, a faraway look in his blue eyes, the corded muscles visible above that tight-clenched pugnacious Irish jaw of his.

"I am going to talk to you today by means of parables or stories which, I believe, illustrate this movement," he says. "I think you can translate their meaning, once I have told them."

And Garvan, his far-seeing eyes focused beyond the walls of that dining room, recalls the tragedy which entered his life in January, 1918.

"Then and there," he says, "my wife dedicated her husband and her wealth and her life to see to it, if she could, that other children would not be called upon to go that way.

"Almost twenty years have gone by. It has been a long, hard-fought struggle of research, of co-operation, of freedom of discussion and of earnest endeavor to benefit mankind. During the past year that result has been accomplished. No other child in America need ever go that way from streptococcus infection; nor any older person need ever go that way.

"We don't know how it happened, but it has been found that a basic chemical known as sulfanilamide, a development of the dye industry, either weakens the streptococcus or strengthens the white corpuscles until it is curing many, many cases."

Garvan did not mention the powerful parts he and Mabel Brady Garvan played behind the scenes of this twenty-year struggle of the microbe-hunters with those tough round-bodied assassins in the coccus family. He merely sketched the outlines of the struggle, distributing credit to scores of researchers; and, stressing the fact that the triumph was the fruit of co-operative effort, he explained that this experience had made him "a little bit nutty on the subject of co-operation," a kind of "nuttiness" which, he added, could carry the chemurgic idea to magnificent accomplishment.

In his brief talk, Garvan expressed the hope that, before long, the line of dye-research which had produced sulfanilamide would produce an effective weapon for combat with pneumococcus, the destroyer that brings death to about a hundred thousand Americans every year.

Now turn over the calendar to November 7, 1937, exactly twenty years after Garvan was lifted from obscurity into a political post that introduced the lawyer to chemistry. It is just a little more than six months after Garvan expressed his great hopes for the future of sulfanilamide. You are again in a sickroom. Outside, in the Manhattan streets, the newsboys are peddling papers, carrying stories about a mounting toll of deaths resulting from a chemist's error of employing diethylene glycol in the manufacture of an elixir of sulfanilamide as a cure for gonorrhea. The stories of that day are written around the American Medical Association's report that a total of sixty deaths have been attributed to this patent medicine. The report would be alarming to the sick man, for he is Francis P. Garvan. But Garvan does not know about the alarming news of the drug he helped introduce, for he is fighting for breath, while the best medical scientists stand helplessly by, watching death deliver him from the strangling grip of pneumonia.

Now you come to the most ironic twist in this amazing story. You come to it by leaving Garvan's deathbed and darting across the Atlantic Ocean to Dudley Road Hospital in Birmingham, England. There, at this moment, Pathologist Lionel Ernest Howard Whitby is winding up a series of remarkable experiments with mice that he has shot full of pneumococci and saved from death with one of the thousand relatives of sulfanilamide. The stuff Dr. Whitby has been using bears the jaw-dislocating name, 2-(*p*-Aminobenzenesulfonamido) Pyridine, but its manufacturers call it M. & B. 693. Dr. Whitby is through with his mouse experiments, for the stuff has been tried out on dying humans and seems to be completely effective as a weapon against death from Pneumonia Types I (the most common), VII and VIII, and seems to lessen the severity of all other types.

But the medical experimenters are cautious. Quietly testing the new drug on human patients whom nothing else can save from the suffocating death, they restrain their mounting enthusiasm, keep their fingers crossed and their lips tight as another year rolls around. Then, in March, 1939, sixteen months after Garvan died, the announcement comes quietly through the United States Food and Drug Administration that the drug with the jaw-twisting name, now called sulfapyridine, has been licensed for sale as a physicians' weapon against the nation's third biggest killer. In Dallas, Texas, Harvard Professor Charles Fremont McKhann informs the members of the Southern Clinical Society that "people just won't die from pneumonia any more."

What was the part Garvan played in this campaign against disease? And what has all this to do with chemurgy? To get the answers to these questions you have to examine the Garvan career more closely than it has been sketched here, and you have to go behind the facts of that career as outlined in his *Who's Who* autobiography. For, though his enemies (he made a lot of them!) will tell you hotly that he was a grandstand player, and his friends (he made a lot of them!) will admit that he was at his best when on his feet before an audience, it is not the greatest nor the least quixotic fact about this man of contrasts that he managed to hide much of his light under a battery of baskets. Garvan's motto might well have been Whitman's line, "Very well then, I contradict myself."

Before Patricia Garvan's death there was little in his life that set it apart from the mine-run biographies of the well-to-do. He was born in East Hartford, Connecticut, on June 13, 1875, the son of Irish-Catholic parents who sent him to Yale, Catholic University and New York Law School. He practiced law in Manhattan for a year, became assistant district attorney at the turn of the century, shone briefly as a prosecutor in the Thaw case, and married on June 9, 1910.

Marriage into a wealthy family often ends the promise in a promising career. Marriage into the Brady family was, however, no prelude to a life of uselessness. The Brady millions had been amassed by Anthony Nicholas who remembered with deep gratitude the opportunities America showered on him when, an immigrant boy from Lille, France, he settled down in Albany, New York, and opened a tea store at the age of nineteen. His family, not forgetful of its origins, was famed not only for its fabulous wealth but for its much more fabulous philanthropy. In 1906, Garvan's comely sister Genevieve married Anthony's son, Nicholas Frederick, the Manhattan utilitarian who, converted to Roman Catholicism, was called "the greatest lay Catholic" when he died in 1930. After her husband's death, Genevieve Garvan Brady continued the Brady tradition for employing wealth as a means to goodness and piety, continued it so effectively that, when she died in 1938, she was known as "the Lady of the Lamp" and had been honored with the rare title, "Papal Duchess," in recognition of benefactions which overflowed the boundaries of her creed. Incidentally, in 1936, Genevieve Garvan Brady's Long Island mansion, "Inisfada," which was later given to the Jesuit Order, was the headquarters of Eugenio Cardinal Pacelli during the American tour of the future Pope Pius XII.

When Garvan followed his sister into this exceptional family, the stage was set for a career of usefulness to society. The stage was set by Mabel Brady Garvan of whom it has been said that she is that rarity, "a wife who is both compliment and complement to her husband." This was said in 1929, when the American Institute of Chemists, after pondering whether to honor the lawyer or his lady "for noteworthy and outstanding service to the science of chemistry . . .," decided the intelligent thing to do was to honor them jointly.

Reason for that honor and for the prized Priestley Medal, which the American Chemical Society awarded to Garvan in 1929, was a series of accomplishments in American chemical and medical laboratories traceable to the vocation upon which the Garvans were launched by the loss of their child in 1918.

Instead of blaming medical science for that loss, this couple faced the cold fact that it had been handicapped by the same lack of interest in science that had been responsible for the nation's dependence on Germany for virtually all chemicals.

Dr. Herty, Garvan's scientific adviser at the time, once recalled that, shortly after Patricia's death, Garvan called to his attention a magazine article urging the need of more organic chemistry in medical research. Shortly afterward, Herty said, Garvan announced grimly that he proposed to dedicate his entire energy to the job of breaking the grip of the German chemical cartel on the people of the United States. He planned to tackle it by encouraging the research which "would save others from the suffering he and his family had experienced."

Garvan said the idea grew out of conversations with Mrs. Garvan who was thinking of endowing a foundation "to fill in the large gaps of medical and chemical knowledge."

However it started, the idea was discussed by Garvan with his chief, A. Mitchell Palmer, the Alien Property Custodian, who later discussed it with President Wilson. At first, it was believed the idea might be translated into something that could be administered by a government bureau. But there were no legal means whereby such an organization could be made a part of governmental machinery. Then, Garvan having offered to head the proposed organization without pay, the plan was given further study by Palmer.

On March 3, 1919, when Palmer, appointed Attorney General, handed his resignation as Alien Property Custodian to President Wilson, he recommended Garvan as his successor. The President approved, and, at this White House conference, the three men translated Mrs. Garvan's idea of *a* chemical foundation into *The* Chemical Foundation, Inc., a semi-public trust to serve the people of the United States as a clearing house for scientific research in chemical and medical fields. Its first act was to buy for $271,850 the 6,400 German chemical patents that the government had seized during the World War. These patents were licensed to American chemical producers on a nonexclusive basis. This action changed the United States chemical industry from a feeble thing into a lusty giant that later paid millions into the Foundation treasury. And, since Garvan was in control of those millions, he became the target for the dead cats the invidious invariably hurl.

Garvan took the criticisms in silence, though the easy-smiling Irish face was becoming more and more the slit-mouthed, jut-jawed mask of a man determined to act without bothering to explain. Behind that mask was a man fired with a vocation. As the millions rolled in, Garvan gave them away—to scientific institutions, to universities, to individual researchers, to student funds and prizes, for the publication of scientific journals, and for the distribution of books popularizing science.

Only recently has it become known that when Foundation funds were inadequate, the Garvan funds were tapped. Mrs. Garvan, for instance, supplemented the educational program by financing, as a memorial to Patricia, a national High School Essay Contest conducted in every state by the American Chemical Society. Many Americans owe their interest in science to the fact that they were selected as judges.

And many Americans owe their knowledge of the work of Louis Pasteur to the propaganda which Herty and Garvan conducted when they used Foundation funds to distribute large quantities of R. Vallery-Radot's biography. Other books that the Foundation put into the hands of American readers were *Discovery: The Spirit and Service of Science, What Price Progress? Chemistry and the Home, American Chemistry, The Romance of Chemistry, America Self-Contained, A Bubble that Broke the World, The Farm Chemurgic, The Advance of Science, Man in a Chemical World, etc.,* plus such Foundation-published books as *Chemistry in Industry, Chemistry in Agriculture, Chemistry in Medicine, The Significance of Nitrogen,* and innumerable pamphlets—all told, a distribution of more than 30,000,000 pieces of educational literature.

But, these things were done *after* the millions began to roll in. Before they could be done, it was necessary to protect the industry that was to pay the millions into the fund.

As we saw in the stories of Hale and Herty, the post-war resumption of imports brought the threat of throttling competition by the German cartel to an American chemical industry too weak to stand rough handling. Garvan urged the War Trade Board to continue certain embargoes, at least until American chemical manufacturers could meet the foreign competition. Refused, he went before Congress and turned on the kind of oratory which once brought him distinction as a prosecutor. It worked. In the last five minutes of the session, after everyone else had given up hope, Congress granted his request.

This sortie into the legislative halls made him turn to crusading. It was then that he called for chemists who could talk to the people, and drew Billy Hale into the partnership that was to produce the chemurgic movement.

"Never resort to logrolling in any effort with Congress," he told his lecturing chemists. "Educate the people," he said, echoing Herty. "With such education accomplished, Congress will protect you." And when the Fordney-McCumber Act, with its protection of chemical industry, was enacted in 1922, it appeared that Garvan, the crusader, would be shelved to give elbowroom to Garvan, the educator.

But it was not long before the invidious again began to mouth the question, "What's Garvan up to?" Suddenly, out of the fog of rumors came the demand from President Harding for the immediate return to the government of the seized patents which the Foundation had bought. In the demand there was more than a little intimation that Garvan's motives were not clean. He refused the demand, and for four years he had to defend himself against whispered rumors as he carried the fight through the Federal courts.

It was a tribute to his legal ability that not one of the sixty-three specifications in the bill of complaint was upheld by the District Court and that this court's decision was sustained by the Circuit Court of Appeals and by unanimous decision of the Supreme Court. It was a tribute to Garvan, the man, when the District Court decision turned from legal considerations to record the opinion:

"The devotion of the property (patents) to the public use stands not upon written documents alone. It has a deeper foundation—the property is in the keeping of men . . . whose devotion to the public interest has been established . . . The defendant has kept the faith."

Often in that dark time, said Herty, this pugnacious, quick-witted Celt, with the facile ability to make a phrase drip vitriol, would rip the mask of toughness off and, revealing the tender-hearted sentimentalist underneath, would say, "Doc, we can't lose. Patricia is leading us." But that was a side of Garvan revealed only to such friends as Herty, who knew how deeply he could be hurt by the whisperers, and to Mabel Brady Garvan, the quiet motivator of his career, who, whether she was behind him or beside him, was always *with* him.

When the long court fight was done, Garvan's health snapped, and he was a semi-invalid for four years. But, while his body rested, his mind churned ideas. He saw clearly now that the development of a complete organic chemical industry in the

United States was contingent upon the creation of a great school of postgraduate training from which men could be drawn to do research on problems of health. Result: An order from the sickroom to his associates; and the beginning of a veritable deluge of scholarship and research grants from the Foundation to literally hundreds of scientific researchers. Backed by these funds, men and women set to work in laboratories, investigating such things as common cold, leprosy, streptococcus infections, tuberculosis, cancer, sinus disorders, pneumonia, diabetes, goiter, children's diseases, muscle afflictions, whooping cough, etc. It is impossible to complete the list of medical triumphs attributable to these benefactions, for the grants were given with no strings attached and on the basis of no questions asked. It was not only unpublicized philanthropy—it was unorthodox. If a researcher with a hot hunch obtained assistance and then found he had wasted his time and the granted money, his apologies were squelched by Garvan's emphatic declaration that neither time nor money devoted to research is ever wasted.

You get a partial glimpse of this phase of the Garvan career from the book, *Chemistry in Medicine.* Written by the foremost authorities in their fields, it describes research results in vitamins, diets, glands, public hygiene, anesthetics, specific diseases and sanitation. Dr. Julius Oscar Stieglitz of the University of Chicago edited it. Its frontispiece is a reproduction of a painting of a lovely little girl, a picture captioned, "May the memory of lost children urge us on!"

It is hard to tell exactly where the Foundation's work ended and where the Garvan benefactions took up the slack. The Foundation, for instance, devoted about $80,000 to the perfection of dependable biological stains which are indispensable in the laboratories where the strategies of the war on microbic enemies are planned. This work, which has resulted in incalculable benefits to humanity, was started by Dr. H. J. Conn, of the New

York Agricultural Station at Geneva, New York, an institution fostered by Garvan's good friend, Franklin D. Roosevelt. Backed by Foundation funds, Dr. Conn obtained through Garvan's intermediation the assistance of a dozen scientific bodies and a number of Federal bureaus and the active co-operation of dye producers. The result is that biological stains made in the United States are now acknowledged to be the best in the world. Measured in dollars, the business is picayune. In its bearing on health, the value defies measurement. It is now known that this project, which seemed insignificant, was one of Garvan's pets, and that his personal contribution to it was much greater than has ever been recorded on any of the project's books.

There was assistance to scores of scientific bodies in the publication of their magazines and bulletins. There was assistance to scholars trying to isolate the active principles of vitamins, to chart the behavior of proteins, to probe the habits of bacteria, to develop "heavy water," and to study the relation of colloid chemistry to medicine. Not infrequently the Garvan benefactions were given so quietly that not even the researchers knew the source of the funds which kept a pet project going.

Recovered from his illness, Garvan was restive. There was another crusade in his system. He felt that the educational work should now begin to bear fruit. So down to Washington he went and, despite his previous resolutions, became a lobbyist. He wanted the people to have their own medical research laboratory as a part of their government. He wanted them to build and maintain the world's greatest medical research center. He got Congress to create the National Institute of Health as part of the United States Public Health Service. Its first function was the provision of Federal supervision of testing, manufacture and sale of all viruses, serums and anti-toxins. It provided government-controlled research laboratories for investigation of causes and prevention of disease. Since then, the government's entry into medical research has borne such fruit as the launching of the national crusade against syphilis by Surgeon General Thomas Parran, and the creation of the National Cancer Institute which was started by the two-million-dollar gift of steelman William H. Donner.

But, as we saw in the beginning of Garvan's story, it was his declaration of warfare on the microbes of the coccus family that started all this. A strange twist of fate that he who participated in finding the weapon against that family should have been one of its victims just as men were defeating it! A fantastic twist that the weapon should have been discovered first by a laboratory worker in that German chemical cartel which Garvan fought so bitterly.

The story of Garvan's participation in this chemical discovery begins with the Garvans' decision to provide a researcher with $10,000 a year to find the cause of the infection which had killed Patricia. The research came to naught. Failure? Not quite. At least, not in Garvan's opinion, for one of the researchers had become interested in something else. In 1928, Garvan set up at Johns Hopkins the John Jacob Abel Fund for research on the common cold. This fund, honoring Johns Hopkins' venerable Dr. Abel, the famous pharmacologist who isolated epinephrine and crystallized insulin, was financed with $350,000. It, too, got nowhere. So they said when the books were closed in 1933. "But," said Garvan, "wait a moment! It *did* get somewhere! It developed a young scientist."

He was a slender, dark-haired, dark-eyed youngster whose father, grandfather and great-grandfather had been country doctors around Bryan, Ohio. His name was Perrin Hamilton Long. He had come to Johns Hopkins from the Rockefeller Institute, had participated in the common-cold research and had become sidetracked, along with Dr. Eleanor A. Bliss, in an experiment with streptococcus germs.

Here were these two young scientists, trying to develop a serum to fight "strep" and having come around the circle, already marked by two "failures," to exactly that job which Garvan had wanted done in the first place! Here they were, eighteen years after Patricia's death, burning up research funds and kilowatt-hours and the bodies of strep-infected mice—and getting nowhere. Now and again they paused to discuss the rumors, coming out of Europe, about a remarkable patented "miracle" drug called prontosil. What was this prontosil? Nobody knew much about it. It was supposed to be an orange dye patented by the German chemical cartel. It was said that Chemist Gerhardt Domagk, of the research staff of a dye factory in Elberfeld, Germany, had somehow discovered, as long ago as 1932, that it saved mice from certain death even when the creatures' bellies were pumped full of strep. But, what was a dye chemist doing with mice and strep? Why hadn't his discovery been announced in 1932? Why had the Germans waited until 1936? Nobody knew the answers.

Planning to attend the Microbiologists' Congress in London in the summer of 1936, Drs. Long and Bliss decided to learn all they could about this fantastic drug which was said to have the unheard-of characteristic of being harmless to strep in a test tube but deadly to it in living bodies.

In London, Dr. Long ran into young Dr. Donald Hare who had accidentally infected himself with strep in his laboratory and had been dragged from death's door by prontosil. Everywhere they went these young American scientists heard glowing reports about the miraculous drug. Researchers at the Pasteur Institute had discovered that the patented prontosil was not the only strep-killing dye. They got the same effect with sulfanilamide, a colorless chemical relative. Sulfanilamide? That was the stuff the I. G. Farbenindustrie Chemist Gelmo synthesized out of coal tar about thirty years ago, the para-aminobenzenesulfonamide that had been classified and forgotten about the time Dr. Paul Ehrlich was stirring up the world of medical science with No. 606 (Salvarsan) as a cure for syphilis. Sulfanilamide! That was the stuff the Rockefeller Institute tried to link with quinine-like drugs in the 1920's but discarded because it became locked in a chemical bond with the other drugs and lost its ability to destroy pneumonia germs.

If the stuff failed in the 1920's, why did it succeed in the 1930's? The Pasteur Institute researchers solved the riddle. Prontosil, they found, is a dye in which sulfanilamide is loosely bonded to a chemical containing naphthalene. Poured in a test tube full of strep it has no effect because it remains prontosil. But, poured into a living body infected with strep, the chemical bond breaks and the sulfanilamide goes to work. The Rockefeller researchers had failed because their sulfanilamide-quinine bond was too secure. The Germans had succeeded because the sulfanilamide-naphthalene bond was weak.

Such were the exciting things Long and Bliss heard. In London they heard of Dr. Leonard Colbrook's encouraging results in the use of these dyes for childbed fever. And, still without answers to many of their questions, they came back to the United States. Backed by Garvan, they plunged into experiments with mice and strep and prontosil and sulfanilamide. They could afford to be reckless, for when Garvan backed a scientist there was no dictation from above. "Pick a good man and don't bother him with dictation," said Garvan. "If your man is good, you can let him go on his own."

The experiments started on Sept. 1, 1936. Shortly afterward Dr. Long faced a difficult decision. In Johns Hopkins Hospital an eight-year-old girl was dying of streptococcus meningitis. Would he dare try sulfanilamide? He looked at the mortality records of the disease. In fifteen years at this hospital nobody had ever recovered from this form of meningitis. He took a chance. On Christmas Day the little girl, completely cured, went home to her parents.

Since then, there has been a tremendous burst of activity on this frontier of the field of chemotherapy. Cures have become commonplace. Sulfapyridine, introduced too late to save Garvan's life, was commonly called "the anti-pneumonia drug" a few weeks after it was publicly announced. Sulfanilamide is giving good results in the treatment of trachoma, a highly contagious and formerly incurable cause of blindness. Sulfapyridine has been reported effective in the treatment of the hitherto incurable influenza meningitis; and, in Ponca City, Oklahoma, a doctor recently reported success in treatment of infantile paralysis with it. At the 1939 meeting of the American Chemical Society, Dr. Moses Leverock Crossley, of Bound Brook, New Jersey, announced that the growth of tuberculosis in guinea pigs had been successfully checked by another member of the sulfanilamide family, called N^1 dodecanoylsulfanilamide.

Since there are at least a thousand known members of this drug family and since the effect of the drugs on the microbes in the body is still mysterious, it may be years before this chapter in the history of chemotherapy can be finished. Only then will Garvan's contribution appear in proper perspective.

Chapter VIII

GARVAN—THE CHEMURGIC CRUSADER

1

You don't manhandle the truth when you say there was no organic chemical industry in America in 1916. You don't boast when you say that, exactly twenty years later, it had become the world's greatest; for, by 1936, America was making more chemicals—in tons or dollars—than were being produced in Germany, England, France, Italy, Japan and Russia combined. It not only led the world in chemical production, but it led *all* American industry in the maintenance of high wages, fat dividends, steady employment, a mounting volume of production and a steady decrease of unit prices.

As Irénée du Pont, vice-chairman of the board of E. I. du Pont de Nemours & Company, pointed out to the chemurgists at their first conference, the credit for the accomplishment must go to Garvan.

"When Garvan hit on the thought that the United States ought to have an organic chemical industry," said Mr. du Pont, "he took off his coat and went after that thought. He succeeded in selling it to President Wilson and both branches of Congress. He even succeeded in selling it to the chemical industry of the United States!"

Because it throws light on Garvan the crusader, it must be recorded here that he did not succeed in selling his "nuttiness about co-operation" to *all* of the chemical industry of the United States. A notable holdout against his crusade was Allied Chemical and Dye Corporation whose reticent president, Orlando Franklin Weber, was cool toward his proposal that Allied join the chemical companies banded together to protect the industry against Germany. When Allied's president indicated that two protectors were better than one, Garvan was aroused to a pitch of suspicion that Allied was on the German side. But when he accidentally discovered that Weber actually shared the Garvan distrust of the German I. G. Farbenindustrie, he became a staunch friend.

The incident throws some light on Garvan's character, but does not illumine it. Indeed, it is hard to put Garvan in a light that explains him. Herty tried it in the 1920's, when a distinguished French chemist asked him to explain why a lawyer should have played such a powerful role in the growth of American interest in science. After Herty finished his explanation, the Frenchman, still mystified, shrugged his shoulders and concluded that "only America could have produced a man of that type."

The Frenchman should have been told that Garvan was a Celt, for this comes nearest to explaining the man.

At the first conference of the chemurgists Garvan announced, "There will be opposition to some of the things we propose. I, personally, hope that the opposition will be fierce, for the greater the resistance the greater the growth. The only thing we have to fear is inertia."

Who but a Celt thus welcomes a fight?

Even the Church of Rome recognizes that the Celt is unique. Unsuccessful in its long endeavor to stamp out the old Gaelic pagan beliefs in the existence of the "little people," the Church learned to ignore this whimsicality of a mind that can entertain burning faith in opposites. To the Celt's capacity for great faith you must ascribe the Garvan faith in the omnipotence of science, a faith burning so fiercely that it made converts of scientists who knew their limitations.

Knowing him as a Celt, you do not have to be told he had vision. All you need to remember is the observation of William Butler Yeats, the Irish poet, that, whereas *all* men are visionaries if you scratch them deep enough, "the Celt is a visionary without scratching."

When you remember these things, it isn't mysterious why Garvan, presented with an unorganized concept of enriching the nation by increasing the industrial uses of farm products, seized the idea and decided it was a faith calling for converts and meriting a crusade.

When Hale introduced him to Christensen, the two men hoped that Garvan would see merit in the Iowa chemist's proposal for the restoration to the American farmer of a part of his former business as a horse-power producer. But Garvan's vision darted beyond that horizon immediately. He saw at once that whatever increased the income of farm labor would expand the markets of industry. He saw that such an expansion of industrial markets would mean a lessening of urban unemployment. He saw that the addition of farm labor and factory labor to the wasted products of nature would create new wealth. And he saw that, if he could infect others with his gadfly patriotism, his faith in the omnipotence of science, his Gaelic vision and his "nuttiness" about the value of co-operation, this movement might become the basis upon which all nations could build the economic independence which would lessen the dangers that threaten world peace.

So the Garvan decision to champion a chemurgic crusade introduced the paradox of the Celt who, liking nothing better than a fight, wanted to rid the world of the economic basis of battle.

Garvan's vision of the international aspects of chemurgy threw him into conflict with the well-intentioned but scientifically unenlightened souls who believe that the only pathway to peace lies in the direction of internationalism.

"It's a funny thing about these internationalists," he said. "You never find them except in America. You can search all over the world and you will never find another internationalist. What have we done to deserve them? Have you ever heard of a Scotch internationalist? A German internationalist? A French internationalist? Or an English internationalist? If you have, you will find him on the pay roll of the fund for propaganda for American consumption."

When Garvan cut loose with that kind of talk he became the target of such epithets as "eagle-screaming patriot" and "flag-waving nationalist," epithets hurled by people who failed to observe that the chemical age is decreasing the interdependence of nations which, introduced in the Machine Age, was the basic economic factor upon which the arguments of the internationalists rested.

It was characteristic of his kind of patriotism that, when he was waging the long battle for control of the seized chemical patents, he did not blame the notorious "Ohio Gang" in Washington for the litigation, but hurled the blame into the teeth of some American bankers who were the fiscal agents for Germany's I. G. Farbenindustrie Aktiengesellschaft. He accused some of the largest banks in the United States of fraud, publicized his accusations with pamphlets and in interviews—and was laughed at for revealing in 1930 some of the shady deals in international finance that became front page scandals following the bank crash in 1933.

He was a buzzing gadfly to the administration of President Hoover. That, said his critics, was to be expected—from a Democrat. But neither his party affiliation nor personal friendship for the President restrained him when he decided it was time to criticize a move by the Roosevelt administration which he believed to be detrimental to American independence. Whenever that happened, his critics "explained" that he was rich and therefore a reactionary. That "explanation," however, did not explain. For, when the apologists for reaction converged upon the first conference of the chemurgists and threatened to turn it into a forum for attacks on social reform, he knocked them groggy with his denunciation of the stupidity of big business.

"Government in business," he barked, "had no miraculous birth. American business allowed the parasite of big banking to fasten itself upon it, feed upon it and speak for it. This induced the government to turn parasite in turn. There is now only one way out. Throw out *all* parasites, whether they are bankers on our boards attempting dual positions in law and honesty, or whether they are politicians using the presence of other parasites to exert the same function. We believe that by co-operatively solving the problems of American life, we will cease to deserve government interference—and we will cease to get it."

Wheeler McMillen, who succeeded him as president of the Farm Chemurgic Council, once admitted that, whenever he introduced Garvan to an audience, he had to battle the temptation to repeat the old story about the shipwrecked Irishman who, rescued by natives of a Pacific island, sputtered, "Is there a government here?" and, receiving an affirmative reply, tottered to his feet and declared, "Then I'm agin it!"

As Herty once observed, it required the vision of the many-sided Garvan mind to grasp the many-sided aspects of chemurgy, and the intense conviction of the Garvan faith to weld conflicting interests into a chemurgic crusade.

2

At the 1938 conference in Omaha, a young scientist, known to few of the chemurgists, called attention to an activity which the American farmer had neglected. Each year, said this young man, we import huge quantities of crude drugs grown in soil and under climatic conditions paralleled in the United States. Citing the effect of Spanish civil war on the price of cork, the shortage of menthol that followed the Japanese earthquake in 1923, and the adverse effect of the undeclared Sino-Japanese War on American imports of tung-oil and ephedrine, he pointed out that United States dependence on imports of crude drugs might in some circumstances deprive Americans of sorely needed medical supplies. Why not grow some of these things in America?

In 1936, he pointed out, the United States imported more than 50,000,000 pounds of licorice, almost 250,000 pounds of belladonna, 1,000,000 pounds of Ma huang (ephedrine), more than 500,000 pounds of gentian, more than 200,000 pounds of papaya, 122,180 pounds of rhubarb, 80,652 pounds of digitalis, 171,125 pounds of opium poppies, more than 2,000,000 pounds of tragacanth and almost 200,000,000 pounds of castor beans; an annual import which, he estimated, results in the spending abroad of almost $8,000,000 for many things which American farms might produce. The licorice plant, for instance, grows so well in the American Southwest that it has become a weed in some localities; yet the American supply, vital not only to medicine but in the manufacture of tobacco, candy, shoe polish, beer, fiberboard, Jacquard cards for the textile industry and chemicals used for etching steel sections in photomicrographic work, is largely imported from Southern Europe and Central Asia. Belladonna, source of hyoscyamine and atropine widely employed in medicine, is mainly imported from Hungary, though it can be grown in many parts of the United States. Ma huang, the source of the powerful alkaloid drug, ephedrine, used in the treatment of asthma, hay fever, low blood pressure and acute sinusitis, comes from Tientsin, China, in normal times, but has been shut off by the Japanese invasion of China.

Because of this cutting off of the supply, there are now under way attempts to grow the shrub, Ephedra Equisetina, in North Dakota.

Gentian could undoubtedly be cultivated commercially in the United States, he said, as well as the drug rhubarb which, now imported from China, is used for indigestion and as a tonic and laxative.

Papain, the dried juice of the skins of unripe papaya fruit, was once mainly used for stomach disorders. Since chemists discovered that it has the ability to make tough meat tender, its use in the United States has increased fourfold. In 1932, we imported from Ceylon, the only supplier, 54,000 pounds valued at $50,000; and in 1938 our imports rose to 223,000 pounds valued at $329,000. Yet this fruit, a delicious addition to the melon family, can be grown in Florida, Texas and California.

The young scientist recommended that attempts be made to encourage domestic production of the Orient's opium poppy, the Japanese mint that supplies natural menthol, and the tragacanth shrub that grows in the semi-arid regions of Persia. Finally, he said, comes the castor plant which, though once an important crop in Oklahoma, Kansas, Missouri and Illinois, has been so sadly neglected in the United States that the expansion of the industrial uses of castor oil has resulted in an increasing dependence upon Brazil, China and British India.

This young scientist who pointed out a neglected American frontier was Dr. Perrin Hamilton Long. At the close of the conference he was elected to the council's board of governors. In the brief history of the movement this was the second famous disease-fighter to become a member of the board. The first was Dr. Roger Adams, the University of Illinois chemist who had contributed to the perfection of chaulmoogra oil therapy in the treatment of leprosy and had gone from that triumph into the field of research expanding the industrial use of soy beans.

If, on the face of it, chemurgy's roster appears to be an association of strange bedfellows, it may be attributed to Garvan's ability as a crusader. Because he, the urban Doctor of Laws, was able to make a complete recovery from a classical education and strike out on new roads to the laboratories of Doctors of Science, men of science respected him. He attracted industrialists and farm leaders—held their interest and won their loyalty despite the caustic criticisms of their shortcomings which he tossed in their faces. Though he never pulled a punch, he was liked—even by the recipients of the punches. Thus, with this paradoxically popular man at the helm, the chemurgic movement rapidly became much more than a mere device for the salvation of the farmer.

Though he was a talker by tradition and training, he was not satisfied with mere talk. Under his guidance the chemurgists shaped a program which began with the creation of a permanent forum. For two years the Chemical Foundation financed the program as interest spread and subsidiary conferences began to function. But the mere creation of forums was not enough for Garvan. He saw that the project launched by Herty had acquired sufficient momentum to carry it to accomplishment. Deciding that he could now turn his attention to something else, he concentrated on the proposal to manufacture power-alcohol from farm surpluses. At the first conference of the chemurgists he invited the leaders of the petroleum industry to co-operate in the research which he deemed necessary before this phase of the chemurgic vision could be expected to become reality. When his invitation was answered with undisguised hostility, he got what he liked—a fight. He instituted a survey in which was assembled a vast amount of sales-promotion literature that had been prepared by foreign branches of American petroleum companies for the marketing of alcohol-gasoline blends through their affiliates in foreign countries. With this evidence of the superior qualities of alcohol-gasoline blends, prepared *by* the opposition, he was provided with an opportunity to make the proponents of pure-petroleum power writhe. And he used it with devastating effect. Introducing the evidence at the 1936 conference and subsequently publishing it in Volume X of the Deserted Village Series, he said:

"We have been fed volumes to the effect that it [alcohol-gasoline blend] was not practical fuel. Now . . . all these worries have been settled. . . . All this chemical research has been done for us. . . . The Standard Oil Company of New Jersey has gone over to England and in its delightful international aspect of life has joined hands with the English Distillers Company, and they together have produced, in their own words, the most perfect motor fuel the world has ever known—33⅓ per cent British alcohol! We were wrong on the ten-per-cent blend. We were wrong on the twenty-per-cent blend, and we thank them for telling us. Our problem now is to advance as rapidly as possible toward that perfect fuel, 33⅓ per cent farm alcohol. . . . We have lots of problems, but the problem of use is over . . . and for this I thank the Standard Oil Company and the Petroleum Institute."

On this occasion Garvan the organizer stepped aside to provide a forensic field day for Garvan the stellar performer of the law courts. But when the forensic fun was over, he moved swiftly to the establishment of a commercial-scale plant to demonstrate that power-alcohol could be produced from farm surpluses and sold in competition with gasoline. Within a year, Buffum and Christensen had converted experimental operations, fertilized by $275,000 of Foundation funds, into a going business in what had been the Bailor Manufacturing Company's alcohol plant in Atchison, Kansas. Starting commercial operations on December 2, 1937, as the Atchison Agrol Company, Inc., with the Chemical Foundation in control, Buffum as president and Dr. Christensen as vice-president and general manager, the plant was producing four months later a total of ten thousand gallons of anhydrous alcohol daily, blending the output with gasoline supplied by independent producers, and marketing the blend through independent dealers and farmers' co-operatives in Kansas, Missouri, Nebraska, Iowa, Minnesota, the Dakotas, Colorado, Arkansas and Oklahoma.

From January 1, 1938, to the following April 1, the plant's business increased 1500 per cent. At that point the company acquired the unique distinction of halting expansion at a time when most businesses were experiencing a decline in sales. The decision to halt expansion was based on Dr. Christensen's survey of raw materials available in the area. Running on barley, rye, corn, grain sorghum (kaffir corn) and Jerusalem artichokes grown on surrounding farms, the plant had reached what its managers believed to be its maximum productive capacity. In other words, it had erased the crop surplus problem in the area!

In this plant, grains were processed for their carbohydrates which were fermented and distilled. The distillate was rendered anhydrous, adulterated to make it unfit for beverage use, and blended with gasoline. The remaining fiber was converted into concentrated stock feed, containing forty per cent protein, ninety per cent digestible, and sold or returned to the farmers.

Garvan did not live to participate in this final crusade of his. That was unfortunate. After things had been going so promisingly the little band of chemists who directed the destinies of this chemurgic project were forced to close the Agrol plant at Atchison's Thirteenth and Main Streets after a year of commercial operation and admit, as Dr. Hale bitterly expressed it, that "the agents of greed and corruption have won."

3

There are chemurgists who will tell you that the outcome of the power-alcohol experiment would have been different if Garvan had been alive to fight for its success. These apologists speak of the scurrilous sabotage to which the experiment was subjected at every turn. To the gray sheet-iron and brick headquarters in Atchison came sworn statements of hundreds of underhanded tricks employed to wreck the project. There were reports from dealers who wanted to market the blend and said they were intimidated and threatened. Among the neatest tricks to discourage the use of the blend were the repeatedly reported demonstrations with which traveling "experts" *proved* that alcohol and gasoline do not mix. The self-styled "experts" conducted this little trick by driving into filling stations and showing proprietors and by-standers that Agrol fluid and gasoline separate into layers. It worked beautifully because the "experts" used small glass tubes which they carefully washed beforehand. Since a drop of water in a small vial is large enough to cause separation in the small amount of blended fuel in the tube, the demonstration was very effective—until the Atchison chemists taught the fuel dealers to insist on the use of dry tubes.

Indeed the experiment was beset by hundreds of manifestations of opposition. These, combined with scores of unexpected problems, ended the commercial operations. But, in that trying year, Dr. Christensen's crew refined old processes and perfected new methods for the handling of grain and its conversion into anhydrous alcohol and by-products. They added new knowledge to the arts of fermentation and distillation. They assembled data covering the use of all types of fermentable grains and tubers. They demonstrated that the use of alcohol as motor fuel is no longer a theoretical matter. They found that operations will be handicapped until means can be found for the stabilization of raw material prices. They proved that there must be a simplification of internal-revenue regulations which, having been designed for the control of beverage and pharmaceutical alcohols, interfere with the production of motor fuel alcohol. They discovered that distribution costs of six to eight cents a gallon more than is considered normal for fuel were a serious problem. They ran into many problems, but they found no problem which they considered too tough to be solved.

After the Agrol plant got under way, there were so many enthusiastic supporters throughout the Middle West that it was not hard to sell stock in proposed new plants. Unfortunately, promoters did not miss the opportunity to exploit the gullible. The Farm Chemurgic Council had to issue warnings that it endorsed none of the schemes.

While these alcohol chemists were demonstrating that man need not be alarmed about his power-supplies so long as the sun shines, other chemists were perfecting processes which multiplied the power-potential in petroleum.

In the fall of 1937, Phillips Petroleum Co. startled the petroleum industry by erecting two massive polymerization units at Kansas City and Borger, Texas, and turning out one hundred octane (100 per cent anti-knock) gasoline in greater quantities than petroleum men had believed possible. The polymerization process, employed by Phillips on a large scale, has vast significance to those who fear that world petroleum sources will soon be exhausted. It has been estimated that its use on all United States petroleum supplies would add about a billion gallons annually to the gasoline output.

Gasoline, which was something of a nuisance to kerosene producers until the automobile came along, was first produced by distilling crude oil. But distillation merely separated petroleum into its constituent fractions. About 1910 it was becoming plain to far-sighted men that the rising automobile industry would exhaust the gasoline supply. In that year, Germany's Friedrich Bergius, who later extracted gasoline from coal and sugar from sawdust, began to study the hydrocarbon molecules of petroleum with the aim of increasing the gasoline yield. Three years later, the "cracking" process of decomposing heavy oils into light ones was introduced on a commercial scale. The cracking process, utilizing heat and pressure to split large molecules into small ones which could be condensed as light oils, increased the gasoline yield. An expensive process, it was virtually a life-saver during the World War, when the demand for liquid motor fuel increased enormously. The gasoline thus produced was an offensive-smelling product which was considered inferior to ordinary gasoline until after the World War, when high-compression engines were introduced and were found to operate better with the cracked gasolines than with the natural fuel. But the early cracking process turned out huge quantities of coke and methane gas as wasted by-products. For this problem, Bergius provided the solution with his hydrogenation process whereby the large molecules of heavy oil were cracked into bits and forced to combine with hydrogen atoms, thus preventing the formation of coke and methane gas and again increasing the gasoline yield.

The polymerization process attacked the gaseous fractions of petroleum which were formerly wasted. Whereas cracking and hydrogenation break big molecules into small ones, polymerization traps very small molecules and squeezes, heats and catalyzes them into the molecules of high-test (anti-knock) gasoline.

But the high-test fuel produced by the polymerization process is chiefly valuable to aviation. The automobile, the largest user of gasoline, was offered no increased gasoline supply until, in January, 1939, the petroleum industry was startled by the revelation of a new process perfected by Eugène Houdry.

In 1922, when Bergius was trying to power Germany's automobiles with gasoline from coal and General Patart's researchers were seeking motor power in carbon monoxide gas, young Houdry, the auto-racing son of a Parisian steelmaker, learned that a chemist in Nice had extracted gasoline from the lignite, or brown coal, plentiful in France. Attempting to perfect the process that seemed to contain a promise of motor fuel for France, which lacks petroleum, Houdry stumbled upon a catalyst that converted crude oil into gasoline without the great heat and pressures required in the cracking processes. When French capital refused to back his discovery, he brought his ideas to the United States. Briefly, the Houdry process takes the petroleum residue after thermal cracking has squeezed out every possible drop of gasoline and, heating it, forces it through the silica-alumina catalyst, converting about half of it into gasoline with an octane rating of 81.

This latest refinement of motor-fuel production reduces the need for tetraethyl lead as an anti-knock agent and extends once more the gasoline-potential in the world petroleum supply. But, with these refinements of motor-fuel production there has arisen a new problem—the formation of gums in engines. This problem, says Dr. Hale, introduces the need for the incorporation of ethyl alcohol to raise octane ratings still higher and rid the fuels entirely of gums.

In this process of juggling the molecules of the hydrocarbons of fossilized sunlight, the chemists who work with coal and petroleum have produced many by-products that compete with the things we have been used to expect only from vegetable or animal sources. Although the primary products of petroleum are still gasoline, kerosene, furnace oil, lubricating oil, paraffin wax, asphalt, gas coke and fuel oil, a large amount of alcohols and their denaturants are produced from the waste gases. At the 1939 meeting of the American Chemical Society, it was revealed that chemists of the Shell Development Company have prepared from propylene, one of the waste gases, a commercially useful but poisonous product, allyl chloride, which yields a synthetic glycerine.

"The cracking of petroleum merely to secure gasoline is one of the most wasteful deeds of man," says Dr. Hale. "By such practices we are destroying at frightful pace one of the great legacies left to us by Mother Nature. There are countless discoveries and inventions to come. Is it not thinkable that our children will have use for petroleum in large measure for some compounds brought into demand by the stress of some future invention? To burn petroleum with the reckless abandon of today is to withhold from posterity an asset in which they, as much as we, have equal rights."

Hale, who is now devoting all of his time to the attempt to abolish this waste, has recently begun to pose the startling questions: Is there a direct connection between the growing incidence of lung cancer in the United States and the fact that the higher polymers of gasoline, known to possess carcinogenic (cancer-forming) properties, are constantly poured into the atmosphere by the exhaust vapors of gasoline-powered vehicles?

4

No doubt Garvan would have enjoyed watching the unexpected development from the Atchison alcohol experiment. Like that streptococcus research which he had inaugurated and which had been marked by several "failures" and odd turnings into unexpected fields, the Agrol research changed its direction and slid off into a field of exploration in which man may find a better lubricating and fuel oil than petroleum provides.

Garvan, who backed research projects and insisted that a good researcher needs no direction from his backer, would have been pleased by the manner in which Dr. Leo M. Christensen, the alcohol hunter, accepted "failure" and, neglecting to weep over the shattered fragments of his dream, went pounding off in hot pursuit of another dream. On February 11, 1939, at the Gulf Coast Chemurgic Conference in Beaumont, Texas, the Iowa chemist who had talked of little else save power-alcohol in the past, admitted that it was great fun to be able to talk about something else.

"Frankly," he said, "I can assure you that I have found it somewhat monotonous to listen to myself telling the same story over and over again. Technically, power-alcohol has proved its case, so there isn't much more I can do about it except to continue to supply such technical information as I may have and which may be required.

"Maybe you will permit me to indulge in a bit of philosophy. I think the thoughts and activities of the research worker must seem a mystery to many laymen. Some think the research worker must be some sort of nut who hunts out dark basements and dusty attics in which to conduct his studies. Others think of research as an activity which requires fine buildings, a great array of expensive equipment and a large staff of highly trained scientists. But anyone can do research and many do, with equipment and facilities ranging from one extreme to the other.

"You become a researcher when you accept a certain viewpoint and mental process. Research consists of patiently testing, one by one, a series of ideas about any subject, recording and remembering the failures, until finally success is achieved. All progress consists of a series of errors. Walking or running is simply a succession of last second recoveries from falling. To every research worker, after many failures, success must finally come.

"Now I have an opportunity to tell about another project of such great potential value that its description is almost like a fairy tale—a development that is the big success in the large number of research projects which we carried out at Atchison. I won't tell you how many ideas were complete failures. But, only at rare intervals does research uncover such a remarkable combination of conditions as we found in our studies of the castor plant."

From alcohol to castor oil! There is no doubt Garvan would have liked this story of the chubby, rosy-cheeked Doctor Leo's restless pursuit of unpredictable goals on the horizonless frontiers in the test tubes. It is a story that may turn out as fantastic in the end as the seemingly aimless explorations which uncovered the germ-destroying dyes.

The story begins simply, with no hint of fantasy. It starts with the restless Doctor Leo sitting in his sheet-iron shack of a laboratory out in Atchison and wondering if there will be enough vegetation in the area to permit him to make his alcohol now he has learned how to do it well and cheaply. He is such a restless fellow that his associates dread the moment when he stops his floor-pacings and says, "Let's go for a ride." For, they will tell you, a ride with Doctor Leo at the wheel and thinking hard about an elusive idea is a breath-taking experience. You watch the speedometer wobble up to a hundred. Then you sit back and pray. He says he does his best thinking that way!

After one of these skull-sessions-on-the-fly, Dr. Christensen came up with the idea that, if this power-alcohol business was to be a success, he would have to promote the growing of suitable crops. And, to do that, he would have to take up farming as a side line. You can't expect a farmer to listen to your advice if you know that he knows you've never even raised radishes, can you? No, you can't. So the Atchison Chamber of Commerce, humoring the man who proposed to bring prosperity to the town, provided him with an experimental "farm." Doctor Leo called his seventeen-acre patch a farm, though Kansas farmers deem such a plot about right for a flower bed.

On this experimental plot he decided to cultivate and display crops with potential value to industry, especially the alcohol industry. What was the best source of alcohol? he asked himself. He thought about that doubly misnamed wild American sunflower, the Jerusalem artichoke, which never grew in Jerusalem and no more resembles an artichoke than an oak resembles a green onion.

There must have been a lot of behind-the-hand chuckling in Kansas when Doctor Leo devoted fifteen of his seventeen acres to the growing of weeds, for weeds are what most western farmers consider this wild girasole the botanists call *Helianthus tuberosus* and only the pigs enjoy. But Dr. Leo knows that the fat roots were relished as a fine potato by the North American Indians. For the Indian there was no need to let the back-breaking toil of potato-farming interfere with summertime hunting and fishing so long as the succulent tubers of this wildling could be dug out of the frozen ground for a fine belly-filling winter dinner. Let the farmers snicker! Doctor Leo has been talking to Farmer Fred Johnson. Johnson has been singing the praises of this weed since the time when he turned his hogs into a girasole-infested field out in Hastings, Nebraska, and saw the hogs not only clean up the field but fatten beautifully and—wonder of wonders!—resist the ravages of the cholera that wiped out his neighbors' pigs. Weed indeed! The pigs have more sense than their owners, for the stuff they love in those tubers is that super-sweet sugar, levulose, a sugar lurking in the starch-like substance, inulin—a sugar so unbelievably sweet that it refuses to crystalize. What better source of alcohol? said Doctor Leo, planting the best tubers he could find and finding them, not in the United States where they grew originally, but in France, where the peasants know the value of a pork-fattening crop that needs no coddling.

On the remaining two acres, the restless weed-farming chemist experimented with row crops of grain sorghums, castor plants and other things not ordinarily planted by plains farmers. The two-acre plot was planted between the main crop and a weedy field swarming with unborn grasshoppers and chinch bugs. It was to serve mainly as a barrier for the protection of the Jerusalem artichokes. There were probably some wise-cracks about the daffiness of that Iowa chemistry professor protecting one weed patch from another weed patch. But Doctor Leo ignored them. In the first ten rows, next to the field where the bugs slumbered, he planted the grain sorghums which were once believed to be unprofitable if grown north of Texas. They had been found to contain hardy individuals which, selectively bred, developed varieties that flourished as far north as South Dakota.

The next row was to have been devoted to castor plants, the seeds of a fine strain assembled by Doctor Leo and his associates, Harry Miller and Leon E. Champer. They had become interested in this ancient Asiatic member of the Spurge family because they detected chemurgic values in the oil of its seeds and in the exceptionally long flax-like inner fibers of its stalk.

The experimenters ran short of seed, however, so the eleventh row became merely two-thirds of a row. Next they planted sweet potatoes and Parnassian potatoes, soy beans, millet, hemp, pyrethrum daisies and Peruvian corn. Why? When that question was hurled at them, they explained they were seeking mainly alcohol crops, thereby accounting for the Jerusalem artichokes, the grain sorghums, sweet potatoes, Parnassian potatoes and Peruvian corn. They pointed out too that sweet potatoes yield a superior starch much like that now imported in huge quantities. This starch, they indicated, may have vast chemurgic value, for it has been experimentally converted into a thin transparent sheet which may one day move into the field now dominated by cellophane. Down in New Orleans, Harold A. Levey, chemical engineering consultant, predicts that man's progress in the development of wrappings, which began with the Egyptians' use of papyrus for bodies and which produced such recent achievements as cellulose nitrate, cellulose acetate and the newer ethyl cellulose, may shortly move into a development in which root and tuber starches are extruded through a slit and dehydrated into a very cheap sheet of transparent and waterproof film. Levey believes that this starch-film research will lead to the exploration of the film-making pentosan gums found in the neglected sugar of Honey Locust and Carob beans.

There is no telling where these explorations may lead.

But, why millet and hemp and daisies? said the doubters. Well, Doctor Leo explained, we're experimenting, and we want to find out why we have to import these things. But do we import daisies? *Do we import them?* American farmers are now spending $100,000,000 a year to fight insects. They have been using inorganic poisons until there is some reason for the alarm about the possibility of Americans slowly poisoning themselves with lead and arsenic. Because of that danger, chemistry is turning attention to organic materials harmless to man but deadly to bugs. One of these non-poisonous mainstays is pyrethrum of which we now import about 20,000,000 pounds every year and for which we pay millions of dollars to Japanese daisy-pickers.

In addition to pyrethrum and nicotine, we are turning to such bug-destroyers as rotenone which, according to Dr. R. C. Roark of the United States Department of Agriculture, we may not need to import if we take it out of the devil's shoestring, a weed that grows from Ontario to Florida.

And why castor plants? Well, castor oil happens to be the best lubricating oil man has ever found, better even than petroleum. It happens to be also the only lubricating oil that does not raise havoc with the structure of rubber. And, if you know anything about engineering progress in the automotive industry, you know that the use of rubber is constantly increasing in and about the engine and the working mechanisms. Automobile makers now use eighty per cent of all the rubber produced. Isn't it remotely possible that we may one day turn to a lubricating oil better than the stuff we've been using? You never know what may happen!

No, you never know what may happen. Doctor Leo, finishing his planting on May 20, certainly didn't expect what began to happen in June. The sorghum and castor plants were knee-high and the grasshoppers woke up and began to look for breakfast.

Christensen and his cronies not only did not expect what happened; they might not have noticed it had there been enough castor seed to fill out that eleventh row!

The hungry hoppers attacked the grain sorghums, and the first ten rows of the barrier planting toppled. But the castor plants, though tattered, stood up against the hordes. "Tough babies!" said Doctor Leo, noticing the frayed castor banners flying above the battle. What he did not notice then was that there were *more* hoppers attacking the castor plants than in any other part of the field. Then, one morning, the experimenters strolled out to their fantastic little farm. Looking at the damage, their eyes fairly bulged. What's this? The hoppers had swept around that two-thirds of a row and, battering down everything in their path, were tearing into the Jerusalem artichokes! Then, for the first time, Christensen noticed that *all* the row crops near the castor plants were relatively unmolested though the hoppers were still swarming around the castors. Sniffing a mystery, he decided this deserved closer study. For the next few days, he watched grasshoppers, watched them live, saw them die, counted living hoppers and dead ones. He made the unexpected discovery that the hoppers seem to have a great weakness for a diet of castor plant and that it was killing them by the millions! Thoroughly excited now, he dug up ten castor plants and transplanted them into a field of corn swarming with hoppers. Immediately the banqueting bugs left the corn and headed for the castors where they munched happily, grew dopey, dropped off and died. Here was something more to think about. Climbing into his car, he roared off across the Kansas plain to do some heavy thinking. In a city park, he saw an ornamental planting of castors. He jammed on the brakes, climbed out to investigate. Passers-by were probably mystified by the odd behavior of this man with his rump upended and his head buried shoulder-deep in a park flower bed.

They probably wondered why the eccentric fellow had such a broad grin on his red face when he backed out of the flower bed in which he had been counting dead bugs. Then, back to Atchison he went and built some grasshopper cages. Jailing his bugs and feeding them castor leaves, he watched and counted and timed. Within forty-eight hours every caged hopper was dead. In other cages, where the menu had not included castor foliage, the ravenous little beasts were gnawing on the wood of their prison walls.

So it came about that the experimenters, testing a plant because they saw chemurgic value in its oil and fiber, stumbled upon an unexpected value. Their tests showed that, whereas grain losses from birds and insects ordinarily ran up to ninety-five per cent in that area, the losses fell to near zero where there were castor plants. Then they turned up another strange fact. Their careful testing showed that, of all the castor varieties and strains grown in that two-thirds of a row, only two varieties were exceptionally attractive to the insects, and of these two varieties only a few plants were extremely toxic to the hoppers.

In their attempts to isolate the insecticide in these plants, Christensen, Champer and Miller found that they were poking into a body of knowledge man had discovered empirically ages ago. Indeed, as they dug deeper into the subject, they discovered that virtually everything now being learned about this ancient plant was known long ago and somehow forgotten.

In India, where the castor is a perennial growing to the size of a tree, there are religious taboos that protect the boundary hedges of castor plants surrounding farms. Among the pioneers of the American West, it was customary to plant the so-called "beans" around kitchen doors to repel flies; the castor was a regular field crop because it grew in the poorest soil and required no machinery for planting, cultivation or harvesting. Until about 1910 it was a cash crop in the West, all the hand-harvested seeds having a ready market in Omaha; but, after that year, the American plantings diminished, probably because hand-harvesting was no longer profitable.

The three Kansas researchers soon discovered that there was another castor investigator in the United States—M. D. L. Van Over, manager of the Harrison, New Jersey, farm bureau of Woburn Industries, a large user of castor oil.

Van Over, a farmer with some knowledge of chemistry, got into castor research in the spring of 1933, after deciding that the farm problem was largely due to lack of crop diversification and attempting to find out what he could do to diversify his own crops. He hit on the neglected castor when he learned that the United States annually consumes 84,000,000 pounds of castor oil for high grade lubricants, automobile brake fluids, superior paint-drying oils, ointments, textile coatings, soaps, detergents and acids—and imports most of it from India and Brazil.

Between these four experimenters an amazing amount of forgotten facts and new facts about the castor family of some 2,000 varieties has been uncovered. For America's oil production alone, a total of 160,000 acres could now be used; and, if the price of castor oil can be brought down to a competitive level with linseed oil, the planting program can be expanded to 1,500,000 acres. The pomace, or meal residue, of the pressed seeds is not only a good fertilizer but an annoyance to insects in the soil. The poisonous ricin in the plant is worth three dollars and eighty-five cents a gram, and virtually nothing has been done about the plant's insecticide value until recently.

Discovering that the plant has borne the names Roman Hemp, Turkish Hemp and Egyptian Hemp, the researchers found that its outside sheath consists of long strings which can be used for making rope, string, bags and substitutes for hemp. Its cellulose content is high enough to make it worth processing. It is a remarkable plant indeed, says Van Over, recalling that the castor once bore the name *Palma Christa* (the Christ Palm) among a people who seem to have respected it and perhaps revered it.

But it is the oil content of the seeds that now becomes the most interesting item. Used as a lubricant first in airplanes during the World War, its superiority in that respect has never been challenged. It can be used also as fuel in Diesel engines. And, with the petroleum industry cracking and squeezing increasingly larger fractions of gasoline out of every gallon of petroleum, castor oil may one day get into the power picture.

"When you think about the 300,000,000 gallons of lubricating oils used in automobiles alone each year in the United States," says Doctor Leo, "you get some idea of the huge potential market for this product."

Now, the emergence of the unexpected was exactly what delighted Garvan most as an "angel" to scientists. He knew enough about the history of science to realize that curiosity has mothered more inventions than necessity ever produced.

"Though without scientific education," he once said, "I am convinced by my nineteen years of close association with scientists that the greatest gift to the country will be the spread of the scientific habit of thought in the solution of national, local and personal problems. The search for truth shall set us free. The scientist himself must grasp this truth, for, very often, when he slams the door of his laboratory, he fails to take out into other activities of life the method of thought that has been so fruitful in his laboratory work. And the businessman is loath to look for anything but results at the door of the laboratory, thus denying himself the enrichment of mental capacity which a careful and persistent study of the mental processes in the laboratory would give him."

No, if you knew the man's monumental faith in the omnipotence of scientific research, you would never think of Garvan calling the Atchison experiment a failure. He was notably devoid of any symptom of that widespread affliction, the myopia of the auditor-minded. He loved his vicarious participation in test-tube exploration for the thrills of the unexpected that reward researchers. He did not measure such things in terms of profit and loss. To this chemurgic crusader neither time nor money was ever wasted, even when the expenditure merely enabled a pioneer to produce nothing more tangible than the question, "Where do we go from here?" Garvan never spelled success $ucce$$.

Book Two

PIONEERS AND PROBLEMS

Chapter IX

BAEKELAND—PLASTIC PIONEER

1

In June, 1930, the people of the United States acquired a valuable collection of early Americana. It consists of furniture, silver, glass, prints, ceramics, etc., which had been scattered in scores of colleges, museums and restored historical shrines throughout the country. Representing the handicraft of the pioneers, the collection was given to the people by Francis P. Garvan who celebrated his twentieth wedding anniversary by setting up the Mabel Brady Garvan Foundation, to be administered by Yale University.

One of the most prized items in the collection is a silver cup made before 1700 by Edward Winslow who, a pioneer in the New England wilderness, possessed such rare skill as a silversmith that his work has been compared favorably with that of Benvenuto Cellini.

At the 1936 chemurgic conference, Garvan, inaugurating the custom of honoring a chemurgic pioneer each year, presented the Chemurgic Council's first Pioneer Cup, a copy of the Winslow creation, to Dr. Leo Hendrik Baekeland, "the father and founder of the plastic industry."

Dr. Baekeland has received literally hundreds of scientific honors because he gave man a new thing. To the chemist that new thing is oxybenzylmethylenglycolanhydride. To you, it is Bakelite, "the king of plastics." To the Bakelite Corporation, it is the "material of a thousand uses." To the welfare of the human race, it is important because its discovery liberated mankind from dependence on Nature for primary substances. Until Baekeland came along, man's inventive progress was largely restricted to adaptation of these substances—stone, wood, metals, etc.—to human use. Baekeland put into the hands of man the power of creation—the power to create tough primary materials out of such things as cottage cheese, urea, starch, sugar, carbolic acid, formaldehyde, etc. So his contribution to chemurgy is huge.

Because the great chemist's physicians had insisted that he remain in Florida until June, the chemurgists' honor was bestowed through Dr. Herty.

Receiving the award for his lifelong friend, Dr. Herty recalled that he entertained rather a low opinion of Baekeland when he first met him. It had occurred in the laboratory at the Technische Hochschule at Charlottenburg, as the Nineteenth Century was drawing to a close. The Georgia chemist, grinding away at his studies, was annoyed by the happy-go-lucky behavior of a Flemish fellow student who seemed to "float in and out of the laboratory" without a single care or problem in his mind.

"My early impression was that he was just a good sport who was enjoying the life of Berlin," said Herty.

Before long, however, the American student revised his opinion. This "good sport," he learned, was none other than the man who had revolutionized the art of photography by inventing the sensitized paper, *Velox,* which made possible the instantaneous printing of photographs.

Baekeland is the kind of man about whom legends grow. They were already growing when Herty met him. This was not astonishing, for, though still in his thirties, he was famous as a scholar and teacher and was independently wealthy because of his photographic invention.

Born in Ghent, Belgium, on November 14, 1863, Leo Baekeland was a brilliant student of chemistry even in childhood. After graduating from the University of Ghent at the age of nineteen, he was added to the school's staff as an associate professor and received a doctorate of Natural Science, *maxima cum laude,* two years later.

Great things were happening in those years in the world of chemistry. In Ghent, the great Professor Kekulé of Darmstadt, falling asleep before his fire after a trying day in his laboratory, dreamed of wriggling snakes and, "awakened as by a flash of lightning," set down the dream-image which solved the problem of the puzzling molecular structure of the compounds of carbon and hydrogen. He converted into an orderly garden the field of organic chemistry which Friedrich Wöhler had compared to "a dreadful endless jungle into which one dares not enter, for there seems no way out."

This discovery paved the way for the research Baekeland was to tackle at the end of the century. But it seems to have meant little to him at the time. As he admitted later, "My most important discovery at the university was that my senior professor of chemistry had a very attractive daughter. Hence, the usual succession of events. I was married and confronted with the necessity of a more adequate income than the meager salary of a young professor."

Before the young professor felt sufficiently secure to ask Celine, the daughter of Professor Swarts, to marry him, he taught chemistry and physics at the Government Higher Normal School of Science at Bruges, thereby adding to his income from his teaching job in Ghent. The combined salaries were still not enough, in his opinion. So he toyed with an idea he had developed as an amateur photographer.

In those days, photography was an activity that took a lot of time. Long periods of idle waiting in the pitch-dark room seemed like a bothersome nuisance to a young man with two jobs and a pretty sweetheart waiting for him. So young Baekeland began to try for short cuts. The result was his development of sensitized photographic paper.

Then, in 1887, four Belgian universities awarded him a post-graduate traveling fellowship, and two years later, when he was twenty-six, he married and came to the United States. He liked the country so well that he decided to remain. Still thinking about the short cut he had produced, he went to work in a photographic supply house to learn the tricks of the trade. Not long afterward he left, formed his own Nepera Chemical Company in a small laboratory in Yonkers, New York, and perfected his idea.

But professional photographers would have nothing to do with his innovation. That was a disappointment to the budding industrialist, but he hurdled it by ignoring the professionals and concentrating on the amateurs. Soon the amateurs were turning out better pictures than the professionals, and George Eastman began negotiations for the purchase of the mysterious paper.

There is a legend that Baekeland, summoned to Rochester for an interview with Eastman, left home determined not to part with his secret for less than $25,000, and almost fainted when he was offered a million. The story may be apocryphal, but it is a fact that he obtained enough to make him feel independent for life. As he put it:

"At thirty-five I found myself in comfortable financial circumstances, a free man, ready to devote myself to my favorite studies. Then truly began the happiest days of my life."

What were these "favorite studies" that provided so much happiness?

"Even while he was looking about in Berlin," said Dr. Herty, "I think there was stirring in Baekeland's mind something about the unattractive plastic mixtures which organic chemists discarded because they wouldn't crystallize."

In old volumes of chemical research there are many reports of experiments that failed because "the reaction resulted in nothing but an insoluble resin which was not further investigated." These epitaphs of dead hopes invariably ended chemists' reports of attempts to join phenol, the coal-tar product known as carbolic acid, with formaldehyde, the alcohol derivative, in their test tubes. Whenever these two disinfectants were brought together the result was a gummy mess which could neither be dissolved nor crystallized and which, resisting distillation, could not be purified, analyzed or even identified. Laboratory assistants, cleaning these sticky messes out of flasks and tubes, called them "gunks." Chemists, watching the stuff form at the end of long and painstaking labors, learned to keep the two chemicals apart.

Baekeland began the "happiest days of his life" by the production of one of these chemical failures. He was trying to discover the secret of a little red bug called *laccifer lacca* which, about a fortieth of an inch long and resembling an apple seed, produces shellac. It seemed important to Baekeland that man should learn how this small bug sucks the sap out of trees and converts it into an overcoat for itself. You get an idea of the importance of that little act when you learn that every pound of shellac represents six months of sap-sucking and overcoat-building by 150,000 bugs, and that the processing of these discarded overcoats of stick-lac is a laborious and complicated hand process in India, from whence comes the 67,000,000 pounds of shellac that the world uses in a year.

Baekeland had an idea that *laccifer lacca's* secret would furnish a clue to the mysterious chemistry whereby Nature makes such resins as rosin, copal, shellac, asphaltum and the waxes of animal, vegetable and mineral origin. In trying to crack the mystery open, he dumped phenol and formaldehyde together and got a gunk. Unlike his predecessors, he did not consider the result a failure. This was what he wanted! This was a resin. True, there seemed to be nothing that could be done with the stuff, but it might be worth further investigation.

Now, it is often said that it's a great waste of time for a researcher to repeat the mistakes of other researchers. It's supposed to be the height of folly, especially when the mistake was made and fully reported by a great predecessor. But Baekeland could afford to ignore wise counsel. He had money now and plenty of time. Just a few years before he had been so sorely pressed for time that he had developed a photographic short cut which brought him wealth and leisure, and here he was, frittering away his time, not only studying the literature of this failure-scarred reaction, but deliberately repeating the recorded experiments to see why they had failed.

An experiment he repeated was one the great Adolf von Baeyer had made in 1872. That was also an attempt to make shellac, an attempt abandoned with a note of disgust. Out of his trials and his reading Baekeland began to learn something about a strange molecular greed which, possessed by formaldehyde and phenol, makes them valuable as disinfectants because their acquisitive natures lead them to attack decomposable organic matter. In the leaf of a growing plant, formaldehyde, though it possesses the simplest formula for a carbohydrate, has the ability to multiply itself by molecular merger into sweet solid glucose, or, losing water, into starch or cellulose. It is a process which chemists now recognize as polymerization, the making of big molecules by the joining of little molecules. This disposition to merge is strong in formaldehyde and in phenol. Therefore, when the two were brought together, the merging process became a sticky mess that tried to merge with everything it touched.

Baekeland attempted to control the reaction of the two substances—to curb the molecular greed. It was no good. He attempted to crystallize it. Failure. He tried every solvent he could think of, but it refused to dissolve. Then he tried heating it, hoping to melt it. Instead it became harder and harder. And, then and there, his curiosity came to the rescue. Looking at the hard, amorphous lump, he wondered if it might have value as a plastic.

What about the literature of plastics? Baekeland asked himself, and reflected that there was no need for him to hurry about getting the job done. So, taking his time and enjoying himself, he browsed in the scientific literature of plastic production. First, of course, came the plastic, glass, the man-made primary material whose inventor's name is lost in mists of antiquity. Thereafter, thousands of years of no activity in this field until 1863, the year in which Baekeland opened his eyes in Ghent. In that year a report came out of Africa that there was a scarcity of elephants in the jungle, especially elephants having tusks more than two and seven-sixteenths inches in diameter. It came to the New York office of Phelan & Collander, whose executives went into a huddle and issued from it with the announcement that they would pay $10,000 to anyone who could produce a substitute for ivory billiard balls.

The offer was read by John Wesley Hyatt, a roving printer, just before he nicked his finger and went to the medicine cabinet for the liquid court plaster. This plaster was a relatively new thing, a developmental offshoot of research launched by the Swiss chemist, Christian Friedrich Schönbein. In 1846, Schönbein dumped vegetable fibers and nitric and sulfuric acids together and got an explosive which chemists called nitrocellulose and plain people, guncotton. There were other offshoots of that research, such as pyroxylin and rayon and cellophane, but the one that looms up as especially important here is this stuff called collodion, or liquid court plaster.

A monument should be erected to the man who discovered collodion—if the name of the discoverer can be found; for, on at least three occasions, it played an important part in chemical progress. A French chemist dropped a flask, saw it shatter but was astonished because it retained its shape. Investigating, he found that it had contained collodion, and he applied the idea to the production of safety glass.

Dr. Slosson once said that the World War could be traced back to the time when the Swedish chemist and pacifist, Alfred Bernhard Nobel, cut his finger and, dabbing it with collodion, used this combination of guncotton and ether-alcohol as the starting point of the blasting gelatine which made modern high explosives possible.

It was this same collodion that started the story of plastics. When Hyatt looked in the medicine chest, the collodion bottle had been tipped over and its contents had spilled out and hardened. Pulling the rubbery stuff from the shelf he rolled it between his thumb and forefinger and thought about that $10,000 prize offered by Phelan & Collander. As he day-dreamed about big money, the stuff between his thumb and finger softened into a smooth little ball. That gave him an idea. The end result of that idea was celluloid, an entirely new substance, the first modern plastic, which Hyatt and his brother Isaiah produced in 1869.

Then, in 1890, Dr. Adolf Spitteler of Hamburg was asked to devise a "white blackboard" for a special purpose in a classroom and, dumping sour milk and formaldehyde together, produced a casein-derived plastic, a synthetic ivory which, unlike the Hyatt product, was not inflammable.

Mankind's achievements in the creation of primary substances had got so far when Baekeland decided to indulge his idle curiosity in his back-yard laboratory.

3

In 1901, Dr. Herty visited Dr. Baekeland in Yonkers and was invited into the back-yard laboratory with an assurance that he would be shown something worth seeing.

Punch-proud, the Belgian scientist displayed a set of billiard balls which he had made out of that stuff which had annoyed so many chemists. Dropping them on the cement floor he counted the rebounds. Then, dropping a set of ivory balls, he showed Herty that the balls he had created were more resilient than balls made of ivory. Out of a cabinet he pulled a phonograph record which he played and then tossed on the floor. Herty was amazed when the record bounced but did not break.

"As you can imagine," he recalled, "Dr. Baekeland was an extremely happy man, but even then I don't believe he had any conception of the vast ramifications that were to follow this discovery of his."

The rest of the story is fairly familiar. Dr. Baekeland, who had never patented his Velox paper "because lawsuits are too expensive," buttressed the bakelite process which he announced in 1909 with four hundred patents—and ran into a tangle of litigation which stuck in the courts for years. When the courts ruled that his rights were basic and that the other companies in the field should render accounts, he went to the defendants, told them not to bother trying to figure out what they owed him, and invited them to join his company because he said, "this is a field that is going to require the brains of all of us." Thus, Lawrence V. Redman who developed redmanol by mixing phenol and formalin, became Dr. Baekeland's research chief and vice-president of the Bakelite Corporation.

The rise of the Bakelite Corporation coincided with the rapid growth of the automobile and the electric industries. Because Bakelite was a perfect insulating material, it played a powerful part in the development of radio and all electrical communication tools of the Twentieth Century.

After Dr. Baekeland pointed the way, the race for the perfect plastic was on in full cry. Today the list of synthetic resins is numbered in thousands. And, although that perfect plastic has not been found, every variety has individual merits which enable it to find its particular field of application in an expanding field. New types and varieties are now being produced so rapidly that it has become difficult to define the word *plastics,* or to classify the uses and varieties. In a fairly recent copy of *The British Year-book of Plastics,* fifty-five pages are devoted to the mere listing of products made of plastics and thirty pages are needed to enumerate the substances from which plastics are derived. As to definition, it has been said that only a chemist can tell whether a substance is a plastic or not and that even a chemist may have difficulty explaining his decision. For instance, much of the tonnage production of this expanding industry makes its appearance not as things which the layman would recognize as plastics but as an ingredient for paints and varnishes and (this is ironic when you think of Dr. Baekeland's original motive!) as a substitute for shellac.

The industry that arose from this piece of research has the unique distinction of having doubled in size since 1929. Within the span of fifteen years the production of synthetic resins alone increased more than a hundredfold. Since the statistic of growth does not take into account the increasing use of such cellulose-derived plastics as rayon and cellophane or the plastics produced from rubber, coal, petroleum, wood, salt, sulfur, limestone, air, water, etc., it is obvious that future developments are unpredictable.

We know only that, despite the enormous growth, the industry is still in the gadget age. It is now being applied to the production of airplanes and automobiles. There are indications that it will be applied to houses. The prospects are staggering to the imagination. Most important to chemurgy and to the hopes of the chemurgists, is the fact that plastic industry is based on the use of exactly those raw materials which are the most common and the most widely distributed throughout the world—the combinations of carbon and hydrogen constituting the things to which we refer when we speak of farm surpluses.

Today, as Dr. Hale and Dr. Karl Taylor Compton have pointed out, the expansion of this alluring horizon is limited only by the relatively high costs of the chemicals employed. An illustration is found in an odd set of circumstances in the United States in 1919. The World War having ended, the government found itself possessor of 40,000,000 pounds of carbolic acid for which it had no use. This stupendous supply was not the brown liquid which one finds in the drugstore, but the concentrated, pinkish-white and dangerously caustic crystalline phenol that had been manufactured in huge quantities for the processing of picric acid for the production of the explosive, trinitrophenol.

Such a store of phenol looked mountainous in 1919, for the main peacetime uses of phenol were then chiefly in the manufacture of sheep dip, disinfectant, aspirin and the medicinals in the salicylic acid group, uses which consumed about 3,000,000 pounds annually.

Since this war-surplus appeared to be an unmanageable supply, the government turned it over to a large phenol producer, ordered it to be marketed gradually and set the price, which had been fifty-five cents, at the ridiculously low figure of twelve cents a pound.

Then, as Williams Haynes, editor of *Chemical Industries,* pointed out at the 1936 chemurgic conference, the existence of the bargain stock became the driving force of two new industries. Radio-broadcasting appeared on the scene, but its expansion as a popular plaything was limited by high costs of materials employed in receiving sets. Bakelite, the phenol-formaldehyde plastic, was the perfect insulating material for them. But it was expensive. Almost overnight, that huge stock of phenol became the answer to the prayers of the plastic-makers and the radio industry. Within three years, the phenol bargain counter was clear, the radio industry had grown without interruption through the post-war depression and the plastic industry had moved out of what "Boss" Kettering calls "the shirt-losing stage" of its development. Twenty years later, there were radio receiving sets in 26,000,000 homes and 5,000,000 automobiles in the United States; and the domestic output of synthetic resins increased from less than 2,000,000 pounds worth $1,400,000 in 1921, to 162,000,000 pounds worth $25,800,000 in 1937.

The significance is this: When the plastic industry began to buy twelve-cent phenol in 1919, Dr. Hale, who had participated in the research that enabled American chemical industry to produce it, realized that the chemical could not be produced for less than fifteen and one-half cents a pound and that there would be trouble when the bargain supply was exhausted. Assembling his best research associates, he set to work on the development of more efficient manufacturing processes. The outcome: The Hale-Britton processes for hydrolysis of chlorobenzene into phenol and for ammonolysis of chlorobenzene into aniline. Perfected within three years, they dropped the price of phenol below the bargain figure. Since then, the price has declined constantly because Hale and his helpers have mastered the trick of utilizing *all* the by-products of phenol manufacture.

Hale's conviction that he would have to find cheap chemicals for the plastic industry resulted in his formulation of the chemurgic idea. The search has turned up furfural, derived from oat hulls and corncobs, as a partial substitute for formaldehyde. It has produced rapid changes in the methods of manufacturing cellulose plastics, of which 36,000,000 pounds were produced in 1937. It has pushed research into the field of protein plastics, a field in which men are probing the plastic possibilities in milk, blood albumens and soy-bean proteins. At Michigan State College, part of the Rackham Fund grant for chemurgic research is being used to investigate the plastic potentialities of alfalfa proteins. Elsewhere, researchers are exploring lactic acid, derived from vegetable and animal sugars by fermentation, and lignin, the wasted wood by-product. According to Larry F. Livingston, the du Pont agricultural engineer, the plastic industry may eventually use such wastes as pig and cow hair and poultry feathers. "Looking into the future of plastics," he says, "is like watching a four-ring circus. You never can tell what will happen in which ring. Undoubtedly we are entering the plastic age. When you consider that farm products form the raw material for from twenty-five to thirty per cent of the plastics manufactured today, you can readily realize what this plastic age will mean as a market for the American farmer."

Chapter X

FORD LINKS FARM AND FACTORY

1

You come now to Dearborn, Michigan. It is 1:00 P.M. of May 7, 1935. The opening session of the first chemurgic conference has been adjourned. The delegates have assembled in the rotunda of the reproduction of Independence Hall which is the central portion of Edison Institute Museum in Henry Ford's famous Greenfield Village. In the center of the group is a table which once stood in Abraham Lincoln's law office in Springfield, Illinois. Beside it is a desk used by Thomas Jefferson in his home. On the desk is an inkstand, an exact copy of the one used by the signers of the Declaration of Independence. On the table is a parchment scroll with the grandiose title, "Declaration of Dependence upon the Soil and of the Right of Self-Maintenance." This document, largely the work of publicity-wise Carl Fritsche, is awaiting the signatures of the chemurgic conferees. The Fordson High-School Band blares "The Stars and Stripes Forever." Garvan reads the title and introduction of the "Declaration," and invites the delegates to sign it. The Reverend Hedley G. Stacey intones a benediction. The band plays "The Star-Spangled Banner." The newsreel cameras buzz as the conferees move toward the table and prepare to sign. Everything is running according to schedule. Then, suddenly, confusion! Three important signatories are missing. A huddle of chemurgic bigwigs, a buzz of excited talk, and out of the group goes a search party for Henry Ford, Edsel Ford and Irénée du Pont.

Long after the ceremonies are over, the three are found. They apologize for having forgotten all about the ceremonies and they blame their forgetfulness on a bean.

No ordinary legume such as that upon which Bostonian fame is built! No; this is the fruit of that ancient Chinese plant, the Eastern Hemisphere's only bean, which the botanist calls *Glycine Max,* the English call the soya, the Americans call soy, and the Chinese revere as "The Little Honorable Plant."

Before the ceremony, the Fords and du Pont had met at luncheon in Dearborn Inn. After luncheon, Mr. du Pont, puffing on his long-stemmed black pipe, leaned back in his chair and said he was interested in the Ford experiments with the soy bean. As Henry Ford was more than willing to explain, the three men, lost in conversation, forgot the chemurgic program and wandered out of sight.

2

In the neighborhood of the Ford Engineering Laboratories in Dearborn are thousands of acres where row on green row of heart-shaped leaves undulate lazily in the sun. They are a symbol of a project that may alter the trend of human affairs. They are bean fields, vast patches of beanstalks with which a modern Jack-the-Giant-Killer is preparing to slay hosts of ogres. The hero of this modern nursery tale is Henry Ford, the farm boy who, tinkering with mechanics, became the mechanic who tinkered with farms, an industrial titan uniquely possessed with the soul of a dreamer, a Croesus whose shrewd materialism is ameliorated by the savorsome salt of a far-sighted mysticism.

The ogres that this modern Giant Killer hopes to topple under a hail of beans are those primordial playmates: War, Pestilence and Crime. The knockout of those three weird sisters is to be consummated by the slaying of the super-ogre that spawned them, the ugly thing called Poverty.

These bean fields are the first step in the Ford program of pioneering toward the horizon of permanent plenty. Each field bears a small sign, "SOY BEANS." Those eight letters are the answer to a troublesome pack of problems that have puzzled Ford for years. One is the problem of War's origin, which Henri Fabre, extracting wisdom from his observations of bugs, reduced to the mathematical equation of one mouthful of food to be divided by two ravenous mouths. Another is the finding of the way out of the economic morass into which the civilized world periodically blunders. A simple son of the soil, Ford looked to the earth for the roots of these problems and found the solution in the soy bean.

The search led to China where cocksure Western civilization not infrequently goes when the hot blast of urgent necessity cooks up a thirst for cool, calm wisdom. In discovering ancient China's solution, Ford uncovered something that may one day permit him to uncork the last laugh at the expense of those who propagated one of those perennial Ford jokes years ago.

Do you recall the gibes that greeted his prediction that man would one day find a substitute for the cow, as revolutionary as the automobile which displaced the horse? It was very funny when the cartoonists and the columnists leaped upon it gleefully—but it may not be so fantastic as it once seemed.

Let's investigate it.

Come now to the foot of Elm Street, in Dearborn, to a rejuvenated farmhouse whose homelike exterior masks a modern laboratory. Scientists manipulate test tubes, stand over retorts, peer into microscopes and trace hieroglyphics on charts. Beyond the windows, cat-tails nod from the marge of a mill pond which is one of the features of Greenfield Village, Ford's museum town of America's disintegrating yesterdays.

Follow the truant chemurgists inside and meet Ford's boyhood companion, Dr. Edsel A. Ruddiman, the food-chemist whose services were enlisted by his old deskmate. In the back room, once a farm kitchen, is an electric refrigerator, filled with food made from soy beans. Milk, butter and cheese—the latter, fresh, dried, smoked and fermented—are there, soy-bean products all. In the pantry are breakfast foods, macaroni, salad oils, crackers, diabetic foods, infant foods, flour, bouillon cubes, soups, confections, coffee substitutes, sauces, gravies and beef substitutes—all produced from the soy.

At the stove a worker is preparing a batch of bread, cake, biscuits and muffins, all made of soy flour so rich in vegetable fat that no shortening need be added. Beyond the kitchen is a room tenanted by hundreds of white rats. Here, a scientist charts life histories of generations of rat families whose members not only subsist but thrive on constant diets of nothing but soy, the only food that contains every element of an adequate diet.

A wonder bean indeed! It contains vitamins A, B_1, B_2, D, E. Its protein content is thrice that of wheat or eggs, more than twice that of lean meat. Its fat equals the average of meat, but is more easily digested than animal fat. Its water content is infinitesimal, making it one of the most compact foods. Its 2,100 calories per pound are excelled only by the peanut. Because it contains little sugar, no starch, it is a boon to diabetics. During the World War, when Germany faced famine, German chemists extracted from the soy the glutamic acid which became the basis of the "beef-tea" that kept patients alive in hospitals. It has yielded lecithin, a compound combining properties of fat and protein, used in medicinal emulsions and as substitute for butter fat in ice cream and milk chocolate. At the Century of Progress Exposition in Chicago, Dr. Ruddiman served a banquet composed entirely of the soy bean in culinary mutations. In Paris a factory converts soy-bean curd into Rocquefort cheese. It gets into Heinz and Lea & Perrins' sauces and into oleomargarine.

Perfect food for man, perfect feed for beast, it actually feeds the soil in which it grows, making it richer and richer in nitrogen. Economic mainstay for centuries in the Orient, the soy once saved Denmark from economic collapse and may one day bring to England that boon which the island has not enjoyed for centuries, the ability to feed itself.

Until thirty years ago, Denmark was self-supporting in the production of cereals. Mass-produced farm crops in America upset the economic balance in the little nation. The Danes turned to livestock and poultry and, feeding the animals soy beans, became exporters of milk, butter, cheese, ham and eggs.

In England, the results of experimental plantings on Henry Ford's 2,000-acre farm at Boreham, Essex, have been sufficiently encouraging to cause students to express the belief that the soy could feed a besieged England indefinitely.

But, though research has proved it to be the most complete food known to man, it is not the food value that interests Ford primarily.

3

To discover his chief interest in the wonders of the soy bean, you cross the farmyard of Dr. Ruddiman's laboratory to an unpretentious wooden building. This is the chemical laboratory where the soy is probed for its contributions to the linking of agriculture, industry and science. If this were a marble temple of science instead of a barnlike laboratory, the proper inscriptions for its façade would be the following declaration of Ford's chemurgic credo:

"I foresee the time when industry shall no longer denude the forests which require generations to mature, nor use up the mines which were ages in the making, but shall draw its material largely from the annual produce of the fields. . . . I am convinced that we shall be able to get out of yearly crops most of the basic materials which we now get from forest and mine. . . . The time is coming when we shall *grow* most of an automobile. . . . The time is coming when the farmer, in addition to feeding the nation, will become the supplier of the materials used in industry. . . . I believe that industry and agriculture are natural partners. Agriculture suffers from lack of a market for its product. Industry suffers from lack of employment for its surplus men. Bringing them together heals the ailments of both. I see the time coming when the farmer not only will raise raw materials for industry, but will do the initial processing on his farm. He will stand on both his feet—one foot on the soil for his livelihood; the other in industry for the cash he needs. Thus he will have a double security. That is what I am working for!"

These beliefs are embodied in the laboratory in which the soy bean is studied for its relations to a better economic future for America and the world. Here, under the supervision of Russell Hudson McCarroll, who learned his chemistry under Dr. Hale at the University of Michigan, the soy is being forged into a link to bind farm to factory. Here the rich oil of the soy is used in the manufacture of glycerine, explosives, enamels, varnish, waterproof goods, linoleum, paints, soaps and printing inks. Of this oil, every Ford automobile takes a half-gallon for its enamel and another half-gallon for the glycerine in its shock absorbers. In addition, the Ford factory uses 200,000 gallons annually for foundry sand-cores and large quantities in soaps and paints.

For the extraction of the oil, Ford researchers developed equipment which farmers can build and install in their barns, thereby becoming initial processors and not merely raw material producers. This equipment, which operates much like an ordinary coffee percolator, was displayed in the "Industrialized American Barn" at the Century of Progress Exposition. The reason for encouraging the grower to do his own oil extraction is that the industrial demand for oil exceeds the demand for meal, which is what is left when the oil has been removed and which is valuable as food, feed or fertilizer.

But the industrial demand for the meal is increasing. Since 1930, when he began his project, Ford has tossed more than $3,000,000 into this research upon which more than twenty scientific investigators have been constantly employed.

Because the meal contains almost fifty per cent proteins, it can be reacted with formaldehyde into a molding plastic. Sometimes called satolite, it is used to make horn buttons, gear-shift balls, light-switch levers, distributor parts and other molded units which are gradually replacing mined minerals and imported products. The meal is used also as an adhesive in making coal briquettes, in foundry and steel mill sand, as glue for plywood and as paper size.

In maintaining the appearance of Ford plants in the United States, a thousand gallons of paint are used every day. Out of soy meal Ford researchers extracted a protein which, acting as the vehicle for the pigment in a water paint, gave them a wall covering safer from fire and health hazards than oil paints. Into that paint go half a million pounds of beans a year.

What else?

At the 1938 chemurgic conference, Ford Chemist Robert A. Boyer reported progress in the use of soy meal in the manufacture of engine gaskets, and displayed a skein of wool-like fiber which his research associates had produced, after eighteen months of experiment, from soy protein. The objective is to use this fiber as upholstery material for automobiles.

Out of the laboratory in 1938 came the plans and technics which, transplanted into what had been a village dump in a scrubby-timbered valley just outside of Saline, Michigan, became the first Ford soy-bean processing plant. It is the latest unit of a score of small factories with which Ford has been revitalizing decadent Michigan villages and beginning the industrial decentralization which, he maintains, must follow the era of centralization through which man had to pass in order to learn how to lighten life's burdens.

"Independence means self-dependence," he says. "No unemployment insurance can be compared to an alliance between a man and a plot of land."

4

Henry Ford may not have been the original chemurgist, but there is no doubt that his mind was moving toward chemurgic conclusions as early as 1919. Thumbing through yellowed clippings of newspaper files and reading his utterances in interviews in the 1920's, you are often startled by the discovery of remarks which, though they must have sounded far-fetched at the time, dovetail nicely into the currently unfolding pattern of chemurgic thinking.

These clippings reveal that the Ford vision saw, beyond the happy high jinks of the Turbulent 'Twenties, the faint signals of world-shaking changes. Since it is the common fate of prophets to be misunderstood, the Ford predictions were often greeted with the sort of reaction that twisted his remark about a chemical milk substitute into a picture of a mechanical cow.

There was merriment when he said the day would come when automobiles would be largely grown. Yet, a few years ago, William J. Cameron revealed that the process of growing automobiles is already under way. Into 1,000,000 automobiles, he said, go 3,200,000 pounds of wool from 800,000 sheep; 1,500,000 square feet of leather from 30,000 cattle; lard oil, oleic acid and bristles from 20,000 hogs; 350,000 pounds of mohair from 87,500 goats; beeswax from 93,000,000 honey bees; 89,000,000 pounds of cotton from 558,000 acres; butyl alcohol, starch and rubber substitute from 11,280 acres of corn; 2,400,000 pounds of linseed oil from 17,500 acres of flax; solvents and anti-freeze and shock-absorber fluids from 12,500 acres of sugar cane; 112,-000,000 feet of crating lumber, 5,000,000 feet of paperboard and 2,000,000 pounds of turpentine from more than 20,500 acres of timber; 69,000,000 pounds of rubber; and 2,000,000 pounds of soy-bean oil.

Recently Chemist Joseph S. Laird admitted that the soy plastic experimenters are far from satisfied with their accomplishments to date and indicated that the aim is to perfect *pure* soy plastics with all the desirable qualities of the best thermoplastic resins. He added that the utilization of the formerly wasted lignin in wood may mark the coming of molded plastic panels for car and truck bodies, airplanes and probably whole houses.

In January, 1938, Ford displayed to reporters a curved sheet of composition made from soy beans. Jumping up and down on it, he said: "If that were steel it would have caved in!"

"Do you still believe that automobiles will be grown?" he was asked.

"You will see the time when a good many automobile parts will be grown," he answered. "The engine, drive shaft and a few other parts will, of course, be of steel. But the rest, including the body, will be made of farm products."

"Maybe fifty years from now?" someone asked.

"Fifty years? Humph!" he snorted. "Much sooner."

Although Ford undoubtedly led the field in the search for industrial uses of the soy bean, he did not introduce the plant to the United States. Nor has he been alone in the research which has uncovered its many applications.

Emperor Shen-Nung, "the father of Chinese agriculture," described the soy in a *materia medica* which he wrote in 2838 B. C., and he listed no less than three hundred medicinal properties to be found in it. Tradition says it was a food staple in

China for centuries before that date. It is mentioned often in Chinese classics and its praise has been hymned by poets. To the Japanese, milk and butter and cheese have never meant cows but soy. Because bean-meal cakes have always been meat and fertilizer to Japan, that overpopulated little nation long coveted Manchuria, where from 500 to 1,500 soy varieties flourish. It was probably the soy that was responsible for Japan's invasion of China in the first place. Two thirds of the world's annual crop of 6,000,000 tons of soy are still raised on the farms of the puppet state, Manchukuo.

Nobody knows exactly how or when the "Little Honorable Plant" first came to America. One version attributes the migration to a Yankee shipmaster in 1804. Another assigns it to a missionary who sent a few of the wonder beans to his boyhood home in eastern North Carolina, where they were grown in flower gardens a hundred years ago. Virtually all of the beans in America were on a few acres in this area until 1854, when the Perry Expedition returned from Japan with additional varieties which were distributed by the Commissioner of Patents.

Then, shortly after the turn of the century, the late C. V. Piper, of the Department of Agriculture, began to champion the cause of this Chinese plant. Recommending it as a good addition to American agriculture, Piper picked W. J. Morse, a New York State farm boy who had graduated from Cornell, as the man to adapt the plant to American climatic conditions and soils. That was in 1907.

Ten years later the total United States acreage was about 500,000. In 1916 interest in soy-farming flared in Illinois. A. E. Staley had become acquainted with the bean as a farm boy in North Carolina and, never having lost interest, encouraged the growing of the crop by building a soy-bean processing mill as part of the A. E. Staley Manufacturing Company's corn products plant at Decatur.

It might be said that the soy bean became a major American farm crop because Mr. Staley suffered from diabetes. Dr. Barnard recalls that this man, who was a successful starch salesman before he became a more successful starch manufacturer, became a soy bean pioneer because he was fond of pastry but could eat no starch.

The annual American planting now exceeds 7,000,000 acres, strains having been developed for all kinds of climate and soil between Winnipeg and the Rio Grande. New varieties are still being introduced for special uses such as edibility, oil yield, nitrogen fixation, fodder potential, etc. Thanks to Staley's pioneering, the University of Illinois took up soy research, the Regional Soy Bean Industrial Products Laboratory of the United States Department of Agriculture was established in Urbana, and the State of Illinois now produces about half of the annual United States production.

In 1922, when Staley built his plant, there were about 1,000,000 acres in this country planted to soy, mostly for forage. Five years later the acreage had doubled. By 1935, 5,000,000 acres were producing 40,000,000 bushels of beans and putting $35,000,000 in our farmers' pockets. Then, in October, 1936, the Chicago Board of Trade, recognizing that the soy outranked rye and barley in value, admitted it to trading. By March, 1939, the newcomer was the highest-priced commodity bushel-for-bushel sold on the Board of Trade. It had become that unique thing, a crop without a surplus, despite a record 1938 crop of almost 58,000,000 bushels.

The annual yield in bushels is no reliable barometer of the growth in total acreage, for much of the crop is used for fodder and for building up starved soil. A green crop plowed under often increases wheat yield six bushels per acre. Though a diet of nothing but soy beans is not fed to livestock because it is too fattening, silage made from soy plants and cornstalks produces more milk and more meat than straight corn silage.

Each ton of dry beans yields 1,600 pounds of meal, largely used for livestock feed, and 30 gallons of oil. To the increasing demand for the oil the expansion of our soy acreage must be largely attributed. It is an odd fact that, although industry provided the impetus for the increased oil demand by discovering non-food uses for it, more of the oil is now being used for food than for all other purposes. This is an unexpected development of American dairymen's fight against oleomargarine. Anxious to acquire American farmers' support against discriminatory taxes on their product, the makers of oleomargarine turned from imported coconut oils to American farm-grown oils. The result: The annual use of soy-bean oil in oleomargarine increased from 7,000 pounds in 1933 to 40,000,000 pounds in 1938. Besides, Americans consumed 124,000,000 pounds of oil in food compounds, vegetable shortenings and edible fats in 1937, leaving to industry only 35,000,000 pounds for all non-comestible uses.

However, while this edible use is increasing, the non-comestible use is more than doubling annually. Principal industrial use is for paint, a result of research pioneering at Purdue University and the University of Illinois. Blends of the oils of soy bean and tung nut are now thrusting aside the old-fashioned lead and oil paints. In Illinois, soy-bean farmers trade so much of their crop in kind to paint manufacturers that in 1935 one out of every ten barns in the state was painted with these new products.

At the Mid-American Farm Chemurgic Conference in Columbus, Ohio, in May 1939, G. G. McIlroy, president of the American Soybean Association, revealed that one soy research laboratory has turned up fairly reliable evidence that soy oil used in scalp treatments prevents baldness. At Purdue University another researcher has found that the soy yields stigmasterol, the chemical which seems to retard age in humans.

Despite the increase of American production, the annual oil import is the equivalent of the output of a million acres. I. C.

Bradley, president of the National Soy Processors Association, claims that the prospect of reaching a productive saturation point is too remote to merit consideration.

"So many new uses are being found," he says, "that it is easy to believe the claims of the chemists that the soy will become one of our major crops."

In the Emperor Shen Nung's "Little Honorable Plant," chemurgy has found its best demonstration of how the test tube of the research chemist can link farm and factory for the economic betterment of the community.

CHAPTER XI

CHEMURGIC OIL FIELDS

1

IN the Emperor Shen-Nung's soy bean the American farmer has found wealth by striking oil.

A mite of a word but a mighty word is "oil." It has magic. It packs menace. It lacks specific meaning.

You catch the magic aspect when you think of a town like Tulsa, Oklahoma, oil-transformed in less than half of a man's lifetime from a score of shacks into one of the nation's most impressive groups of skyscrapers. Or when you think of oil-wealthy, sprawling, depression-defying Texas. Or the golden geyser gushing from the soy.

Of the menace you catch glimpses in history and headlines. Lack of oils and fats cracked the might of Imperial Germany in 1918. The map of Asia changed when Japan seized the oil-rich acres of Manchuria's soy beans. Oil was important among the temptations which drew Italy into Ethiopia and Albania. The lure of Rumania's oil may set military machines in motion tomorrow.

Yet this mighty, magic, menacing word's meanings are so many that "oil" is meaningless. In Tulsa and in Texas and to most men it means earth-oil. And earth-oil is what? Plants? Animals? Marine organisms? Scientists disagree. Scientist Kettering says "fossilized sunlight."

But, earth-oil aside, the word is still meaningless. Consider for instance its meaning's time-changes. A century ago it was whale oil. Later it was coal oil. Then rock oil. Then petroleum. And today, what?

Today "oil" may mean fuel or lubricant to a man; and to his wife, salad or cooking or cosmetic. Geographically chameleonic, it may mean fish in Maine and Washington, animal blubber in the Arctic, soy beans in Illinois, tung in Florida and Mississippi, peanut in Alabama, pine in Georgia, cottonseed in any southern state, corn in Iowa, castor in Kansas.

Even in the trades and professions the meanings of "oil" are slippery. To a cook it may be olive—even when it is actually cottonseed or corn. Or it may be fat, which is hydrogen-hardened oil whether the processor was pig, cow or chemist. To the painter it is linseed but it may be tung or soy or a blend of both. To a soapmaker it is likely to be any one of dozens of vegetable or animal fats, according to which is cheapest at the moment; in the making of the 10,000,000,000 pounds of soap the world consumes annually, price is the major distinction between oils. Like the soapmaker, the chemist thinks of "oil" as oil, a combination of carbon and hydrogen and oxygen masquerading as the acids linoleic, oleic and stearic, according to the number of hydrogen atoms present. Though the chemist makes distinctions between "fats" and "oils," he regards them collectively.

To the chemurgist, "oil" may mean, in addition, the seed-fats of such plants as perilla and chia, members of the mint family. But what the word most means to the chemurgist right now is potential wealth for America. For he has struck oil, not in the bowels of the earth, but on the surface.

For the chemurgic discovery of oil, the palm goes to no solitary pioneer. It has been less a discovery than a gradual dawning of awareness, like the inching creep of dayspring. Typical of the manner in which awareness emerged is the story, already told, of the roundabout recognition, through curiosity about alcohol and levulose and girasole and grasshoppers, of the oily wealth of the castor. Typical, too, the roundabout recognition of wealth in the oil of the soy, and the riches in furfural, the oil-like non-oil in the cereal wastes.

Oil-like non-oil? Absurd? Everything about oil is absurd! There's the saying: "Oil and water don't mix." Yet, much of the industrial value of the vegetable oils lies in the fact that they *do* mix with water. As miscible oils, used in plant sprays, they are replacing mineral oils and metallic poisons because they are deadly to insects but harmless to plants and animals. Peanut oil yields a compound which, as insecticide, may replace the 3,000,000 pounds of Paris Green used annually. As soluble oils, known as sulfonated oils because they are treated with sulfuric acid, the vegetable oils become bath oil, soap and soapless shampoos, lipsticks and face creams, water softeners and waterproof papers, and they contribute to the softness of bath towels, the luster of silk and rayon, the durability of color in textiles and the pliability of leather.

Oil is a subject bristling with absurdities. Denmark exports butter and imports oleomargarine. The Mediterranean nations export olive oil and import corn oil and cottonseed oil. The United States grows more cotton than it can use and buys cottonseed oil abroad. We have become the world's greatest consumers of animal and vegetable fats and oils, and, despite our unquestioned ability to produce these raw materials on our idle acres, our imports of them are exceeded only by our imports of rubber. According to A. M. Loomis of the National Dairy Union, Washington, D. C., the domestic production of oils and fats would have to be increased 2,000,000,000 pounds per year to make the United States self-sufficient in this respect. This increase would necessitate doubling the present peanut acreage, tripling the soy-bean acreage, tripling the corn-oil production, maintaining the present cotton acreage, increasing tallow and grease production and developing the growing and processing of flax, sesame, perilla, hemp and sunflowers.

And out of this welter of absurdities emerges the paradox that "oil," the meaningless, has become the most meaningful word in the chemurgic vocabulary—meaningful because *Americans use three thousand tons of imported fats and oils every day.*

2

Because the picture of oil resembles a surrealist scrawl from whatever angle you view it, the chemurgic aspects seem to be best presented by scissoring the whole into segments, making a jigsaw picture of oil-sources. You can't cut the picture into segments representing uses. They shift too rapidly. You can say that we eat a third of these oils, whether we produce or import them, and that olive and cotton are the edible favorites. And you can say that our largest non-comestible uses are the oldest of such uses—soap and paint; that soap favorites are palm and coconut, and that paint-makers prefer linseed but are turning to tung, perilla and soy. But when you have said these things, you have to add that butter and lard vie with the edible oils of vegetables, and that animal greases and fish oils are the top favorites of the soapmakers. Moreover, you have to add that almost all of these oils compete with one another; and, since oil is oil and price is seldom the same thing twice to many oil-users, the picture of oil uses is likely to resemble a kaleidoscope in a palsied hand.

So, looking at import-export statistics, you find we are sorely dependent on the rest of the world for oils and fats which we could produce. Though we produced huge tonnages of cottonseed, corn, peanut and soy oil in 1937, we imported more than $30,000,000 worth of edible oils, $86,000,000 worth of non-edibles and more than $63,000,000 worth of oil-bearing seeds. During that same twelvemonth we exported about $6,000,000 worth of oils and oil-bearing seeds. Looking at those 173,000,000 winging dollars in trans-oceanic flight, mostly to lands where wages are too miserably low to provide America with customers, the chemurgists wince when they think of the music 173,000,000 ringing dollars would make if they were added to the American farm income annually.

Examining the individual oils, you find that the leading import is:

Coconut. Almost 500,000,000 pounds of this oil came into the United States in 1937, virtually all of it competing with domestic oils. Soapmakers used 352,000,000 pounds, but, depending on tallow for about half of their fats, soapmakers employed coconut oil for only seventeen per cent of their total use. It began to flow into the United States in increasing tides after manufacturers of oleomargarine switched from animal to vegetable fats. Before 1919 the majority of fats in oleomargarine were animal. By 1933, animal fats contributed only twenty-five per cent. When an excise tax of three cents a pound was imposed on imported oils in 1934, makers of oleomargarine turned to domestic oils such as soy. Their use of imports fell to a low point in 1937, but low coconut prices in 1938 shifted the balances again. In 1937, oleomargarine was sixty-seven per cent domestic vegetable oil, thirty per cent imported oil; and in 1938, domestic oil dropped to fifty-nine per cent and imports rose to thirty-four per cent.

Palm. Imports of palm oil and palm kernel or palm-nut oil are increasing rapidly and are all competitive with domestic oils. In 1937 we consumed more than 160,000,000 pounds of them in food and used more than 250,000,000 pounds in soap.

These tropical oils cannot be produced in the United States, but they compete with domestic acres, as do the approximately 100,000,000 pounds of imported oils such as sesame, rapeseed, babassu, sunflower, perilla, etc.

Flax. For thirty years the United States has been using more flaxseed than it has been able to produce. About 15,000,000 bushels, one-half our consumption, are imported annually at prices ranging from a dollar and fifty cents to two dollars a bushel. Grown in Minnesota, Dakota, Kansas and California, flax is now being tried in Texas where chemurgists have discovered that its seed production compares favorably with that of the best areas. About half of the oil used in paints in 1937 was linseed, the oil of flax. Since the plant also yields strong linen fibers, the chemurgic research program includes perfection of strains able to fight weeds and diseases, and improvement of methods of obtaining the fibers. For centuries, the fiber has been obtained by the tedious process of retting (alternate wetting and drying of stems) which destroys valuable by-products. A special decorticator has been invented which may revolutionize an ancient industry.

COTTON. Americans consume more than 1,000,000,000 pounds of cottonseed oil annually, spend more than $200,000,000 for it, use almost 1,000,000,000 pounds in lard substitutes, more than 100,000,000 pounds in oleomargarine, almost 200,000,000 pounds in salad oil and other edible products—and imported almost 200,000,000 pounds of it in 1937, a year of a bumper cotton crop. For cures for the "sick crop," chemurgy looks to a host of developments, such as new uses for cotton, substitution of new fiber crops such as hemp and flax and jute, etc., and especially to the propagation of "bald-headed" cotton plants which will produce less fiber, more oil.

The oil of the cottonseed, which the cotton grower discarded as worthless a generation ago, began to compete with lard when Chemist David Wesson, a manufacturer of bicycles, devoted his spare time to the perfection of a process whereby an odorless oil could be extracted. Wesson Oil was his contribution. By 1935, the use of lard substitutes exceeded the consumption of lard.

CORN. Cotton became corn's competitor when we began to use wasted cottonseed as substitute for the corn-fed hog's lard. Yet, consumption of corn oil increases annually. We could use three times as much as we now produce of this by-product of the corn-refining industry. Expansion of the domestic supply of corn oil is handicapped because corn's main products—starch, sugar and syrup—have to compete with such coolie-produced imports as tapioca and sago. But the corn chemist, further refining his product, is finding new things, such as zein, a protein with promising value in the plastic industry, and sorbitol, a rare chemical known since 1876 but now capable of being produced from starch by an electrolytic hydrogenation process perfected by Dr. Henry Jermain Creighton of Swarthmore College, under the sponsorship of Atlas Powder Co. Sorbitol is a humectant; i.e., it controls humidity, and is therefore valuable as a stabilizer of moisture content in tobacco, glues, leathers and cellulose wrappings.

Soy. This protean oil is chemurgy's best offering as an all-purpose oil with which to end the necessity of importing vegetable oils. Although soapmakers use little of it and edible-oil consumers still prefer cotton and olive, paint and linoleum manufacturers find that consumer prejudice is declining. This prejudice was built up by poor drying qualities of the first soy paints, produced cheaply without the addition of drying oils. Paint and linoleum industries now use about 20,000,000 pounds annually, employing tung and perilla as dryers. Recently, Henry Reichhold, president of Reichhold Chemicals, Inc., Detroit, reported to the chemurgists that he had perfected a quick-drying process which will make soy paint less expensive than conventional oil paints.

Tung. "As yet, no other oil or combination or modification of oils has been developed to take the place of tung oil," says Mr. Charles C. Concannon, chief of the Chemical Division of the Bureau of Foreign and Domestic Commerce, who has been one of the pioneers in establishing the tung-oil industry in the United States. In 1937, the domestic crop yielded less than 4,000,000 pounds while the demand approximated 175,000,000. About one-quarter of the oil used in the paint industry is tung. Used also in printers' inks and linoleum, it finds expanding markets despite the violent price fluctuations to which it has been subjected since the Japanese invasion of China. It is estimated that the domestic demand will reach 400,000,000 pounds annually before many years. This estimate was made before Harvey G. Kittredge of Dayton, Ohio, revealed details of his patented process whereby rubber substitutes can be made from tung, soy and other vegetable oils. Next to soy, tung is the most promising oil crop on the American agricultural horizon.

CASTOR. New processes have been developed by which the chemical structure of castor oil is converted into a drying oil somewhat comparable to tung oil; but, in 1937, we imported almost 150,000,000 pounds of castor seeds in which oil content ranged from thirty-five to fifty-five per cent. Sorely needed for adapting the plant to American agriculture are varieties with seed heads that mature simultaneously. Too many varieties "explode" their seeds one by one as they ripen, thus necessitating hand harvesting. By obtaining seeds from Kansas gardens in which castor plants had been raised as ornamentals for many years, Dr. Christensen and his associates acquired strains which, through accidental selection, have the desired ripening qualities.

PERILLA and CHIA. These two members of the mint family are now being subjected to chemurgic experiment. Both have seeds whose oils are valuable as dryers in paints and varnishes. Japan supplies perilla, which is heavily burdened with taxes. Chia grows in Mexico and has been grown experimentally in our Southwest. Perilla seems best adapted to the Cotton Belt, but thrives exceptionally well in southern Virginia. Francis Scofield, consulting chemist for the National Paint, Varnish and Lacquer Association, Washington, D. C., offers seed samples to farmers for experimental growing, and is pioneering in this field.

SESAME. In Oklahoma, where "oil" is earth-oil, chemurgists hope that the word may one day mean also the seed-oil of Sesamum Indicum, the warm-climate annual which yields the edible seed called sesame or benne in the United States, gingili or til in India, sim-sim in Africa, ajonjoli in Mexico, goma in Japan and mua in China. In most countries the seed is valued for cookery and confection, but in the United States the use of the oil in food products is increasing. In 1938 we imported 7,000,000 pounds of seeds and more than 6,000,000 pounds of oil. In 1939 the Oklahoma Farm Chemurgic Council sponsored more than a hundred test plantings.

PINE. Not many years ago the pine tree was chiefly a source of lumber. When naval stores (turpentine and rosin) were wanted, it was subjected to what Herty's German teacher called "butchery." As early as 1608, the fat of pine was sought around Jamestown, Virginia, for the pitch, tar, turpentine and rosin used for calking wooden ships and treating cordage. Hence the name, naval stores. But, between 1880 and 1910, the forests were lumbered off and the naval-stores industry seemed doomed. Then chemists found that there were millions of tons of naval stores locked in pine stumps which lumbermen had left behind. But nobody knew how to get them out. About 1900, steam was used to turn dead stumps into turpentine. It was not a new process, for turpentine with a noxious odor was already being recovered as a by-product of the destructive distillation process employed in pine tar and charcoal plants using dead stumps. But this new variety, though not malodorous, was such a novel kind of turpentine that, for several years, nobody knew how to use it. Then Herty perfected his method of tapping the live tree without killing it and the production of gum spirits from live trees increased so rapidly that nobody wanted the stuff from the dead stumps. The infant industry, based on the distillation of stumps, was about to die when it was discovered that stumps contained huge stores of rosin which could be released with solvents. Again it was discovered that the product of dead stumps was so unlike the product of living trees that there seemed to be no relation between the rosins. But new uses for these unfamiliar products were found and the little industry survived. What saved it was a chemist's discovery that pine oil, not present in the living tree, could be used in flotation processes for the recovery of metals from low-grade ores. Then it was discovered that pine oils were valuable to the textile industry and in the manufacture of perfumes. A few years ago, a continuation of the pine-oil explorations yielded the discovery that camphor could be manufactured from turpentines. Thus, in a roundabout manner, American dependence on Japan for camphor was ended, and wood-wastes were converted into wages for idle hands and wealth for idle acres. Today it may be said that a line of investigation which began with curiosity about the fat in dead pine stumps is resulting in the current scientific curiosity about lignin. Lignin, you will remember, is that most abundant and most troublesome of the chemical wastes in wood. Lignin research, which began to show promise when W. H. Mason applied high pressure and steam to wood-wastes, is now yielding valuable results at the United States Forest Products Laboratory in Madison, Wisconsin, where chemists recently found that the hydrogenation of this mysterious stuff yields at least five organic chemicals for which there are needs in industry. Until the chemists began to work on lignin, this material, which constitutes about one-fourth of the bulk of all wood, was bothersome to forester, papermaker and rayon-manufacturer, for there was nothing that could be done with it but dump it into the rivers, and even that solution was a poor one because it polluted streams and destroyed fish. Now it may turn out that in lignin may be found that "perfect" plasticizer that men have sought since Baekeland created the first man-made resin.

PEANUT. Wheeler McMillen, president of the National Farm

Chemurgic Council, likes to point out that America's frontiers cannot be said to be fully explored until every native weed has been probed for its values and every needed foreign plant has been transplanted into the United States and given a chance to adapt itself. He cites the fact that corn, the American Indians' maize which became the American pioneers' food mainstay, was originally a tropical plant. He likes to add that we don't know anything about the permanence of our dependence on other nations until it has been proved that we cannot produce rubber and tea and coffee on American acres.

If there are doubts about the possibility of adapting tropical plants to temperate climates, they may be quickly dispelled by consideration of the peanut. It is neither pea nor nut but a bean-like plant unique because it ripens its seeds by pushing its blossom-stems into the soil. It seems to have originated in the Brazilian jungle. Introduced to pre-Incan agriculture by some unknown Peruvian plant-wizard long before Europeans "discovered" America, it was carried to Spain by the Conquistadores and spread from there in migratory waves that carried it around the world.

But, although the peanut has adapted itself to virtually everything but Arctic and Antarctic climates, it is a crop without surpluses. This is due to another of its many unique attributes. Though there are more than three hundred different and apparently unrelated things into which peanuts can be converted, the one thing that most people everywhere most want to do with peanuts is eat them. Since people like to eat peanuts even when they are not hungry, there is no surplus of them. And since there is no surplus, there would seem to be no reason for the chemurgists to consider them. But they *do* consider them; for, among other things, the peanut yields oil, and, although our production of its oil has increased 381 per cent in the past decade, we had to import 16,000,000 pounds in 1938. So, looking at tables charting the rise in the production and use and import of the things the peanut yields, some chemurgists believe the United States ought to double the peanut acreage.

In addition to being one of man's most prized foods, the peanut builds up the soil in which it grows, provides fodder for livestock and, divested of its oil, returns a meal residue which is a good stock feed. Because the demand for oil is increasing, researchers at the Georgia Experimental Station are centering hopes on an improved strain which is said to yield eight hundred pounds of oil, nine hundred pounds of meal and a ton of hay per acre.

If you use the phrase, "Mere peanuts!" as a synonym for insignificance, consider the following:

You consume more than eight pounds of peanuts every year, in the shells. American acres produce about a billion pounds annually, besides the unknown tons that pigs are permitted to "hog off." The value of the annual crop to the farmers is about $45,000,000. The annual world production is more than *three million tons*—and increasing every year! In all its aspects, the peanut accounts for more than $200,000,000 worth of business each year—and $200,000,000 "ain't peanuts!"

Indeed, the peanut is such a superlative plant that it may be compared only with China's "Little Honorable Plant." The comparison is a natural one, for peanuts and soy beans are the two American farm crops which have increased in value in recent years, while the total farm income was declining. Incredible as it seems, the lowly "goober," pound for pound, tops the best sirloin steak for proteins, the best potatoes for carbohydrates and the best butter for fat. The pods have as much food value as ordinary hay. The red inner skins are as valuable as bran. The leaves and stalks equal the nutritive value of clover. The meal, ordinarily used for fattening livestock, is prized as fertilizer by Ceylon tea-planters who use 35,000 tons of it annually. The nuts stand storage indefinitely. Archaeologists have found them in Inca tombs and have roasted and eaten them. The plant withstands prolonged droughts. When all other plants wither and die under the blast-furnace heat of a rainless summer, the peanut curls up, waits for rain and, when it comes, races to maturity.

But the most wonderful thing about this wonderful plant is its history. And, because the narrative is closely woven into the life of the patriarchal chemist who has worked the most wonders with the peanut, its history is best recited as part of the story of the first and greatest chemurgist.

Chapter XII

FIRST AND GREATEST CHEMURGIST

1

Long before there was a chemurgic council there was a man who was famous for his chemurgic counsel. His original laboratory was equipped with junk salvaged from rubbish dumps, but the value of the discoveries that came out of it are inestimable. At least a quarter of a century before Dr. Herty tackled the problem, the scientist in this laboratory made paper from Southern pine. Not only from pine but from cotton stalks and tomato vines, from chinaberry and mulberry, from wisteria vines and the caladium that is called elephant ear. Starch from sweet potatoes and the doubly misnamed Irish potatoes, which attained chemurgic values as industries in Mississippi and Maine in 1938, were made by this man before the Twentieth Century dawned. Years before a rocklike plastic made from wood-wastes became a chemurgic promise, he made synthetic marble from wood shavings.

This first and greatest chemurgist is a Negro whom race-proud southern whites have called "the Savior of the South." He is a scientist who was born a slave, a chemist most widely famed for the more than three hundred useful things which he has extracted from the peanut.

So extraordinary are the facts of his life that they all seem to call for exclamation points. The strangeness leaps from the terse biography of *Who's Who:* "Carver, George Washington; born of slave parents about 1864; in infancy lost father, was stolen with mother, who was never heard of again. Was bought from captors for a race horse valued at $300. . . ."

Now, because Dr. Carver was born in slavery and because he is chiefly famous for his chemurgic wizardry with peanuts, his story and the story of the peanut are inseparable.

You begin the story with an unrecorded event. It may have happened hundreds or thousands of years ago, we don't know exactly when. Some time before the ancient pre-Incan races of Peru built their civilization, an unknown plow boy or plant-wizard detected value in a jungle wildling which is *mani* in the Quechua (Incan) tongue, *Arachis hypogaea* to the botanist, peanut to you, goober to the southern Negro. Transplanted to the gardens of Peru, it flourished and became so valuable that men made pottery images of it and buried its fruit with their dead for the journey to *Hamack*, the Heaven of the Incas.

So much for the beginning of the story of the peanut. Now you skip across the ocean, from Peru to Portugal. On a bleak and lonely cliff just east of Cape St. Vincent, the son of a Portuguese father and an English mother has built a monastic retreat for himself. He has fought the Moors and is war-weary. A prince, he has had a surfeit of ritualistic bootlicking in his father's court. The possessor of a mind bedeviled with questions, he has decided to dodge the dull routine of the princely round by retiring to his crag where there is only the song of the roaring surf. To his fortress-laboratory he has invited other questioners—geographers, mathematicians, astronomers, map-makers, sailors. His purpose: Research—scientific sifting of rumors of unknown lands beyond the southern horizon, rumors of hot lands teeming with creatures that look like men but may be apes.

We are at Sagres, the private research laboratory of Prince Henry of Portugal, the great school of navigation for the founding of which the warrior-prince became Henry the Navigator. Applying the research of Sagres, men sailed farther and farther beyond the horizon, discovering more and more of the western coast of Africa but finding no final answer for the hair-splitting verbalizers of Europe who wrangled endlessly about the question: "Are the black creatures of Africa beasts or human beings?"

The explorations launched by Henry go on and on. Beyond the western horizon, a land is found and is called "The New World" after it is determined not to be Asia after all.

To it flock men, pig-eyed with greed, habituated to hunger, their minds warped by want and dreaming crazy dreams of a paradise of plenty with gold on the ground. First they find the gold, not on the ground where it abundantly is, but in the trinkets and baubles of the prosperous people of America. Their little minds recognizing no pathway to plenty save the way of the warrior, the plunderer and the enslaver, the Europeans cheat and steal, murder and destroy. Having taken the baubles in their bloody, gold-greedy paws and wanting gold and more gold, they drive the people of America under the ground to mine it as slaves. But the Americans love liberty with such a fierce love that they die in droves when they lose it. They are not worth their salt as slaves.

Now the midge-minded Europeans turn to Africa for black slaves. They have finally begun to realize that the gold-on-the-ground is an unprecedented plenty of valuable food crops which those superior hunger-fighters of America have developed. Being warriors and not workers, the Europeans must have slaves. Despite the edict of Pope Paul III that savages are human and not beasts to be bartered, Africa is ransacked for slaves for America.

Among the food crops that poured out of the bounteous soil of America into the always-empty larders of Europe were peanuts. Spain plundered the Incan home of the peanut and Spain got peanuts and liked them. Then, somehow or other, Africa got peanuts and liked them. How did they get to

Africa? Some say missionaries took them. Is it not more likely that slavers took them as a lure for the blacks?

In 1619 a Dutch man-of-war put into Jamestown, Virginia, and landed what its log described as "20 Negars." Thus the Negro came to what we now call the United States. With the Negro came his beloved goobers. Then, in the middle of the Nineteenth Century, these United States were disunited because of Negro slavery. A war was fought. The South was ruined. The Negroes were freed. The soldiers of the Northern Army, returning to their homes in the North, introduced the home folks to the Negro's goober.

From America the peanut spread in two world-encircling waves. Today, in China, the *mani* of the Inca is esteemed almost as highly as the "Little Honorable Plant" of Shen-Nung.

It is 1864, the third year of the War between the States. The scene: The plantation of Moses Carver in the extreme southwest corner of Missouri, near the village of Diamond Grove—much too near the Arkansas line over which slave-raiding night-riders of the South thunder on moonless nights. On such a night the sheeted horsemen came to the plantation of rich Moses Carver, bound his slaves and dragged them along the muddy road to Arkansas. Among the captives were a Negro woman and her frail baby boy. Moses Carver dispatched agents into Arkansas to try to ransom his slaves. The agents effected a contact with the raiders but found only the pickaninny whose mother had disappeared, and whose puny frame was so sorely wracked with whooping cough that the raiders willingly parted with him when offered a broken-down race-horse.

The motherless child, nursed to health in the home of Moses Carver, was a strange little boy. He loved to be alone in the woods and always fell asleep with a wild flower in his little black fist. He was such an appealingly honest little fellow that the Carvers called him George Washington and added their own surname. As he grew up, he was told he was no longer a slave, but he remained. Still frail, his work was woman's work—cooking and sewing and laundering and housekeeping. The only book in the Carver home was a little blue-backed Webster's speller which he memorized. In 1874, he begged permission to attend school in the one-room log schoolhouse at Neosho, eight miles away. The Carvers told him that he was free to go, but added that they were now too poor to help him. So, penniless, he went to Neosho where he slept in barns, kept soul and frail body together by working at odd jobs and eagerly soaked into his thirsty mind all the book-learning the teacher could provide.

He wanted to continue his education but the nearest school was at Fort Scott, Kansas, more than sixty miles away. A mule-train was going in that direction and the gangling black boy accompanied it. At Fort Scott he enrolled in the high school and "took in white folks' washing" to pay his way.

Suddenly, in his twenties, the skinny Negro boy expanded into a six-foot ebony giant of a man whose physical hunger was great but whose mental hunger was enormous. The strange thing about this transformation was that the huge man retained the voice and the shyness of the child.

That ravenous mental hunger had now absorbed all that the teachers at Fort Scott could give and the black man, having graduated after seven years in high school, wanted a college education. So, home to the Carvers he went for a summer, home to ask Mrs. Carver if he might have the spinning wheel his mother's hands had worked. That, the only memento of his lost mother, was given to him and he clung to it always. He has it even now in his bedroom, and he never passes it without touching it with his long, caressing fingers.

He wrote a letter to a college in Iowa and his application was accepted. With his precious spinning wheel he went north, only to discover that the college admitted no black students. He had spent all his money for train fare and he could not get out of town. So he remained, worked as a hotel cook and at odd jobs until he accumulated enough money to start a laundry. As the time for the opening of schools arrived he discovered that Simpson College in Indianola, Iowa, drew no color line. He enrolled, paid his tuition and, having one dime left, invested it in corn meal and suet to tide him over for a week while he looked for odd jobs.

Three years at Simpson. It was 1890 now and he was about twenty-six, when he enrolled at Iowa State College at Ames. There, four years later, he received his degree in agriculture.

Two years after that he was a Master of Science. Up to this time he had worked at nothing but odd jobs. The college authorities, impressed by his wizardry in agricultural chemistry and his uncanny skill with plant life, appointed him to a teaching position in the greenhouse. He was no longer a chore-boy.

3

The soft berth at Ames became a bed of nettles for Professor Carver, and all because a man made a speech in Atlanta, Georgia, on September 18, 1895. That date is momentous to the American Negro. It marks the first time in the South that a black man was allowed on a speakers' platform among distinguished white men. The occasion was the opening of the Atlanta Cotton States and International Exposition, and the most momentous moment of the occasion came when Booker Taliaferro Washington, the Negro who had come up from slavery to be an educator of his people, stood and addressed a mixed audience. The speech is famous. It is recorded in full in Booker Washington's autobiography, and is still well worth reading. In it, there is an anecdote about a ship lost at sea. Sighting a friendly vessel, the crew hoists a signal appealing for drinking water. "Cast down your bucket where you are" is the reply to the repeated appeals. Finally, the captain of the distressed ship, heeding the admonition, casts down his bucket and draws up fresh and sparkling water from the great mouth of the Amazon River.

"To those of my race who depend on bettering their condition in a foreign land or who underestimate the importance of cultivating friendly relations with the southern white man . . ." said Dr. Washington, "I would say: 'Cast down your bucket where you are'—cast it down in making friends in every manly way. . . ."

Dr. Carver, already becoming famous for his work in the bacteriological laboratory at Ames, was invited to come to Tuskegee and teach his people. His people? Who were *his* people? The people of the South? The people of Iowa? "Cast down your bucket where you are." Well, that is what he proposed to do—stay right there in Iowa among those friendly people. But they're not *your* people, the stinging nettles of doubt reminded him.

So he went to Tuskegee, to the pitiable little collection of shacks in which his people, hungering for knowledge as he had hungered, were trying hard to satisfy their hunger.

When he arrived he was shocked. "I had never seen anything quite like it," he said. "The soils were remarkable. There was yellow soil and red and purple and brown, and riveted and banded, and all sorts of things, except grass." He was told that grass was unhealthy, that the thing to do with a dooryard was to sweep it on Saturday night and sprinkle it with clean sand. On the school grounds he found erosion gullies in which an ox could get lost. The school's strawberry patch yielded a cupful of berries every day. The school's three cows gave a gallon and a half of milk.

He asked for a two-horse plow, and his people, who had never seen a two-horse plow, slapped their thighs and rocked with laughter. When he got his two-horse plow and a twenty-acre patch for an experiment station, they lined up to watch the antics of this new professor from Iowa and belittle his efforts.

When, despite his use of a two-horse plow, the experimental plot yielded only spindly cowpeas with a miserable pea to each stalk, he received gratuitous advice. He took it good-naturedly and quietly applied his knowledge. For his laboratory equipment he and his students scoured the trash heaps, collecting bottles and jars and bits of wire and rubber. His experimental acres were among the worst in the South, having been worked with an annual loss of sixteen dollars an acre. To them he carried muck from the swamps, leaf mold from the woods. On them he diversified his crops to demonstrate the fallacy of the South's cotton economy. Out of them he extracted in one year a net profit of four dollars an acre. But the experiment attracted attention only after he harvested a five-hundred-pound bale of cotton from one acre, an achievement almost unheard of in Alabama.

Now he "let down his bucket" with a new kind of drive. He had found his people, not only the black ones but the white ones as well, starving from the hidden hunger of pellagra, starving on the acres which, as the original American knew, could produce gold-on-the-ground abundantly. He took it upon himself to teach these people to raise garden crops on some of the cotton land.

It was a terrific task he and his associates tackled. They wrote nature study leaflets. They carried movable schools to farmers. They lectured on the laws of soil fertility which Justus von Liebig had laid down and they demonstrated how to apply fertilizer. They simplified the laws of soil chemistry and put into children's language the explanations of the interlocked relations of plant and animal and soil and sun and rain and air.

But they found that it was not enough to teach people to grow better crops. They had to show them how to use their produce!

So Dr. Carver became the author of hundreds of tracts and bulletins, such as: "Twenty-nine Ways to Cook Cowpeas," "Ten Choice Wild Vegetables," "Forty-three Ways to Save the Wild Plum Crop," "The Pickling and Curing of Meat in Hot Weather," "How to Save Sweet Potatoes, and Thirty-one Ways of Preparing Them for the Table," "One Hundred and Five Ways of Preparing the Peanut for Human Consumption," etc., etc.

He taught his people how to raise more and better crops and how to use them to their best advantage. To teach efficiently, he had to know his subjects. Well, besides farming he knew the household arts, so he also taught his people how to make furniture and rugs and draperies and clothing out of such scorned things as flour sacks and burlap bags. With his own neeedlework he won prizes. With his own fingers he gave piano recitals to raise money for the school.

Thus, little by little, the complexion of Alabama agricultural life changed and men began to greet him with a respectful "Doctor."

Then, about 1907, when he was becoming the recognized pilot of farming in the area, he saw disaster coming. The boll weevil was spreading and destroying the cotton fields in its path. And he began to preach the growing of cash crops other than cotton. Plant peanuts, he preached; plant them not for the hogs as you have been planting them, but acres and acres of them to sell and to eat. Plant sweet potatoes, too, but plant acres and acres of goobers.

They began to refer to him as "the peanut man."

Throughout what is called the civilized world there are many monuments to military mass-murders and political plunderers who, though conquering heroes to their contemporaries, may one day be regarded by a more pacific posterity as pests.

Come now to a place where a people have honored a pest deliberately. In the center of the main street of Enterprise, Coffee County, Alabama, is a monument to a bug. Placed there in 1919 by relatively poor people who managed somehow to raise $3,000 to pay for it, this monument flaunts an inscription declaring the citizens' "profound appreciation of the boll weevil and what it has done as a herald of prosperity. . . ."

The pest, here honored, turned the farmers of the area to the raising of peanuts.

This monument, often called a tribute to the goober, is about seventy-five miles almost due south from another monument which is a tribute to "the peanut man." A bronze bust of an aged Negro with kindly eyes and a wrinkled brow, wearing a very old-fashioned coat, it is a likeness of Dr. Carver, done by Atlanta's sculptor, Steffen Wolfgang George Thomas, paid for mostly with the nickels and dimes and quarters of poor folk, and unveiled at Tuskegee Normal and Industrial Institute in June, 1937.

But Tuskegee's tribute would have little significance in a story of chemurgic pioneering if Dr. Carver had merely succeeded in changing the pattern of southern agriculture. The significance lies in the fact that he changed it and then discovered, with a great deal of heartache, that he had made a terrible mistake.

Acting on his advice, farmers had increased their acreage of sweet potatoes and peanuts only to bat their heads against the hard fact that the capacity of the human stomach is limited. Dr. Carver looked at the crops rotting in the fields because there was no market, and felt that he had committed a great evil. What could he do about it? Well, from the time, far away and long ago, when he was a toddler on the plantation of Moses Carver, he had been rising daily at four o'clock in the morning to walk in the fields and woods and talk to his God. No ostentatious church-goer, this humble scientist has a sincerity of faith which is such an unexpectedly beautiful thing that, talking to him, you find yourself thinking of Saint Francis. Hearing him tell of that time of trial, you believe him when he says he walked in the woods and asked and asked, "Mister Creator; *why* did You make the peanut?"

Even if you are cross-grained and callous you believe him when he tells you, with the candor of a child, "I did nothing. God saw fit to use me. I made mistakes. The achievements were God's."

So, every morning at dayspring, he went alone into the woods "to get instruction." How? "Mysteries," he says, "are merely things we do not understand because we have not learned how to tune in. When we know the truth, the truth sets us free. Mysteries disappear when the groping mind has learned how to tune in." He illustrates this by telling of a time when he, the lover of music, sat in silence for an hour in a fine southern home whose owner had told him to turn on the radio while awaiting his return. "The music was there," he says, "but it was mystery to me because I did not know how to tune in."

Thus, after his mornings of "tuning in," the mysteries began to unfold themselves in the cluttered laboratory where he hid himself every day, trying to correct the evil which he felt he had wrought. Out of those sessions came 118 products derived from sweet potatoes and more than 300 things from peanuts.

Here was chemurgy before chemurgy was a word. Here was transmutation of waste into wealth. Here was pioneering of plenty.

From sweet potatoes—starch, vinegar, shoe-blacking, ink, library paste, dyes, candy, synthetic tapioca, ginger, and coconut, chocolate compound, stock feeds, coffee substitute, molasses, rubber. Also a flour that was widely used in wartime when cereal flours were scarce.

From peanuts—milk, butter, cheese, coffee, shaving lotion, breakfast food, flour, soap, ink, cosmetics, pickles, sherbets, salad oils, soft drinks, wood stains, axle grease, tan remover, insulating boards, dyes, etc., etc., in a constantly expanding list.

Miracles? No, he says; he merely took the goober apart chemically, separating the water, fats, oils, gums, resins, sugars, starches, pectoses, pentoses, pentosans, legumen, lysin and amino acids, spreading them before him, trying endless shufflings of the parts under varying temperatures and pressures.

Out of those shufflings came a crop-use that is now putting $45,000,000 a year into peanut farmers' pockets—$200,000,000 a year into the peanut business.

And the man who did that still wears tattered old clothes and shoes that are more patches than shoes—and has not a red cent to his name. Thomas Alva Edison once offered him $25,000 to join him in his Menlo Park laboratory. Carver replied that his work was among his people, and Edison became his friend. Farmers and industrialists in all parts of the world seek his chemurgic counsel and get it—gratis. Some peanut growers in Florida sought and obtained his diagnosis of and treatment for a disease which was blighting their crops. Grateful, they sent him a check, adding that they would send the same amount monthly as retainer fee. He returned the check, pointing out that God did not charge them anything for growing peanuts and that he could not charge for curing sick peanuts. An industrial group, adopting his process for making synthetic marble out of wood shavings, offered him a princely salary to take charge of the laboratory. He refused, and the industry moved to Alabama, getting his advice free.

He has no money because he needs none. When money comes, it goes to his school and to the endless succession of youngsters, black and white and red, whose education he has financed. He wears the coat he wore when he came to Tuskegee in a year when Grover Cleveland was in the White House. In the lapel, there is a fresh flower always. He makes his own neckties and scarves, coloring the fabrics with dyes extracted from plant juices.

He is an accomplished painter. One of his pictures is in the Luxembourg in Paris. An unusual painter, he makes his canvases and frames out of agricultural wastes, and his colors, which he applies with his extraordinarily long and supple fingers, from Alabama clays, peanuts and cattle dung. He is a member of the Royal Society for Encouragement of Arts, Manufactures and Commerce of Great Britain, a holder of the Spingarn Medal for Negro Achievement, the possessor of honorary doctorates of science, a collaborator of the Division of Mycology and Disease Survey, Bureau of Plant Industry, United States Department of Agriculture. He has been visited by the world's great and near-great, including Presidents of the United States. And yet—

When the Ways and Means Committee of the House of Representatives pondered the petition of southern peanut planters for a tariff to protect them from the competition of the coolie and slave labor in foreign peanuts, and Dr. Carver was sent to Washington to speak for the petitioners, he got off the train in the nation's capital with his box of exhibits under his arm, and, asking a porter for directions, got this hurried reply:

"Sorry, grandpop. Ain't got time. Lookin' for a big scientist comin' here from Alabama."

At the legislative session, each speaker was granted ten minutes for his plea. His name was the last one on a long list. When it was called, the lawmakers were visibly weary. As the old, shabbily-dressed, white-polled Negro shuffled up to the front of the room, struggling with his big box, laughter greeted him. Placing his box on the table and taking out his watch to time himself, he prepared to speak. From among the legislators came a wise-crack about watermelons and peanuts as the sources of Negro happiness. There was a shocked hush, but the friendly eyes in the black face did not change as the scientist began his speech. Out of the capacious box he pulled an array of things made from peanuts. Simply giving the credit to "Mister Creator," he told them how it was done, keeping his eye on his watch. The ten minutes done, he bowed. "Thank you, gentlemen, for letting me come here," he said stuffing the exhibits back in the box. From the legislators, who had been stifling yawns ten minutes before, came a chorus of protest. Complying with their shouted demands for "More! More!" he told them the story of peanuts.

One hour and forty-five minutes later there was a crash of applause, and the peanut was protected in the Hawley-Smoot Tariff Act.

At the 1937 conference of the chemurgists, he revealed that he had found in the oil of the peanut something which not even he had expected. He had refined special kinds of peanut oil for treatment of acne. Users reported satisfaction. Then, one day, a woman told him, somewhat indignantly, that the oil massage made her face fat. Shortly after he heard this, a boy came to his cluttered laboratory to ask him whether anything could be done for one of his legs which was weak and flabby from infantile paralysis. Dr. Carver thought of that face-fattening oil. Would it fatten the muscles of the boy's leg? It is worth trying, he said, and, locating the wasted muscles with the long fingers that had mastered the art of the masseur in Ames long ago, he started a series of oil-massage treatments. The limb responded.

"That boy," he told the assembled chemurgists, "is playing football in college now." And, exhibiting a series of before-and-after photographs of a number of cases he had treated, he said he did not know whether to credit the oil, or the gentle massage of dormant muscles, or the faith of the patients.

Today, hundreds of letters come to him, asking about the curative effects of these limpid oils. Some of the letters come from doctors, who were indignant when the report first got into print. He makes no claims for the oils.

He makes no claims for anything he has done. Though he would disclaim the credit, there is no question that he, the first and greatest chemurgist, should be credited with much of the enthusiastic acceptance of the chemurgic program in the South.

CHAPTER XIII

TOO MUCH FOOD!

1

You have now met some of the pioneers of plenty. You have observed how chemurgists, generally ignored only five years ago, are tackling America's baffling problem of crop surpluses. It is now time to consider that problem itself, to consider it as a "new thing under the sun." For, from time's beginning down to recently, perhaps no creature has ever been called upon to consider the problem: Too much food! Because this never happened before, it is a problem which cannot be solved with the thought-tools inherited from our hunger-dodging ancestors. They were fashioned for the problem of scarcity. They can no more solve this problem of ours than a cave man's stone hammer can do the atom-splitting job of a cyclotron.

Too much food! Your grandfather would not have dreamed of that combination of words as the expression of a problem. In his world there had always been more mouths than mouthfuls. He would have told you that it had always been that kind of a world and that there was no occasion for believing that old conditions would change. He could have cited an endless array of facts, gleaned from the hunger-hounded ordeal of civilization, to prove that plenty would never replace scarcity and that want, warfare and waste are the normal manifestations of natural law. But, despite all this evidence, there stands before us the startling fact: *Too much food!* Because it is the one most significant fact confronting man today, we cannot hope to understand it unless we look at it through the startled eyes of a resurrected ancestor. For that point of view, let's think of our planet, Earth, as a vehicle roaring through space, carrying human passengers and their food.

Consider the vehicle and its load. At the end of 1937 it was carrying more than 2,000,000,000 human passengers. This was twice as many as it carried only a hundred years ago, almost *five times* as many as three hundred years ago. Dr. Raymond Pearl, of Johns Hopkins University, believes that before 1600 the planet's load of human passengers grew very slowly "because the conditions necessary to a more rapid growth did not exist." In other words, the planet-vehicle's pantry could not feed more than about 445,000,000 people.

Now, the passenger list has not only been growing explosively in the past three hundred years but it is still increasing. During the past twenty-four hours, a sixth of a million new passengers arrived—a delivery of about six hundred tons of small humans. New passengers arrive now at the rate of about two a second. Each comes with a driving desire to ride on the planet as long as possible, a desire expressing itself in a demand for food. The pantry must supply thirty tons of food for the average ride. It is now being done so effectively that the average chances of a new passenger for a long ride are increasing. It is being done so well that, in 1938, when the planet carried this unprecedentedly immense load, the larder bulged under the strain of a 5,000,000,000-bushel wheat crop, about 1,000,000,000 bushels more than all the passengers could hope to eat in a year.

A hundred years ago, when there were only half as many passengers, the best minds shared the gloomy view of Thomas Robert Malthus. He believed that human population always increases faster than the food supply and that misery and want and war are the inevitable consequences. Three hundred years ago, when the population was about the same as it had been for thousands of years, famine was a periodic experience which came so regularly that man accepted it as normal, like the succession of the seasons. "Seven famines and ten years of famine in a century" was the "law regulating scarcities" prior to 1600, and men accepted it as some now accept the "law of business cycles."

Too much food! For six years now the political representatives of the American people have tried to solve the strange problem by reducing the productive power of prolific acres—an attempt to wipe out in a few years the plenty-potential which man has been striving to attain for thousands of years. Fortunately, every attempt to create artificial scarcity failed; and now, at long last, the people's political leaders are beginning to adopt the chemurgic approach by setting up and endowing four research laboratories designed to find new non-comestible uses for surplus foods.

Who put the bee in the bureaucratic bonnet? Perhaps it was the discovery that, of all bumper crops in 1937, there was one virtually without a surplus. There was no surplus of honey because producers no longer depend solely on biscuits to soak up their product. Much of it is now used for curing hams and briar pipes, for making cosmetics, candles, polishes and insulation, and as cores for golf balls.

Honey as a core for a golf ball would have seemed a sinful waste to our ancestors; for, less than two hundred years ago, honey and barley were the chief sources of sugar. Cane sugar, a rare and expensive luxury from the New World, was sold by apothecaries in the time of Louis XIV. Because only kings and courtiers could afford it, plain people said it caused fever, chest disorders and apoplexy—and stuck to barley sugar and honey. Those beliefs prevailed even after Napoleon Bonaparte fostered the research whereby chemists extracted sugar from beets and made it plentiful. Then there arose in France the adage: "Sugar hurts only the purse."

Today, thanks to chemists, sugar is a common substance. Yet so laggard are thinking processes in the political realm that sugar, abundant in most living things, is not as plentiful as it would be if its production were not burdened with taxes, tariffs and subsidies. The tea-loving Briton, for instance, dipping into his heavily-taxed sugar, knows the meaning of the French adage.

The intentions of such political expedients may be excellent, but the fact remains that all of the so-called statesmen's attempts to solve the problem of plenty by trying to create artificial scarcity are indications that there is great need for better understanding of the causes of this strange new thing: Too much food!

2

What *are* the causes of this strange thing? To examine all the sources of crop surpluses would require years of research. Dr. Henry Schultz, of the University of Chicago, devoted eight years to the study of how demands for such things as corn, cotton, wheat and sugar have been declining every year. Since the World War, he found, each of us has been reducing his share of corn consumption at the rate of half a bushel a year. Our demands for wheat and cotton are decreasing annually. Our individual intake of sugar is falling off at the rate of about 0.42 pound annually.

Why?

Our diet has changed. Until 1906, when man began to discover that rickets and scurvy and pellagra and beri-beri were hidden hungers, *diet* was a word for something which only the rich "enjoyed." In the 1920's the average American consumed 120 pounds *more* food per year than he did in the 1890's—but he consumed 120 pounds *less* cereal! That 240-pound dietary difference represented an increase in the use of meat, fats and oils, sugar, milk and fresh fruits. Today the use of sugar is decreasing and the demands for dairy products and fresh fruits are increasing. Before 1929, for instance, fruit juice meant grape juice and cider to Americans. In 1937 it meant 80,000,000 gallons of fruit juice, other than cider, and more than 50,000,000 gallons of tomato juice. Tomorrow, thanks to new processing and preserving methods, the juices of celery, spinach, carrot, garlic, onion, beet and lettuce will be added to the constantly expanding list. That dietary shift, providing necessary vitamins and minerals, has a surplus-building effect because it uses perishable foods which would have been wasted ten years ago. Forty years ago the most readily available fresh fruit in America was the apple. Americans then ate 112 pounds of apples per person per year. Today that per-capita consumption has dropped to 39 pounds, but the difference is more than accounted for by the per-capita consumption of oranges, bananas, grapefruit and the rest of the formerly perishable fresh fruits now available the year round.

These dietary shifts are now moving rapidly. In the 1920's, for instance, the average American's use of fish and meat was increasing. Then, in the 1930's, the per-capita consumption fell from 138 to 126 pounds per person. But, in the same period, that 12-pound decrease was accompanied by a 34-pound increase in the use of vegetables and a 16-pound increase in consumption of citrus fruits.

Involved in these dietary shifts is the fact that machines are replacing muscles as power sources. A generation ago we counted calories because we needed fuel for muscular machines. Today, says Dean A. A. Potter, of Purdue University, the power available in the United States is the equivalent of four hundred human slaves for each family. These "slaves" consume mainly fossilized "foods" (coal, oil, etc.) produced eons ago, whereas the muscle power of our ancestors' world came mainly from the annual production of available acres. Before the steam engine arrived, the labor of at least four or five men on the farm was required to maintain themselves and one man in the city. By the middle of the Nineteenth Century one man's labor on the farm maintained him and one man in the city. Today one man on the land provides abundance for himself and nine men in the city. The increased efficiency on the farm released farm labor for other pursuits. The release of labor introduced urbanization. And urbanization, or the cityward drift of population, contributed additional impetus to the building of crop surpluses.

This drift of people toward cities was so rapid that, whereas only seven out of every one hundred Americans lived in cities in 1820, the seven had been joined by fifty in 1930, leaving only forty-three in the country. As Henry Ford pointed out in 1921, the mass-movement of people into cities was an important chapter in the education of the race, for only by packing themselves closely together in cities were men able to "work out those necessary devices of successful living which, when transplanted into the country, make the gray waste of life a colorful thing."

Ford added that the cities, as we know them, can now be expected to disintegrate, because people will leave them as rapidly as they can take with them into the country "the discoveries and inventions which make life safe and pleasant, and which unburden men of the loads that are better borne by machines."

Thus, although urbanization has had a surplus-building effect, there is nothing final about urbanization. Indeed, the countermovement from city to country, detected by Ford almost twenty years ago, is already assuming such proportions that the statisticians, preparing for the 1940 census, have been puzzling over the definition of a farmer. This question emerged because, since 1930, so many city persons have moved into the country, farming part time or when unemployed elsewhere, that it is almost impossible to say whether a rural man is a farmer or a business or professional man.

It is obvious that the problem of farm surpluses is the culmination of a vast network of man's conquests and triumphs:

his conquest of distance or shrinkage of the physical world; his triumph over temperature and abolition of waste; his multiplication of power and his stretching of the acre's productivity.

While the mile-shrinkers and power-providers, typified by James Watt and Michael Faraday, were reducing the demands on the average acre, the acre was being stretched by such hunger-fighters and fertilizer-finders as Justus von Liebig, Jean Baptiste Joseph Dieudonné Boussingault and Sir John Lawes. Their pioneering work in the 1850's may be said to have begun the job which wrought in less than a century far greater changes in the art of filling the mass-stomach than had been accomplished in the thousands of years before the Nineteenth Century.

But behind the forces unleashed by such comparatively modern pioneers of plenty there were other forces moving toward abundance. One of these was the change from the soil-depleting agriculture of the medieval commons to the improved farming that came with the general adoption of enclosures in the Seventeenth Century. Before then, most farmland was held in common and its rehabilitation was nobody's concern. Under that system, eight bushels of wheat to the acre was the maximum. Men farmed and fasted. The fortunate few hoarded and survived the famines which came with clocklike regularity. Food animals were little better than wild animals—more waste than food. Actually these animals were man's competitors for the scanty production of his acres. We know that now. The Chinese recognized it long ago. Dispensing with what Europeans called "food" animals, they worked out an agriculture based mainly on a vegetarian diet.

What the Chinese strove to do with elimination of animals, we have done by scientific breeding of *real* food animals, such as the Aberdeen-Angus breed of beef cattle which, in 130 years, was transformed from a rangy, bony cereal-devourer into a short-legged, elongated, thousand-pound cube of human food. Between 1727 and 1785, the average weight of meat-animals sold in British markets was doubled, largely due to the pioneering of Robert Bakewell, who laid the foundations of scientific breeding for better food and clothing.

What Bakewell did in his field, another forgotten pioneer of plenty named LeCouteur did in another field. As far as is known, this gentleman-farmer, who lived on the Isle of Jersey in the early 1800's, conducted the first scientific experiments in grain improvement.

Decreased acre-dependence, brought about by the reduction of power-animals in America, contributed to crop surpluses. The American Petroleum Institute estimates that Americans now have installed and ready for work 1,670,000,000 horse power. Of this tremendous total, 1,550,000,000 constitutes transport power, ninety-two per cent of it under the hoods of 30,000,000 motor vehicles which consume 1,000,000,000 barrels of petroleum annually. Dr. Hale estimates that, in 1900, one of every five American farm acres was producing horse power, and less than one of every ten is now required for the purpose.

However, this consideration of the surplus-building effect of the reduction of power-animals ignores entirely the changes in human food demand wrought by the shift from muscle to machine. How, for instance, do your food demands compare with those of your grandfather? He traveled fewer miles in his lifetime than you travel in a year, but you ride in heated vehicles in winter. What you call dinner, he would have scorned as a snack. He bundled himself in clothing whose weight you would deem unbearable. He battled weather with body-heat which he fortified with wool and replenished with calories from acres. Acres yielded the fuel for his dwelling. To prepare it, he wielded an ax which, propelled by his muscles, drew its power from acres. You have heard the expression, to "eat like a thresher," but you are a rare modern if you know what the phrase means.

Turning valves and flicking switches, we expend units of cricket power on chores to which our ancestors referred when they coined the expression: "work like a horse." We are, in effect, lucky heirs of an enormously rich estate which we neither earned nor expected; and, too baffled to think of reasonable methods of enjoying it, we are running true to form by summoning lawyers to help us dissipate it.

There is one phase of this problem of plenty which merits greater consideration than we have given to the other sources discussed so far. To the chemurgist, the most encouraging fact in the tangled fabric of our unique age is this: Man is abolishing waste!

Sir Flinders Petrie, the famous British archaeologist who has investigated man's past for clues to the future course of civilization, believes there are cycles of waste and economy in human history and that we are due to end the latest 130-year cycle of waste by swinging back to rigid economy by about 1950.

There is more than a little evidence that we are moving toward a less wasteful economy. And there is no question but that this move will add to the plenty which we decry as surplus.

You can think of man's war on waste in a number of ways. It seems to be best illustrated by the old story of the Englishman who, visiting America and impressed by the enormous quantity of food Americans produced, asked, "What do you do with it?" Told that "we eat what we can and we can what we can't," he puzzled about it until he learned what *canning* meant. Then he reported to his fellow countrymen about the droll American who had said: "We eat what we can, and what we can't, we put up in tins."

As a symbol of man's war on waste, nothing equals that much maligned little instrument—the can-opener. Every year, it disembowels nearly 9,000,000,000 tin and glass containers of their more than three hundred varieties of food. Of tin cans alone, the United States annually produces enough to fill five Empire State Buildings from sub-cellar to tower or to cover an eighty-foot highway from the Atlantic to the Pacific.

As food-containers they are a monument to a pioneer of plenty who learned the trick of preserving perishable food but upon whom historians have played the dirty trick of not preserving the facts of his life. The art of food preservation is generally attributed to a Frenchman named Appert whose given name was either Nicolas or François, and who is said to have laid the foundations of the canning industry in 1795, although some authorities claim he was not born until 1797. However, since he was awarded a 12,000-franc prize for his accomplishment in 1806, his claim to the honor seems secure.

As food containers, the towering stacks of tin cans and glass bottles represent a triumph over food-waste. But as rubbish, rusting and disintegrating on the collective United States dump, they are a waste which is due to be curtailed. Tinned can and glass bottle are already meeting the competition of such novel food-preserving methods as quick-freezing, waxing and electric refrigeration. In the decade between 1927 and 1938 the frozen-foods industry developed from zero to an annual pack of 450,000,000 pounds. It is now doubling annually. The canning industry is also being met now with the competition of co-operatively-owned quick-freeze plants and cold-storage lockers, used by almost a million American families in 1938. Add the rapidly increasing use of mechano-chemical refrigeration in consumers' homes, an increase represented by a six-fold multiplication of sales of electric refrigerators between 1927 and 1937. Add again the recent competitive threat of the process called "cryovac," preserving food by enclosing it in a vacuum inside a flexible latex container. Add still further the potential effect of those 133,000,000 cellulose containers which the German canning industry used last year as substitutes for tinned steel. And you see the beginnings of a phase of waste-elimination which may remove unsightly rubbish dumps from the outskirts of American communities.

In 1933, the tinned cans which we tossed on rubbish dumps used more steel than any other industry except the automotive. The steel and tin in cans are all lost, while the automobile industry not only re-uses considerable metallic scrap but has adopted rust-inhibiting technics, reducing the waste which existed when, thirty-five years ago, one-quarter of the iron annually released from its oxides by the world's blast furnaces reverted, via rust, to its primitive forms.

Such wastes, says Dr. Hale, will be curtailed by the increased use of cellulose, synthetic resins and light-metal alloys. In the laboratory of structural analysis at Massachusetts Institute of Technology engineers are now devising streamlined structures of light metal alloys to replace structural steel in such things as bridges. Professor John B. Wilbur, director of the laboratory, points out that many steel bridges require as much as five-sixths of their strength to support their own weight, allowing only one-sixth for the job they are designed to do. In the field of containers, aluminum and cellulose are already replacing steel and tin in Europe; and in the United States there is now under way a shift from glass bottles to waxed-paper cartons as milk containers—a shift which, says Dr. Barnard, will create a greater demand for farm-derived cellulose than the current demand for newsprint.

On a thousand-and-one fronts mankind is now fighting waste. In the meat-packing industry, once notoriously wasteful, the policy of eliminating waste by using every possible by-product has resulted in benefits to producer, processor and consumer. Though there are but fifty-five pounds of edible meat in a hundred pounds of beef-cattle, seventy pounds of pork in a hundred pounds of hog, and forty-seven pounds of mutton in a hundred pounds of sheep, the transformation of inedible wastes into useful by-products has enabled the packing industry to market meat on a profit-margin so narrow that, if the profit were removed, the consumer would save less than one cent per pound or the producer would get only one-sixth of a cent more per pound. As a result of this waste-elimination policy, Americans eat about one-quarter of the world's production of beef and pork and devote about half of their farm land to the production of meat.

It has been demonstrated again and again that the conversion of waste into wealth brings about such boons as improved markets for raw-material producers, larger total profits for processors and distributors, higher wages and better working conditions for labor and lower costs for consumers.

Chapter XIV

TOO MUCH MILK?

1

Near the coast of France is a British isle with a fame all out of proportion to its tiny area of forty-five square miles. Jersey is its name. As "the Jersey Lily," Actress Lillie Langtry brought fame to her island birthplace. But Jersey has greater claims to fame, claims which would make it loom large in history, if history were to emphasize welfare and plenty and relegate warfare and plunder to the footnotes.

If a place can be spoken of as a pioneer of plenty, Jersey is the place. On its acres Farmer LeCouteur pioneered in the genetics of wheat, the "staff of life" which, long frail enough to require reinforcement of prayer for "daily bread," seems to have become stout enough to resemble a menacing club. Moreover, Jersey gave the world an excellent strain of potatoes, a fine family of cabbages, a woolen jacket sufficiently famous to merit a lowercase *j,* and, most famous of all—a cow.

For the purposes of this chapter we can forget all the Jersey contributions but jersey, the jacket, and Jersey, the cow. For the cow is a symbol of a problem best expressed by the question: Too much milk? And the jacket is retained because it is a symbol of a chemurgic solution of the problem.

The problem is milk, man's first food, and, like it or loathe it, man's best, because most complete, food. The problem is milk because the marketing of milk is currently a mess. As a farm crop, milk provides the American farmer with about eighteen per cent of his annual income. But as an unmarketable abundance it provides a headache, for the surplus of milk played a large part in the billion-dollar decrease of farm income from 1937 to 1938.

It has been said that the plow opened the furrow in which civilization grew. But there is evidence that the hand of man tamed the cow before it learned to handle the plow. Yet, as ancient and as familiar as is the milk of the cow, it was not a general food item in the Western World until about a century ago. To savage and semi-civilized people in many parts of the world, milk was a food for babes and weaklings; yet the fierce and warlike Mongols were milk-drinkers, and the comparatively peaceful Chinese, living next door, did not learn to drink milk until Europeans introduced them to the practice. Among civilized Europeans, the peasants drank milk; but, to the residents of cities, it was a beverage for the foolhardy, as it had an ugly reputation for harboring fevers.

Boussingault, the French chemist who discovered the role of nitrogen in the soil in 1855, was the pioneer investigator of the composition of milk. Until less than a hundred years ago, man knew practically nothing about the milk which his ancestors had been converting into butter and cheese for thousands of years. And until Louis Pasteur came along with his burning curiosity about microscopic bugs and found the causes of milk's reputation as a fever-breeder, man dared do little with it save convert it into butter and cheese or use it in cookery.

As a cooking ingredient, milk began to be used in England in the Seventeenth Century. By 1808, such use had increased to the extent that milk-transportation became a problem. The problem was solved by bringing the cows into the city In that year there were about 8,500 cows in London, mostly in filthy stables. Their milk was sold at five-pence a quart, which was expensive in 1808 wages. Peddled from house to house by street venders, it was so flagrantly adulterated that it was called "London blue."

Because sensible people of those days did not think of cows primarily as sources of milk but as producers of butter fat, there was a great deal of interest in a special breed on the Island of Jersey. Traders visited the little island and took Jersey cows to many countries, for these small cows produced milk that was rich in butter fat or cream. On the neighboring island, Guernsey, cattle-breeders perfected another fine cow similarly exported and, like its relative, the Jersey, prized mainly for its butter.

Then, in the Nineteenth Century, man began to solve literally thousands of problems that had baffled his ancestors for millennia. He learned about the bacteria that live in man's food and drink, and he discovered how to use heat and cold to kill these lurking assassins. He was learning too how to move himself, his goods and his ideas increasingly rapidly and easily from place to place. He began to master the microbe and minimize the mile. And, as one result of this combination, he began to value milk as milk, the almost perfect food.

The revolution of transport played a powerful part in converting dairying into the milk industry. This was especially so in the United States and Canada, where the mile-shrinkers did not have to struggle uphill against a host of hard-headed habits, customs and monopolies. In these North American countries the transition from scarcity to plenty was relatively easy. And, in the course of this transition, cows became milk-factories and Americans became the greatest collection of milk-drinkers on earth.

In the less than two centuries that man has been breeding cows scientifically for their milk, the average milk-production per cow has been more than doubled. Today, a good Holstein-Friesian cow, yielding more milk but less butter fat than the Jersey or Guernsey, will give 1,100 gallons a year. A Jersey named Sybil Tessie Lorna has produced in a 305-day test, 20½ more pounds of butter fat than the weight of her body—*seventeen times her weight in milk!*

Below this record performance of a thousand-pound Jersey are the amazing records of the ten best milk-producing cows in the United States: an average of thirty-five quarts of milk per cow per day. And below these are the record performances of 200,000 cows of the five principal breeds, animals whose daily milk production averages fourteen quarts a day, or double the average of all American cows.

There are now more than 25,000,000 milk cows in the United States and Canada, about one cow for every five humans. These cows give enough milk to supply every man, woman and child with just about a hundred gallons of milk.

In that flood there is a headache called the problem of the milk surplus.

2

Without the hand of man to relieve her of her abundance the cow is helpless. She can bellow. If her bellow is not heeded by man, she dies in pain, the victim of too much milk.

If you had your ear turned in the right direction in 1938 you could have heard something resembling the bellow of a cow demanding help. It was a concerted but confused mooing about the problem of marketing milk. Farmers were complaining that they were selling milk at less than the cost of the feed, and this at a time when the price of feed was low because of bumper crops. Creamery operators, frightened by threats of government investigations, loudly aired statistics proving that they were losing as much as 1.14 cents on every quart of milk they handled. Creamery employees, complaining that they were overworked and underpaid, were joining unions, organizing strikes and walkouts and, in some cases, punctuating their protests with baseball bats and bombs. Consumers were complaining that they were paying too much for milk. State legislators were plagued by producers, consumers, distributors and processors, all of them clamoring, "There ought to be a law . . ." In Washington, in November, 1938, Assistant Attorney General Thurman Wesley Arnold unleashed the monopoly-harriers of the Temporary National Economic Committee and sent them baying on the trail of something that smelled like a milk-trust. There was obviously a milk-marketing mess.

Examining the mess casually, you might say, "Too much milk!" And you would be right. But you would also be wrong. Wrong, because there cannot be too much milk so long as the nation contains, simultaneously, milk in need of consumers and consumers in need of milk. Right, if by "too much milk!" you mean that the commodity is now approaching that stage of abundance upon which the private enterpriser, whose best playground is scarcity, can no longer operate profitably.

There are some observers of the milk-marketing mess who contend that it can be solved only by making the handling a public utility. This contention is based on the belief that whenever anything, mass-produced for man's basic needs, approaches plenitude, it also approaches relative socialization, and is therefore removed from the field of private enterprise. Proponents of this theory cite the fact that drinking water, which was a scarce and speculative commodity peddled by street-venders in London two hundred years ago, became a socialized transport service wherever it became abundant. The transition of a commodity from scarcity to plenty is marked by the appearance, first, of that form of mythical competition known as price war and, next, by attempts to stave off profit-wrecking with that mythical form of competition, the fixed price. In the later stages of the transition, the affected commodity's major cost becomes a transport cost, and the last-ditch attempt of private enterprise to remain in the unprofitable business is almost invariably a movement toward monopoly.

There's no doubt that transport costs have now become milk's major costs. That there are trends toward monopoly in milk-marketing seems to be indicated by findings of Federal investigators. Indeed, there are indications that milk is rapidly moving toward that stage of plenitude upon which not even monopolies can operate profitably. One of the large milk distributors, charged with monopolistic practice, submitted authenticated cost breakdowns to prove that it had suffered increasing losses on all sales in at least two major cities after January, 1938. In December, 1938, Federal investigators dug up indications that the monopoly in this milk-marketing mess may be the not illegal monopoly derived from the holding of patents on machinery for the manufacture of glass milk bottles.

For a solution of the problem chemurgists stack their hopes less on the Federal inquiry than on the current trend toward paper milk containers. Though the chief chemurgic interest in this development centers on the hope that deliveries of milk in paper will open up to the American farmer a wood market with a tonnage demand exceeding that of newsprint, there is a secondary interest. Since the shift of milk from scarcity to plenty has placed the emphasis of its cost on transport, this cost now involves the not inconsiderable expense of transporting to and from the consumer glass containers weighing as much as their contents, to say nothing of the cost of cleaning and sterilizing, replacing breakage and loss, and maintaining central collection agencies for assembling, sorting and distributing bottles.

Too much milk? Looking casually at the milk-marketing mess, you might answer in the affirmative. Thinking of the all-time record of more than 78,000,000 pounds of reserve butter stored in the nation's cold-storage warehouses, most of it in hock to the American taxpayer, you might be tempted to make the affirmative emphatic.

But, no, says the chemurgist; not too much milk, but too much waste in the distribution of this unprecedented abundance—waste waiting and bellowing for the hand of man to use it.

3

For a chemurgic use of that waste, turn now from Jersey, the cow, to jersey, the jacket.

To the chemurgist, milk is no longer solely food. Since 1890, when whimsical Adolf Spitteler tossed formaldehyde into sour milk and turned out a white "blackboard," chemists have become increasingly curious about the cow's chemical products, especially casein.

The story of that development begins in 1917, when embattled and surrounded Germany sought substitutes for many necessities. In that lean time a chemist named Todtenhaupt made a synthetic wool from casein. It was weak and shoddy, one of many faulty, wartime synthetics which lent a bad odor to the German word, *Ersatz,* and a none-too-pleasant odor to the English equivalent, *synthetic.*

After the Armistice in 1918, darkness descended on this casein-wool development, a darkness that lasted fifteen years. Then, in 1933, Adolf Hitler having become leader of the German nation and having started to move toward closer ties with Benito Mussolini's state, Italy's Snia Viscosa (Societa Nazionale Industria Applicazioni Viscosa) perfected a textile called *Snia-fiocco.*

Snia Viscosa, one of the world's greatest manufacturers of synthetic fibers by the viscose process, made this new fiber from wood pulp which it processed like viscose rayon (artificial silk) into an artificial cotton.

The wood-derived cotton was developed as part of Italy's attempt to attain national self-containment. Though the fiber cost more to produce than cotton, the flannels and mercerized goods made from it were cheaper than cotton because the fiber's staple lengths could be controlled by the spinner and because it lacked cotton's dirt and leaves. But, for months after Snia Viscosa began producing it, Italians saw little of it, for German mills were taking the output, about 90,000 pounds a month.

Then, in 1934, German chemists produced their own wood-cotton, called *Vistra,* which was soon being made in four plants, running day and night. With no silk, no cotton and only 3,500,000 wool-producing sheep, Germany was striving for self-dependence in textiles by replacing silk with rayon, cotton with Vistra. At year's end, German chemists were predicting that substitute wools for suits and overcoats would soon appear and that hats would be made of a cellulose fiber called *Flirro.*

But, though the Germans later developed *Carnofil,* a wool derived from dried fibers of tough beef, and the Japanese Chemist Genmaro Kokura made a wool-like cloth from the flesh of fish, it was an Italian chemist who took up the neglected Todtenhaupt process and improved it.

The process of converting skimmed milk into wool was perfected by Commendatore Antonio Ferretti after Italy had embarked on the Ethiopian campaign and the League of Nations was threatening to apply to Italy that form of embargo called economic sanctions. As a method of combating sanctions, Mussolini commandeered Ferretti's process and turned it over to Snia Viscosa's Milan plant.

The world began to hear about this Italian product when Dino Grandi, Italy's Ambassador to Great Britain, appeared in London wearing a suit which, he boasted, contained forty-eight pints of skimmed milk. Achille Starace, Fascist Party secretary, gave the product further publicity when he ordered that all party flags were to be made of "this product of Italian ingenuity." And international-minded Snia Viscosa, having sold patent rights to German, French, Belgian and English firms, began to look to the United States as a possible outlet. When Princess Cora Antinori Caetani, descendant of one of the leaders of the silk weavers' guild in Renaissance Florence, displayed the fabric in New York, Americans met *Lanital,* as it was called.

When *Lanital* appeared in the United States in November, 1937, chemurgists were quick to recognize it as a potential boon to producer, processor and consumer of milk; for, in the Italian process, about a hundred pounds of skimmed milk were used to make 3.7 pounds of non-shrinkable, easily-dyed, moth-proof wool, distinguishable from sheep wool only by experts.

Some editorial writers predicted that this fabric would do to the wool business what rayon had done to silk.

Exactly what has rayon done to silk? In 1911, when rayon was a novelty and its world production was only 18,000,000 pounds, the total silk production was 57,000,000 pounds. In 1936, when rayon production had climbed to the staggering total of 1,307,000,000 pounds, silk production, though it had been decreasing annually from the 1933 peak of 115,000,000 pounds, was still 82,000,000 pounds, or about 25,000,000 pounds *more* than it had been before rayon had begun to "compete."

It appears, therefore, that rayon has not been silk's competitor. With what textile has it competed? Cotton? In 1911, world cotton output was 25,000,000 bales; in 1936, 26,000,000 bales. Actually, as Dr. Herty liked to point out, rayon does not compete with cotton because both are cellulose. The Georgia cellulose chemist used to add that cotton's competitor is not rayon but trees. "Cotton," he said on one occasion, "though it is about ninety-six per cent cellulose, cannot be expected to compete, at fifteen cents a pound, with Norway spruce's ninety-four per cent pure cellulose at four and a half cents a pound. Not even waste cotton linters at four cents a pound can be brought into a proper state of purity to compete with spruce as a source for textiles."

The fact of the matter is that it would require omniscience to predict anything about the probable effects of these textile innovations. When it was announced in August, 1938, that the use of rayon in automobile tires would be adopted because the synthetic fiber improved their strength, the prophets looked at the tire industry's 1937 consumption of more than 280,000,000 pounds of cotton and wrote off that 280,000,000 pounds as a loss to the cotton farmer. They forgot that rayon is often cotton. They forgot also that cotton processors have chemists; for, only two months later, a cotton research laboratory perfected a cotton thread which was said to last 317 hours under intense friction-heat, while rayon cord failed at 143 hours, and ordinary cotton at 87 hours.

Now, what about this so-called "threat" of milk to wool? World wool production was fairly static from 1911 to 1923 with an average annual total of about 2,800,000,000 pounds. In those years United States production declined from 318,000,000 pounds in 1911 to 270,000,000 pounds in 1922. Thereafter, production increased annually here and in the rest of the world.

When *Lanital* made its New York debut, wool production and marketing were both so unprofitable in the United States that a group of dealers were that week asking a Senate investigation of trading in wool-tops futures because the tops, or partly processed wool, were selling at from five to ten cents *less* than the raw, un-processed wool. Wool-production, obviously in need of a technological shot in the arm, is complicated by the fact that old wool, reclaimed by ragpickers, competes increasingly with new wool. It is estimated that some 600,000,000 pounds of salvaged wool, ranging in price from one-third to one-half the cost of new wool, has been used in the United States in the past six years. The Department of Commerce estimates that one-half of all wool used in clothes is reclaimed and used again and again. This practice affects Australia especially, where there are seventeen sheep to every human, and where, in 1938, the Secretary of the Wool Board published a plea to Australia's swimmers, urging them not to shorten their bathing suits "because an inch off the garments may upset the economy of Australia."

Because casein-derived wool is not quite as warm as the wool of the sheep, there will undoubtedly continue to be a market for the sheep's fleece; for, as a study of the statistics of rayon and silk indicates, the new synthetic fibers invariably create their own market, becoming ultimately more boon than bane.

Unlike rayon, whose largest producer is Japan (550,000,000 of the 1938 world-total of nearly 2,000,000,000 pounds), casein-wool fiber may become chiefly advantageous to the United States, the world leader in milk production. Moreover, American industry will not be required to pay tribute to the Italian Government for use of the process. In August, 1938, Chemists Stephen P. Gould and Earl O. Whittier, of the Department of Agriculture's Bureau of Dairy Industry, perfected another process, and patented it in the name of the people of the United States. This American process, an adaptation of the cellulose-rayon technic, produces a fiber resembling the best grades of washed and carded Merino wool, and commercial production costs will probably not exceed those of rayon (fifty cents a pound, or about thirty cents less than wool) because rayon plants may use existing equipment. It has been estimated that, because of the almost unlimited supply of milk, there will be possible an annual production of about a billion pounds, or two-and-a-half times our total wool production.

5

Basis of the new fiber is casein, the thick substance in sour, skimmed milk from which cottage cheese is made, and which dairies discarded until it was discovered that casein dumping grounds had become exceptionally fertile fields. The first plant for the use of this formerly wasted material was built in 1898.

Recovery of casein is simple. After separation of butter fat from milk, skimmed milk is soured, and its curd, or crude casein (about three per cent of whole milk), is separated from the whey which, formerly used only to fatten hogs, is now finding chemurgic uses as a source of lactic acid. The casein is washed, dried and ground. Then, softened in water and dissolved in caustic soda, it becomes a sticky dough which, after kneading and curing, is diluted and forced through tiny holes that break it into hairlike filaments. These are then hardened into wool-like fibers in an acid bath.

Since 1898, the non-comestible uses of casein have grown enormously. In 1938, while Italy was producing 20,000,000 pounds of casein wool and we were producing none, there were almost 46,000,000,000 pounds of skimmed milk available in this country. Of this supply, about 38,000,000,000 pounds were used as stock feed, less than 7,000,000,000 as human food, and about 1,000,000,000 for making commercial casein.

Commercial casein manufacture has increased rapidly since 1921, when the annual total was only 8,000,000 pounds. About seventy per cent of it is now used for coating paper, about twelve per cent goes to paint and glue manufacturers, and the rest gets into plastics. As paint, casein splashed Chicago's Century of Progress Exposition with color. As glue, its imperviousness to moisture made possible the use of laminated woods in early airplanes and propellers. As plastic, its molecules are hardened by heat, pressure and the greed of formaldehyde into a bonelike conglomerate which, perfected in France after Spitteler pointed the way, was called *galalith* (milk-stone) but now appears under many names as fountain pens, bathroom tumblers, lamp shades, powder boxes, brush backs, combs, cutlery handles, etc. As a bone substitute, it is widely used for buttons. It has even done duty as bone in skull surgery. It imitates amber and jade. As synthetic ivory, it may end the wasteful slaughter of elephants, the use of ivory having declined thirty per cent in the past ten years.

What else from the milk pail? One commercial plant is making lactic acid by fermenting milk sugar out of whey. This can be used in synthetic resins which show promise in the manufacture of lacquers that adhere to metals and resist alcohol and water. Another research group is attempting to convert lactic acid into acrylic acid for making plastic glass. Still another group has simplified and cut costs of the process for recovering milk-sugar by capturing the albumins and flavins which, formerly lost, are now utilized in baby foods. In addition, new uses for whey are being found, and a process for preserving it has been perfected.

6

Already the rapid shift of milk from scarcity to abundance in the United States has produced a number of startling effects. Because they were unpredictable, they indicate how the most carefully calculated prophecies may become retrospectively silly when chemurgic forces are unleashed. Now we shall see how seemingly unimportant events may wreck the most carefully engineered monopolies.

Fifty years after a German chemist made artificial ivory from milk as a curiosity, the forces he set in motion opened a tiny fissure in the tight ivory monopoly that has long fattened the treasuries of the rulers of Madras, Travancore and Mysore. The cow, as the elephant's competitor, has begun to disturb the low economic status of the notoriously underpaid Indian ivory-carvers in Trivandrum, Travancore's capital. Who could have predicted it fifty years ago?

Twenty years after another German chemist made a shoddy wool from milk in a country where both milk and wool were scarce, the spurting of a chemically-treated milk by-product through rayon spinnerets provided a vast new horizon for the pioneers of plenty in the United States. Only yesterday, some of those pioneers, working in the du Pont laboratories and applying to their research the lessons learned in converting wood and cotton and milk into textiles, announced that before long the spinnerets will be spurting a synthetic silk that will be indistinguishable from the real article.

Consider the potentialities! Consider them against a background tapestry of history in the weaving of which an Oriental silk monopoly figured for thousands of years.

China's monopoly of silk was tight for millennia after the Empress Si-Lung Chi discovered that a worm could convert mulberry leaves into rich garments for royalty. The first fissure in the monopoly was not to appear until about A.D. 400. Then a Chinese princess, betrothed to the King of Khotan, smuggled silkworm eggs to her bridegroom in her headdress.

The tribute which "mighty" Rome paid the monopoly was staggering, in money, in social decay and in economic upheaval. Pliny complained that this luxury of Roman women drained about $4,500,000 annually out of Rome into the Orient. Because silk, imported into Rome, was expensive, the textile was unraveled and rewoven into diaphanous gauze. When it was worn by women and men about nineteen hundred years ago, Roman reformers became so disgusted they stirred up revolt and the Roman Senate decreed against it. Not until about A.D. 500, when Justinian was ruling Rome from Constantinople, did the first tiny crack in the monopoly begin to widen. It had by that time fallen into the hands of the Sassanians after the Sassanid Empire's conquest of Parthia. Christian monks, seeking imperial backing for missionary work in the Orient, informed Justinian that silk was the product of worms that could be brought to Constantinople. Sent out to "convert the heathen," the monks returned with silkworm eggs concealed in their staffs.

Could any of these odd turnings of history have been predicted? Would anyone dare predict today how our destinies may be shaped by the hundreds of innovations popping up each year in the textile industry since man began to investigate the silkworm's secret? If one were to assemble a record of all such innovations in the half-century since Count Hilaire de Chardonnet made a crude artificial silk by nitrating cellulose, the recital would fill a large book—a book that would be out of date tomorrow. The innovations are coming fast nowadays. In one week in the autumn of 1938, four of them were announced. From Germany, where most of the pioneering in synthetic fibers was done, came the announcement that Arthur von Weinberg, Otto D. Eisenhut and Hans Rein had perfected a process whereby synthetic "copper-silk" (cellulose regenerated through cuprammonium solution) becomes "wool" when the filaments are dehydrated in an alcohol bath. That was one of several recent indications that, in the future, the textile manufacturer may alter at will, by changing the chemical baths, the nature of the filaments that spurt from the spinnerets, diversifying them to cotton, silk, wool, etc., no matter what their origin may have been.

In the realm of mechanical innovations, there is the new rayon plant at Painesville, Ohio. Equipped with new types of machinery, it reduces to six and a half minutes the spinning job for which yesterday's equipment required ninety hours. The silkworm devotes months to the perfection of a thread from 500 to 1300 yards long. These new machines spin 200 feet a minute, and one of them was still going strong after having pushed out thread 30,000 miles long!

Would you predict tomorrow's potentialities? If you would, you're more daring than Hiram S. Rivitz, the man who heads this plant. Says he: "There may be something entirely different in ten years. This industry is only thirty years old. We're about in the Model T stage now."

Only a hundred years ago, your ancestor, requiring an overcoat, went to an architect-builder-of-garments called a tailor, and after consultations, fittings and alterations, acquired a piece of portable shelter called an "overcoat." It was so expensive that, unless he was wealthy, he had to "live in" it for the rest of his life. Sometimes he handed it down to his favorite son. The mechanization of the textile industry, which your ancestor probably viewed as a potential menace to the economic status of tailors, unpredictably replaced a few technologically unemployed with thousands of garmentworkers. It elevated the living standards of these and other thousands. It reduced the end-costs of overcoats so drastically that they can now be obtained at prices representing labor-hours instead of labor-weeks—obtained so cheaply that not even the poor need to wear them a lifetime.

Now isn't it within the realm of possibility that posterity will have garments which, surpassing ours in quality and beauty, will be so easily obtainable that they will be discarded as we today discard paper napkins and paper towels? There is already being manufactured in the United States a synthetic "linen" which, in pillow slips and bed sheets, is discarded after one use. Is that waste? Your grandfather, who required no huge waste-baskets because he saved every scrap of paper, would have called your paper profligacy "wasteful." To the organic chemist, "waste" has acquired new meanings. Probing into nature's secrets, he knows that paper in a rubbish-burner is disintegrated into chemical compounds that reach growing plants through the soil and the atmosphere and may again be processed into stuff from which paper may be made. To the organic chemist and to the chemurgist, "waste" is coming to mean the refusal to use the things nature produces.

The only thing man can waste is energy. Modern society's most flagrant waste of energy is refusal to provide employment for all available hands and minds.

Even gold, silver and copper represent wealth only as they represent energy required to find, collect and purify them, says Chemurgist George R. Harrison, of the Massachusetts Institute of Technology. The supply of matter on earth does not change appreciably for, although a little hydrogen and helium leak off from the planet's atmosphere, far more matter is brought to earth by meteorites. "Only energy is needed to gather as much of every material as we may need from the air, the land, or the sea," he says.

On the expansion of industries that convert wastes into necessities the chemurgists base their hopes for a general elevation of living standards; first, among farmers of the United States whose activities are most wasteful according to organic chemistry's standards; second, in the Western Hemisphere, where the ratio of man to material resources is most favorable to man; and third, by natural extension, throughout the world. The chemurgist is a realist. He believes that the place to begin improving man's lot is right under the nose of the self-appointed improver.

In the same week in which the German chemists announced their "copper-silk" conversion and the new rayon plant started up in Painesville, Celanese Corporation of America approved construction of a $10,000,000 factory near Pearisburg, Virginia, for the production of a new synthetic silk; and E. I. du Pont de Nemours & Company announced that an $8,000,000 factory would be built at Seaford, Delaware, for the manufacture of Fiber 66. This is a synthetic material developed by the late Wallace Hume Carothers after ten years of research. It is said to be one of the most significant developments in the history of industrial research in the United States.

Carothers' aim was "the synthesis from readily available native raw materials of a wholly new group of chemical compounds capable of meeting deficiencies in certain existing industrial materials that are in the main now imported." (Parenthetically, it was under his supervision that the late Father Nieuwland perfected the first successful process for making the synthetic rubber called *Duprene* or *Neoprene*. It too was motivated by the desire to convert native raw materials into a chemical compound capable of meeting deficiencies in an existing raw material in the main imported.)

Like Father Nieuwland's rubber, Carothers' fiber, now called *Nylon*, is already proving superior to the natural things it replaces. Its superiority to natural silk lies in its strength, fineness and elasticity. In some cases individual fibers are 150 per cent stronger than silk. They are capable of being drawn to a fineness one-tenth to one-seventy-fifth the diameter of a silk filament. They are almost insensitive to moisture. Unlike inelastic rayon, they can be stretched with complete recovery. Though lustrous and silky, the fibers may be treated to destroy the luster. Though *Nylon* will undoubtedly revolutionize the hosiery industry, which used $83,651,000 worth of Japanese raw silk in 1938, it is also produced in large fibers as artificial straw, mohair substitutes, strings for musical instruments, horse hair, dental floss, etc. Its first use was as a substitute for imported hog bristles in toothbrushes, for which it was called *Exton*. Of this substitution. "Boss" Kettering remarked: "I never relished the thought of hog bristles for cleaning teeth, because I couldn't believe that hogs had any idea about cleanliness when they grew them. It seems to me that nature was just carrying us along with hog bristles until we learned how to make better ones." Dr. Kettering's droll comment was given serious emphasis a month later; the United States Public Health Service issued a warning against a particular brand of Japanese shaving brushes found to be harboring anthrax bacillus.

Like the Nieuwland rubber again, the Carothers fiber is partly derived from coal. Now, critics of the chemurgic program frequently point out that, in the search for synthetics, chemists often employ raw materials from the earth's depths rather than from the farmer's acres. However, though this new fiber is *now* produced from coal, air and water, its inventors point out that it can be made from organic materials. Ultimately, because a superabundance of cheap and readily available fertilizer is now making it possible for the farm to compete with the mine, the cheapest materials for this purpose will be grown on the farm.

Coal, as every schoolchild knows and no chemist ever permits himself to forget, is merely sunshine, converted into chemicals by plant leaves, and buried. The period in which the conversion began is commonly called "the Coal Age"—although there was probably no coal anywhere on earth at that time!

On July 15, 1930, Dr. Herbert Levenstein, addressing the Society of Chemical Industry, spoke of our age as "the age of fossil power," and added that this coal-power and oil-power age of ours is a mere incident in economic evolution which "will have lasted, when it is over, for a shorter period than the Moorish occupation of Spain." To the chemist, it is within the realm of possibility that all of our fossil-derived chemicals will ultimately be drawn from replaceable sources on the soil surface rather than from the irreplaceable stores in the earth's depths. As Dr. Kettering has expressed it, "Nature has been carrying us along with buried sunlight until we can learn how to pick up our sun-energy direct."

Nylon is defined as "a synthetic fiber-forming polymeric amide having protein-like chemical structure." Though it offers no immediate new outlet for farm surpluses, it deserves to be called a chemurgic factor because, in providing a domestic substitute for something hitherto imported, it contributes to that potential national self-dependence which is one of the chemurgic aims. But self-dependence does not mean isolation.

The point to be remembered in this connection is that, as Dr. Kettering has said, "In this age in which we call ourselves scientific, we know *just exactly nothing* about how the leaf of a plant is able to pick up the radiant energy from the sun and convert it into new chemical compounds."

The chemicals produced by plant leaves and solar radiation millions of years ago and stored as coal and petroleum are being produced on the earth's surface today. In hundreds of laboratories all over the world, scientists are chipping away at the wall of ignorance. When a German chemist makes "wool" from meat, an Italian chemist makes "wool" from milk, and American chemists make "hog bristles" and "horse hair," "silk" and flexible "glass" and "rubber" from coal, they are all knocking holes in the wall. When and if the wall is toppled, say the chemurgists, no nation will have to look beyond its borders for its "place in the sun." From the sunlight streaming on acres of vegetation, each nation will be able to derive everything its people need. The smashing of that wall will be the smashing of some of the world's most impregnable monopolies—monopolies based on "rights" of fortunate groups to sites containing rich deposits of fossilized sun radiation.

Someday, said Havelock Ellis, man may discover what the ancients instinctively believed—that the chemical elements of the planet are only transmutations of one element. Today's transmutations, surpassing the wildest dreams of the alchemists, may bring man to an understanding of matter, not as a variety of substances, but as various quantitative arrangements of some single basic thing.

That hope is no longer as fantastic as it appeared when it was expressed only about a decade ago. By the end of 1938, all the chemical elements, except two, had yielded to the old alchemic dream of transmutation.

7

Now, let us return to the probings in the milk pail by the modern super-alchemists, whose activities are creating the new horizons of abundance. There is irony in the contemplation of the forces set in motion. Whether fact or fiction, the fire that altered the destiny of Chicago has been traced to a cow. The first crack in the Indian ivory monopoly is certainly traceable to the cow. And it is ironic that the destinies of India should be altered by the cow, revered as a sacred animal there. Irony is heaped on irony when you consider that India, the *world's greatest cattle-producing nation,* is being affected by a milk surplus in the United States, *the world's greatest milk-consuming nation.*

Here you get a striking illustration of how man's adaptation to his environment may result in either scarcity or plenty.

Considering the world as a whole, there are seven cattle for every nineteen persons. In the United States seven cattle produce abundance of beef and dairy products for every thirteen persons. But in India, where there are *six* cattle for every *ten* persons, the world's largest collection of cattle means scarcity—for cattle *and* human beings.

India, the one country in which the cow is worshiped, has the lowest average milk yield per cow and the lowest average milk consumption per person. India's veneration of the cow and taboo on beef-eating have produced, in a land where fencing is uncommon, a tremendous waste of human labor devoted to useless herding, enormous devastation of crops intended for human consumption, extensive deforestation, and overgrazing, soil-exhausting erosion, frightful floods and famine.

Man in India is not master. He is mastered—by his animals and by monopolists. He is host to a horde of parasites. He has been host to his parasitic cattle since about 500 B.C., when Buddhism replaced the Vedic religion under which, according to the Rig Veda, cattle existed for man's benefit. He is host to a few of the world's "wealthiest" men whose dominance is implemented by the perpetuation of the twin myths that wealth is metallic and mineral and that scarcity is cyclical and certain.

"The wealth of India" is one of the most flagrant myths to which humanity is heir. It is a figment of mass imagination kept alive by such events as the appearance in Buckingham

Palace of Lieutenant-General Krishna Shumshere Jung Bahadur Rana, Nepal's Minister to the Court of St. James's, under a plumed and bejeweled hat valued at $250,000. That bonnet represents the dominance of the metallic-wealth myth, a dominance under which India's "saving for a rainy day" has heaped up the world's most enormous pile of privately hoarded gold and silver and jewels—and has made "rainy days" a permanent condition for a nation in which famine is still familiar.

The myth of India's "wealth" is kept alive by the British who, of all people, ought to know that India is horribly poor. In 1937, India exported to Great Britain $324,000,000 worth of goods, less than a dollar's worth of income for each of India's 360,000,000 human beings; while Canada's 10,000,000 people derived about forty-two dollars each from exports to Great Britain. In the same year, Great Britain exported $200,000,000 in goods to India, and $138,000,000 to Canada; which means that, while the average Indian was returning to the Empire sixty cents of the dollar he received, the Canadian was returning only thirteen dollars of the forty-two dollars he received.

The mastery of India's masses by monopolistic myth is best illustrated by a comparison of the Indian's lot with the American's.

It has been calculated that, in 1919-1920, the food available per person per day in India was only 1.2 pounds. This, remember, is in an agricultural country, where there is no question of machine dominance. And in the United States, where there are some strange expressions of doubt about the man-machine relation, a Department of Commerce tabulation shows that between 1922 and 1927 the food *consumed* (not merely *available*, mind you!) was 4.8 pounds per person per day.

The startling aspect of this comparison is this:

At no previous time in recorded history has man had the opportunity to compare statistics of starvation with statistics of surfeit!

Hunger, the flint-hearted taskmaster of the race, is being shackled. The whine of the flailing scourge which has always whistled ominously behind the surface splendor of history's pageantry, is falling silent. *That* is the heartening evidence from the existence of the crop-surplus.

How did it happen?

Chapter XV

STARVATION TO SURFEIT

1

Thomas Henry Huxley, the courageous Victorian who championed the cause of science when it was distrusted by mob and snob, once said:

"Let us understand, once and for all, that the ethical progress of society depends, not on imitating the cosmic process, still less in running away from it, but in combating it . . ."

India's miserable millions do not combat the cosmic process. They are dominated by it. In the Twentieth Century, they constitute a glaring example of the kind of existence which, for thousands of years, our Eastern Hemisphere ancestors called "life." Until about three hundred years ago, our ancestors knew all about starvation, nothing about surfeit. Famine was a familiar fact, a perpetual problem of more mouths than mouthfuls. They accepted it as the will of God, the order of nature, the natural performance of the cosmic process. Wherever they looked, they saw the ruthlessness of nature, millions of creatures born where only hundreds could survive, creatures destroying and devouring one another. *That* was the cosmic process, and the best they could do was dream of "a better world" in which there was no want, no warfare, no occasion for fright, fight and flight.

To reach this better world, one had to die. Meantime, one had to live. And, since life was an endless succession of fear, contest and escape, our ancestors became adept at imitating the cosmic process by perfecting their skill in warfare and plunder;

or they tried to flee from the process, by perfecting their skill as creatures of rapid and easy movement. The migrating dodgers of warfare and poverty became the moving dreamers of welfare and plenty, the searchers for the place of perpetual peace and prosperity, "the land with gold on the ground."

Today, man is combating the cosmic process and doing it so effectively that it can with justice be said that the mind of this physically puny creature is becoming as big as the universe. As Anatole France expressed it, "The wonder is not that the field of the stars is so vast, but that man has measured it."

When you think of the tremendous length of time in which man struggled with the cosmic process with virtually no success, it is not only astounding but encouraging to think of the high estate to which he has attained in the past three hundred years. Not only astounding and encouraging, but baffling! How did he reach this height in so brief a span? Three centuries ago, the planet's passengers were limited to a total which had been the limit for many centuries. Then, the passengers doubled in number and doubled again. Why? How?

The answers ought to be in history. But the historians seem to have ignored them. "Most events recorded in history," said Henry David Thoreau, "are more remarkable than important." But the cause of this explosive population growth would seem to have been both remarkable and important.

Suppose we look at human history as the story of man's attempt to achieve deliverance from the condition of scarcity. Suppose we think of it as that terrible book, the unwritten History of Hunger, of which Jules Michelet spoke.

First, by habit, let us look at the exclusive contributions of the Eastern Hemisphere to this conquest of scarcity. In their myths and folklore virtually all the peoples credited the sun-god with the gift of fire. And, for some mysterious reason, virtually all attributed the gift of the wheel to the goddess of fertility, or grain-goddess.

2

Fire and the wheel. These two were valued highly enough to be credited to deities. Were they given exclusively to the Eastern Hemisphere? There is no reason for believing it of fire. To the wheel, however, the claim is clear; for, as has been observed by many students of American archaeology, the principle of the wheel seems to have been unknown in the Western Hemisphere until this greatest of labor-saving devices was brought to America by Europeans.

Western Hemisphere man had fire. He had mastered the other five primary machines—lever, wedge, pulley, screw and inclined plane—but he knew nothing of wheels. It is astonishing when you realize that five-sixths of all the wheels on the planet today are in the United States, a part of that half of the earth upon which there was not one wheel five hundred years ago.

The wheel, therefore, seems to have been the Eastern Hemisphere's greatest exclusive gift to the race. Where and how did man first think of it? We do not know. We know that the warriors of Sumer clattered into battle on wheels; that Egypt got wheels from Asia about 3500 B.C., and that primitive rites often combined a wheel with fire. But this Ceres-gift brought man no safe deliverance from hunger. Even with wheels, he remained a creature of hunger-fright.

"The mouthful to be procured engenders war between the consumers," said Jean Henri Fabre, the entomologist. What Fabre said of insects may stand as an observation of man's struggle with the cosmic process in the Eastern Hemisphere. Wanting welfare, the fellow refined warfare. Did it solve his problem? Superficially, it would appear that if there are too many mouths the problem might be solved by destroying some of them. But you can't destroy mouths without destroying hands. And since hands were desperately needed in a world of want, warfare produced no gain. To replace destroyed hands, the warrior tried slavery. Since slave hands are accompanied by slave mouths, *that* was no gain. Besides, slave hands are rebellious hands and the slaver himself is enslaved.

Thus it went, for thousands of years. Around and around in his prison of scarcity went this trapped creature, slowly converting his precious wheels into mouthless mechanical hands, slowly expanding his range of warfare and wandering by fashioning wheels into such devices as the fire-spitting musket and the compass.

At long last, the compass brought him to the Western Hemisphere and the musket enabled him to seize it. Could he have seized it so easily had he not been the unique possessor of one Ceres-gift and had not the goddess of agriculture, withholding the wheel from men in the Western Hemisphere, compensated for her slight with a gift equally great?

The invader's way was made smooth, not solely by his exclusive possession of wheel technics, but by his discovery and easy acquisition of an unprecedented abundance of provender. Here was a turning point in the hunger-driven ordeal of civilization.

The sudden spurt of man's activity and achievement in combat with the cosmic process in the past three hundred years is often attributed to the expansion of his mind. But a mind linked to a hungry belly is not very elastic. "He that pines with hunger," said Samuel Johnson, "is in little care how others shall be fed." In other words—as anyone who has ever been desperately hungry knows well—a mind concentrating on the problem of obtaining bread, bacon and beans contains little room for dreams of "life, liberty and the pursuit of happiness." Scarcity forces men to think with their bellies; abundance enables them to use their heads. So it should be obvious that, without the inexhaustible treasures of vegetative abundance developed by wheelless man in the Western Hemisphere, the expansion of the human mind would have remained restricted. Without this abundance which Arthur Stanley Riggs calls "the richest gifts for the greatest number that man has ever known," there would have been no problem of farm surpluses, and, therefore, no occasion for the activities of the chemurgists. Without these gifts—for which the invader repaid the donors with wolfish rapacity and cruelty, the coinage of his heritage of hunger—there is no question that the level of living standards would have remained on that low plane of which we have a belated mirroring in twentieth-century India.

3

What schoolchild is not familiar with the story of Tisquantum, called Squanto for short? Kidnaped six years before the Pilgrims came to these shores, taken to Spain and sold into slavery by Captain Hunt, Squanto escaped and fled to England. There he found a friend and protector in John Slanie, the merchant, who returned the red man to America in time for him to become the English-speaking saviour of the Pilgrim Fathers. Saved from starvation, the Pilgrim Fathers wrote in their records that Squanto, the "savage," lived with them for two years, taught them how to plant and how to fertilize their crops, how to combat the cosmic process with the hunger-fighting technics of his people.

The American Indians were excellent farmers. Champlain reported vast cleared and cultivated lands in Ontario, the country of the so-called "shiftless" Hurons. In 1779 General Sullivan's army of four thousand spent weeks destroying crops around Seneca villages. Father Hennepin noted that the Iroquois tilled fields that had apparently been farmed for hundreds of years without loss of soil fertility. In 1643 Roger Williams observed their superiority in the cultivation of strawberries. "In some places where the natives have planted," he said, "I have many times seen as many as would fill a good ship."

They invented the "rag-doll seed-tester," widely used today. They had fertilizing, crop-spacing and food-preservation on scientific bases. They not only fed themselves well, but preserved their soil and improved their crop plants. Dr. Howard E. Pulling, Wellesley College botanist, maintains that no other people accomplished quite so much by plant-breeding, and that at least a third of modern American agriculture is of American Indian origin.

If the entire contribution of the American Indian had been only maize, or the grain we call corn, that alone would have given him clear title as a great pioneer of plenty. For Indian corn is the largest single crop-base of our plenty-potential. Paul de Kruif, in whose *Hunger Fighters* is a glowing tribute to the Maize-Finder, calls it the greatest trapper of sun energy in the family of green living things.

This cereal which, as food for man and feed for man's food animals, has become the chief food source of the Western Hemisphere, is an amazing plant. Tough and resourceful, it grows in ninety-odd days into a tree three-thousand times the weight of its seed, yet takes only about five per cent of this energy from the soil. It yields three-hundredfold in bog land with just enough root-system to hold it upright, and it pushes down tremendous tap-roots for moisture in semi-desert country. It employs tricks to dodge the killing effects of late spring and early fall frosts. And yet, paradoxically, it is so helpless in propagating itself that, without the hand of man to store and plant its seed, fight competitive weeds in its infancy, and harvest the progeny, it would quickly disappear from the face of the earth. Though it is the most domesticated plant known to man, nobody knows its origin.

Wild forms of most grains are known, but maize has only two Western Hemisphere cousins: the wild grasses, teosinte and tripsacum. Teosinte was believed to be the ancestor until Dr. P. C. Mangelsdorf and Professor R. G. Reeves dug up good genetical evidence that teosinte resulted from the crossing of maize with tripsacum, probably by the Mayas around A.D. 600. Later these two Texas scientists unearthed indications that the Peruvians perfected maize out of a primitive type of grain called pod corn which, though unknown in the wild state, has certain wild characteristics. Another enigma is the fact that a drawing of maize appears in the *Li-chi-tchin,* a Chinese natural history written in 1562.

The American Indian says maize is as old as fire, that it came from the gods. And, with all of their modern scientific lore, today's horticultural experts have been unable to effect many improvements in this product of the forgotten pioneers of plenty.

The list of Amerindian contributions includes tobacco, a mountain from which the Federal government mined more than $500,000,000 in internal revenue taxes in 1937. It was tobacco which, pouring wealth into Europe in the days called "Colonial," fulfilled our ancestors' dream of a land with gold on the ground.

Then there are sweet potatoes. Among the fine foods the peaceful and gentle Lucayans set before the half-starved men of Columbus' crew was an assortment of yams. The American pioneers of plenty had slowly converted them from small, accidental root-swellings of the wild morning glory into a food family that has been called "the most valuable of root foods." Hungry Europe seized on the value of this gift. Long before the conquest of Peru, sweet potatoes were fighting hunger in Spain. Italy got them next. Then they went to Belgium, Austria, Germany, and then into England long before white potatoes were brought home by Sir John Hawkins. The value of this contribution, which was food staple, dye source and alcohol source to the American Indian, is only now being explored by the chemurgists who respect it because it is a grateful plant, responding to proper cultivation by increasing its production from a ton to five tons per acre.

The list continues with vanilla, the universal flavoring extract which the "savage" ancestors of Montezuma derived from an orchid by a complicated process involving a fairly thorough knowledge of plant genetics plus considerable knowledge of chemistry.

4

But this by no means exhausts the Indian's contribution. One must include the doubly misnamed Irish potato, which is Incan in origin and not a "batata" (yam), and of which there are hundreds of varieties, all of them developed, long before the arrival of the invader, by American plant wizards. They perfected a wild plant, with a peculiar habit of growing swollen terminal buds on underground stems, into a group of tuber crops adaptable to virtually every climatic condition in the Western Hemisphere. Spaniards took the first of them out of Peru, brought them from Spain to Florida, where Sir Francis Drake and Sir John Hawkins found them and took them to England. From England, where they were not appreciated, they went to Ireland and to New England. During the Thirty Years' War the humble "spud" staved off famine in Europe. The failure of the crop in Ireland in 1845 brought a wave of Irish immigrants to America. Potatoes bulk in volume as the world's largest food crop, with Germany and Russia chief producers and consumers. They are such a valuable crop that most of them are consumed where they are grown.

Then there are the potato's cousins, tomatoes, as widely distributed as wheat today, and peppers, both developed from the deadly nightshade family; and tapioca, which the "savage" scientist derived from a poisonous root containing deadly hydrocyanic acid; and chocolate, the processing of which involves a whole chain of scientific skills; and pineapples, big source of Hawaii's wealth; and the mighty peanut, of which we learned in the story of Dr. Carver. Add pumpkins and squashes ("askutasquash," from the Mohican language). Add beans, which Herbert Spencer erroneously attributed to the Egyptians who knew no beans save the unrelated broad bean. The American pioneer of plenty perfected scores of varieties. Add—but, why go on? If you are interested in discovering the relationship between your "more abundant life" and the original "forgotten man" of America, you will find a fairly complete list (and an evening of pleasant reading) in *Foods America Gave the World,* a book written by A. Hyatt Verrill in collaboration with Dr. Otis W. Barrett, a botanist who has devoted years to the study of American horticulture.

When you have given men of the Western Hemisphere credit for freeing the human race from hunger-dominance, you have by no means recognized your full debt. To this same "savage" medicine is indebted for at least three great contributions—cocaine and the pain-killers that derive from it; quinine, the first and still one of the most effective fever-fighters; and that *sine qua non* of the laboratory, the prolific guinea pig which he developed out of an unknown wildling into one of the very few animals he domesticated. What else? When Dr. Friedrich Bergius provided hungry Germany with sugar prepared from wood, that accomplishment was front-page news throughout the world. Sugar from wood! News? It would not have been news to the early white settlers of America, who got *all* their sugar from wood—after the Indian taught them how to tap *Acer saccharinum,* the sugar maple, and convert its sap into a sugar that has no equal for flavor. He got sugar also from soft maples, box elders and hickory trees, thereby demonstrating that he was something of a progenitor of the modern wood chemist.

He got bread from flour in the roots of aquatic plants such as the cattails and waterlilies, and from the wild acorns whose bitterness he knew how to remove with a chemical process. Long before the modern American farmer found that the misnamed Jerusalem artichoke is a remarkably sweet tuber, this pioneer of plenty knew that this was no weed but a never-failing root-food whose flavor was improved by freezing.

What else?

Rubber. "We might get along without steel; we could get along without petroleum," said Kettering to a group of industrialists in New York in the fall of 1938, "but our civilization would collapse without rubber."

Just a hundred years ago Charles Goodyear, whose burning curiosity about rubber plunged him into miserable poverty, disgustedly tossed a batch of crude rubber, white lead and sulfur on the kitchen stove and changed a laboratory plaything into one of man's most useful substances. Today, the stuff which the American Indian used in his ball games is employed in virtually all of modern man's sports and in all of the transport-tools with which man, the mile-minimizer, has shrunk the formerly huge planet, Earth. It has about thirty-five thousand known uses. It represents the employment of four million people, the investment of more than two and a half billion dollars.

In July, 1939, Dr. Gustav Egloff, of Universal Oil Products Company, revealed that he had devised a new way to make synthetic rubber by stripping hydrogen atoms from the molecules of butane gas. At the same time, Commodore Ernest Lee Jahncke, director of the Louisiana State Department of Commerce and Industry, announced that surplus sugar and turpentine may shortly be converted into rubber via a process perfected by Swiss Chemist Ernest Kleiber. These developments indicate that another of Dr. Hale's spectacular predictions is being fulfilled.

By the end of 1941 Kettering's remark about rubber was given dreadful significance by war in the Pacific. As Japanese thrusts threatened to sever America's rubber "life line," the people of the United States, the world's greatest consumers of rubber, began to ask how and why they had allowed themselves to lapse into almost total dependence upon distant and endangered Asiatic sources for this vitally essential product which had been uniquely American in the first place. Sharply aware of their plight, Americans asked, "What about synthetics?" And in that field, too, they discovered leadership in production of artificial "rubbers," though invented by Americans, had been permitted to drift into German hands now arrayed against the United States.

5

Rubber by no means ends the list of the Indian's contributions. It seems almost endless. As you think of the more than fifty pounds of rubber in even the smallest of automobiles, you come up against the fact that the Indian also contributed to modern sports and to the conquest of distance such things as *lignum vitae*—the wood of life—used in bowling balls, pulleys and as salt-water-defying stern-bushings for propeller shafts of ocean-going ships; and balsa, the lightest of woods, with which he built rafts and which has contributed much to aviation.

You could go on and on and on, and yet—

Books are written about the transition from scarcity to surfeit without even mentioning the Indian who led our ancestors out of their fright-fight-flight trap into the green pastures of abundance in this potentially bountiful New World of ours.

Long before our hunger-dodging ancestors found these green pastures of abundance, this New World was the land of the free. Its brave people, as the chronicles of Spanish Conquistadores attest, loved liberty so fiercely that they sickened and died when enslaved. The same chronicles show how they lost to the invaders from the Eastern Hemisphere the paradise of plenty which their peculiar genius had created.

The abundance of the original Americans, implemented by the inventive ingenuity of Old World people who fled to this New World, has become in our time a problem of surplus, a problem of poverty amid plenty. Shall modern Americans, loving liberty as the Indian loved it, solve this problem for the many, and show to the rest of the world an example of how life ought to be lived?

Or shall these green pastures of abundance once more become such a strong temptation to plunderers that mankind's brightest hopes for a better world shall be here trampled underfoot by Old World masters of mass destruction?

Chemurgists believe that a strong America can lead the world to a condition of permanent peace and plenty by solving its unique problems so effectively that the solutions will become patterns for other peoples. As Dr. Karl T. Compton has evaluated the chemurgic aim, the fundamental and most attractive aspect of this appeal to science to assist the farmer with the cooperation of industry is that it introduces a new recipe for securing the good things of life.

From the beginning of time, Dr. Compton observes, there have been until now only two methods of obtaining the more abundant life—toil and theft.

"Now, for the first time in the history of the world," he says, "science has given man an opportunity to secure the good things of life without taking them from someone else, and in a degree going far beyond the amount of labor he expends. This situation, in which everyone is the gainer and no one is the loser, is unique.

"I believe that in the field of human affairs its advent is an economic and even an ethical event which may well come to stand on a par with even the Golden Rule in its beneficial social results."

Here, then, is a new way of life—the uniquely American way. If it is not to become just another of the many lost hopes of mankind, it must be implemented by freedom-loving Americans, conscious of their destiny of leadership, strong in their determination to down the ancient and evil way of mass destruction under the weight of their peculiar genius for mass production.

To enforce their will for peace, Americans must once more discover America.

BOOK THREE

AMERICANS DISCOVER AMERICA

Chapter XVI

AMERICAN INDEPENDENCE

1

The late Francis Garvan once defined "the American way" as "the ever intense and advancing struggle for higher independence."

"Each and every man who has come to our shores," he said, "came here seeking greater independence—political, religious, economic."

Thrusting his sharp vision into the future, Garvan saw that the ultimate aim of this struggle is "independence, even of nature itself."

Somehow, that concept of the meaning of America tends to become blurred in the minds of men. Latent in those minds are the inherited Old World habits of thought which identify independence with exclusive nationalism. Hampered by that mental heritage, even native Americans tend to forget that the American struggle for independence is an attempt to conquer, not nations, but nature.

It seems that we Americans cannot discover America without being compelled to do so. Again and again, as our history reveals, emergency has made us emerge from the ruts of habit and add intensity to the advancing struggle which, daringly declared in 1776 and hoped for by all immigrants who transplanted themselves into the free atmosphere and fat soil of this New World, is never quite attained.

"America is a fortunate country," said Napoleon Bonaparte. "She grows by the follies of European nations."

As a defeated expert in what is oddly called the "art" of war, Napoleon had ample time to reflect upon the debits and credits of his participation in that basic folly of the Old World—the fatuous but persistent belief that the good things of life may be possessed by taking them from someone else. Though he may not have gauged the full significance, the European warfare of his time actually nurtured the beginnings of an American idea which, shaping itself into America's principal source of strength in the brief span of a century, is now forcing itself into the Old World and demanding recognition as a new hope for mankind.

The principle of mass production, America's unique contribution to human welfare, was born of the New World's need to protect itself against the folly of Old World warfare. Confronted by the danger of involvement in that Old World folly, the people of the United States, acting through their government, called upon Eli Whitney to undertake the manufacture of ten thousand guns. Confronted with this tremendous task, the ruined inventor of the cotton gin turned the full force of his Yankee ingenuity to the invention of the revolutionary principle of mass-produced abundance through the fabrication of ingenious machines which could produce complicated mechanical parts speedily and with such great accuracy that their assembly into finished instruments could be effected with ease.

Applied to the natural abundance inherent in the soil of America and implemented by the inventive ingenuity of many freedom-loving minds seeking independence in the New World, this novel principle of mass production became one of the major reasons why, as Dr. Compton pointed out, man has at last been given "an opportunity to secure the good things of life without taking them from someone else, and in a degree going far beyond the amount of labor he expends."

Thus, in Napoleon's time, Europe's loss was America's gain. Eventually, as the American way of mass production is refined into a strong weapon against the Old World way of mass destruction, the gain will redound to the benefit of all mankind. Each new outbreak of Old World folly since the Napoleonic wars has added fresh impetus to this movement. Since 1800, every major war has advanced America's mastery of the arts of mass production and forced other peoples to recognize in the mastery of that principle a hopeful pattern for all nations seeking economic independence through peaceful conquest of materials by the mind of mankind.

A century after Napoleon's failure to solve great human problems by resorting to Old World habits, another world war showed Americans how far they were from independence.

Until 1914, we believed that only German chemists could wrest dyes, medicinals and photographic chemicals from coal tar. For fertility our acres were dependent on nitrates from Chile and potash from Germany. For the vast quantities of paper we employed we found ourselves dependent on the forests of other nations. Not until these other nations fell once again into the folly of warfare did we Americans bestir ourselves and discover America.

In that Twentieth Century discovery of America the trail-blazing pioneers were such men as Garvan, Herty and Hale, among others. And, as we observed in an earlier chapter dealing with Baekeland's story, the trails which were then blazed very often twisted toward unexpected frontiers.

"Our horizon," as Thoreau observed, "is never quite at our elbows."

2

As the 1930's drew to a cataclysmic close, a major outbreak of Old World folly again made it necessary for Americans to look beyond their elbows. Another ex-corporal was striving for world domination through an attempted harnessing of mass unrest of unhappy millions ready for revolution, and, once again, the fierce fires of war illumined the broad gaps in the ramparts of American independence.

True, we had learned some valuable lessons in the quarter-century between the two emergencies. We had gained world leadership in chemical manufacture. Our essential chemicals were now coming from our own by-product coking industry, a great industry built entirely upon the utilization of hidden values in the smoke which once blackened the skies above our iron and steel manufacturing centers. In addition to our partial mastery over coal smoke, we had learned to extract a broad group of alternate chemical products from our land's vast subterranean stores of petroleum and brine. Goaded by the emergency needs of 1914-1918 we had uncovered neglected mineral deposits which were supplying our potash requirements. Our nitrogen capacity, synthetic and by-product, was fifty per cent in excess of our normal peacetime needs for fertilizer and capable of supplying wartime needs for explosives. Our iodine, formerly supplied by Chile over many sea-miles now rendered increasingly perilous, could be supplied by California oil-well brines. The forests of our southern states were capable of supplying the pulpwoods for which we were once dependent upon Baltic nations. Our sulfate pulp industry's expanded demands for salt cake, formerly imported from Germany, were being met by newly opened natural deposits in the West and by a new synthetic process that had been recently developed.

Forced to re-examine our horizons, we Americans found new sources of strength in these and hundreds of similar fruits of our native Yankee ingenuity. But when the need for immediate rediscovery of America was thrust upon us by the spread of World War II, we also found ourselves desperately in need of many things which we should have been able to supply ourselves but for which we had blithely allowed ourselves to remain dependent on other lands now thousands of perilous sea-miles away from our ports.

Our vaunted independence was given the lie by lacks of such things as tin, chromite, manganese, nickel, aluminum, magnesium, tungsten, copper, zinc, antimony, mercury, mica and lead. In some of these minerals we were potentially rich but technically poor. Of others our natural deposits were few and low-grade; and our weakness lay in our failure to recognize our insufficiencies in time to develop stock-piles and devise adequate alternates. Within our national boundaries, for instance, we possessed the world's richest deposit of molybdenum which, though coveted by every steel-making nation, was generally neglected by ourselves.

For cork we were dependent on Spain and Portugal although it was known almost half a century ago that California could produce it.

For rubber, cocaine and quinine we were dependent on the East Indies, although all three were originally products of vegetation peculiarly American. And, although our own Father Nieuwland had pointed the way toward independence by supplying the trick of synthesizing from fossilized vegetation a series of man-made rubbers superior in many ways to the natural product, we had allowed Germany to forge ahead in this frontier while we, the world's largest consumers of rubber, had complacently continued our dependence on the East Indies.

By the end of 1941 Japan, schooled by her Axis partners in the Old World way of profit by plunder, recognized the weak points in our armor and struck suddenly and stealthily at the long and tenuous rubber life line between us and the Indies.

Slowly, sometimes painfully, we Americans learn.

Though Eastern Hemisphere follies threatened our rubber supply while we frantically strove to augment our production of synthetic elastomers and sought to restore natural rubber production in the Western Hemisphere where it originated, we were fortunately a bit more independent of the Orient for other essential commodities.

Thanks to the pioneering efforts of Nieuwland's du Pont associate, the late Wallace Carothers, the synthetic nylon (and the similar vinyon fibers) provided us at least potential independence of the Orient's silkworms, hog bristles and animal hair. Our lack on these frontiers was a lack of trained chemists to supervise the complicated processes whereby fossilized vegetation is converted into superior tailor-made fibers.

Thanks to American wood-waste explorations launched during and after World War I, the camphor for which we were utterly dependent upon Japan as recently as 1920 is now derived entirely from American trees. In the winning of our independence in that sector there is a sharp reminder of the basic difference between the economic outlooks of the Old and New Worlds. For, to gain a camphor monoply, the Japanese robbed the Chinese of Formosa. As the monoply became secure, the price was raised until it reached three dollars and sixty-five cents a pound. At that price, the use of the commodity was virtually restricted to medicinals, although there were great potential needs for it in the manufacture of plastics and photographic film. Eventually, the pressure of those needs implemented the explorations of American wood-wastes and the resultant synthetic product, manufactured at forty-eight cents a pound, forced the natural product off the market.

Today, when Eastern Hemisphere follies once more compel us to seek alternates for critical and strategic metals, the contribution of synthetic camphor to our economic independence becomes significant. Our forced expansion of the use of plastics is already revealing horizons undreamed of as recently as 1939.

Yes, we learn, we Americans. We learn fast under the lash of grave danger.

Threatened in these ominous 1940's, we are once more discovering America—frantically seeking on a thousand frontiers, scorned or overlooked only five years ago, the additional materials we need for the struggle for independence.

War was far from the thoughts of the chemurgists when they met for the first time in May, 1935. But, less than five years later, wartime dislocations of ocean transport began to demonstrate the worth of the programs they had inaugurated. By 1941 it was apparent that chemurgy had arrived. The National Farm Chemurgic Council, which had declined to but eleven corporate contributors and thirty-three members shortly after Garvan's death in 1937, acquired new strength, with more than 150 corporations contributing up to $2,500 each, plus about 1,600 individual contributing members. Under the leadership of Wheeler McMillen, who had become editor-in-chief of *Farm Journal & Farmer's Wife,* the Council soft-pedaled the highly controversial power alcohol program which Dr. Hale, resigning his Council offices, continued on his own.

As early as October, 1939, the events in Europe had begun to turn the attention of Americans toward weaknesses in the American economy. It began with little things, little and inconsequential things such as ocarinas and costume jewelry.

Ocarinas, or musical "sweet potatoes," disappeared from the market after Germany's seizure of the Austrian area in which they had been manufactured from a special kind of clay. To fill this lack, an American manufacturer turned to plastics. For the cut glass which Czechoslovakia supplied for American costume jewelry before German troops overran that country, a New England manufacturer of buttons substituted jewels of dyed, crystal-clear plastics moulded in rubber forms.

By the end of 1939, scientists and industrialists alike were seeing the weaknesses of an America which each day imported 3,000 tons of vegetable oils, $400,000 worth of sugar, $100,000 worth of jute, $60,000 worth of flax and linseed oil, while millions of American acres were either producing surplus crops or being subsidized in idleness. By then, the significance of chemurgy was becoming clear.

As the German motorized military machine piled up a succession of victories, there was less and less talk among the economic and military "experts" about that machine's "inevitable collapse" due to lack of rubber, motor fuel and lubricants. As Dr. Hale had predicted after his last visit to Germany in the summer of 1939, the Germans' synthetic rubbers were *not* breaking down, and the lack of petroleum products was *not* a vital factor to a military machine deriving its motor power from coal and alcohol and its lubricants from vegetation.

America's awakening was slow. But it was an awakening.

In the du Pont laboratories along the shores of the Brandywine, chemists redoubled the efforts to fill more of the needs of American factories with materials drawn from American soil. In the South scientists turned to surplus cotton for substitutes for imported jute and burlap. In Maine, Idaho, Mississippi and Louisiana potato and sweet-potato starch plants began to replace Java's tapioca and sago starches. In Texas, the newsprint pulp mill at Herty, near Lufkin, began operations at the very moment when the need for its product became urgent. Across the nation, educators reported marked increases in enrollment for chemical engineering courses, and in dozens of schools and colleges young minds with fresh viewpoints brought their ingenuity to bear on research into new industrial uses for soy beans, peanuts, castor plants and fiber crops.

The first encouraging results were reported at the Sixth Annual Chemurgic Conference, in Chicago in March, 1940. The reports included a description of a successful chemurgic project which was providing unexpected revenue for western flax farmers, work and wages for North Carolina workers, and an end of American dependence on Europe for fine papers. From the laboratories of the A. E. Staley Manufacturing Company came a report of a non-crystallizing corn syrup to take the place of imported cane syrup. Dow Chemical Company's silviculturist, Phelps Vogelsang, reported success in the breeding of hybrid poplars which, capable of an annual growth of twelve feet in height and one and a half inches in diameter, promised to bring new economic value to Michigan's cut-over and burnt-out timberlands and a plentiful supply of cellulose for ethyl cellulose plastics.

New opportunities beckoned. Dr. Paul Kolachov, director of research for Joseph E. Seagram & Sons, Inc., described opportunities for more profitable agriculture and American independence in the production of essential oils, and offered the research facilities of his company to get American acres started in the production of vegetation capable of yielding such oils.

For imported starches, waxy corn was offered as a substitute for arrowroot, and domestic potatoes and yams moved into tasks formerly performed by imported sago and manioc. As Japanese depredations in Asia threatened to dry up entirely the flow of 100,000,000 pounds of tung oil which American industries required from China every year, we began to recognize the value of 13,000,000 young tung trees which chemurgic pioneers had planted on 2,304 farms in Mississippi, Louisiana, Florida, Alabama, Georgia, Texas, South Carolina and California. Mostly planted since 1935, our American tung trees were still too young to supply more than 6,000,000 pounds of oil in 1941 but their production was at least a partial solution for grave difficulties. Just in time, American chemists developed a dehydration process whereby other domestic fats and oils could be converted into drying oils at least partially capable of replacing tung oil for some functions, and American chemurgists discovered that Gulf Coast acres could grow castor and perilla for the oil-bearing seeds formerly imported from India and Manchuria.

One by one, the government's four regional laboratories for chemurgic research opened up and swung into action; but Dr. Horace T. Herrick, director of this program, warned that it would be ten years before the full effects of this organized research would be felt.

From Newtonville, Massachusetts, researchers brought reports of experiments which were promising to end the flagrant waste of skim milk in the United States and provide substitutes for curtailed imports. From casein they were pulling superior paints for the marking of streets and highways, tough glues for plywood, and strong, silky, wool-like fiber which shortly moved into replacements of imported fine wools from New Zealand, imported carpet wools from India, and the imported rabbit fur used for felt hats.

After that 1940 conference, the Columbus headquarters of the National Farm Chemurgic Council at 50 West Broad Tower became a buzzing hive. An augmented office staff, under Managing Director Ernest L. Little, worked twelve hours a day, shipping seeds of imported plants and cultural directions to test plots in the forty-eight states, answering requests for information, planning conferences, preparing and mailing bulletins and pamphlets, sifting ideas and ordering laboratory tests.

By the fall of 1940, a large plantation operated by a council member shipped 3,000 bales of cotton to Akron's tire cord mills. The chemurgic significance of the event lay in the fact that this cotton was grown to exact specifications laid down in 1935, when the plantation manager had learned from the tire technicians the exact length and thickness of the fiber required, and had gone home and bred the plants to produce it.

In Texas, a 30,000-acre planting of papaya trees was ready to bear when cargo space limitations began to cut down the imports of this product. In California, test plantings of pyrethrum promised to supply insecticides for which we were normally dependent on Japan. In Southern California plantings of cork oaks were expanded. In the Southwest, the guayule shrub, rich and neglected source of rubber latex, became the subject of scientific research.

And, in test plantings all over the nation, experiments began in the culture of aromatic plants and herbs which had always come from abroad: coriander, caraway, anise, fennel, angelica, licorice, sage, thyme, celery seed, marjoram, dill, rosemary, poppy seed, savory, sesame, paprika, mustard, chili and red pepper. The value of these experiments was high-lighted within a year. When German dive bombers swooped down and sank the steamer *Xenophon* in the harbor at Piraeus, Greece, just after it had taken on 6,000 tons of Balkan spices and herbs for the United States, the 200 wholesale spice dealers of the American Spice Trade Association lent their support to these strivings for American independence.

At the end of 1940, it was estimated that the farm products of 40,000,000 acres were being used by chemurgic manufacturers.

"Within ten years," said Ernest Little, "the productive capacity of 50,000,000 additional acres will be required to meet the demands of industry. This is only the beginning."

And the beginning, as the events of the 1940's proved, came none too soon.

Chapter XVII

STRAUS—FINE PAPER TO BURN

1

Hunting headlines at the annual conferences of the chemurgists, newspapermen discovered early that Dr. Harry Barnard was the man to consult. At the first conference in Dearborn he had singled out his good friend Dr. Herty as the man whose project was most likely to become news. His advice proved sound. At the 1936 conference, Dr. Barnard inaugurated his "Symposium of New Things" as an annual feature of the sessions.

Presiding over the second symposium on Tuesday evening of May 25, 1937, Dr. Barnard introduced another man whose project he said was worth watching.

"Tonight," he said, "we bring you several examples of chemurgic developments which are wholly new in their application although many of the facts out of which research has secured them have long been known.

"The first report discusses a subject as old as the wrappings and parchments in the mummy cases which have rested for thousands of years in Egyptian tombs—the making of paper from flax and hemp. But you will hear now of a chemurgic discovery which is less than a year old and which promises to revive the growing of flax and hemp, not for use in making linen and cordage of pioneer days but for a new product for a new market. May I present to you Mr. Harry H. Straus, president of Champagne Paper Corporation."

Up rose a big, balding, soft-voiced man whose accented speech and courtly manner marked him as European. He was, he said, seriously concerned about America's dependence on Europe's ragpickers. His subject was "Paper from Flax and Hemp."

"Flax," he said, "is grown in this country principally for seed which, converted into linseed oil, plays an important part in the manufacture of paints, varnishes and other products. Flax grown for production of fibers such as are used for textiles has practically disappeared from American agriculture. . . . Hemp is being cultivated for twine, thread for sewing leather, marine ropes and oakum for packing, but not much progress or increase in production is noticeable. There is a substantial importation of both flax and hemp, running into many millions of dollars, but the volume of imports, or of articles manufactured from them, has not increased of late.

"Most of these crops now utilized in this country are manipulated by old-fashioned methods, such as nature retting, hand scutching, hand pulling, etc. Little progress has been made in the development of mechanical and automatic processes of preparing flax and hemp stalks for industrial or commercial use. To this, in my opinion, can largely be attributed the slow progress of the production of these fibers and their uses in American industry. Fibers which are treated by the slow nature process of retting or hand manipulation, or even half-automatic handling, are expensive and, therefore, cannot be produced here in competition with imported fibers."

At the conclusion of the symposium a newspaperman approached Straus for his story.

"There is no story," he said politely.

Revealing that he had come to the United States from Germany in 1902 as a boy seeking to learn the English language and American customs, he said, "I fell in love with the country and remained." Now, he added, he was trying to help his adopted country achieve independence in a field which was his specialty—the production of fine papers.

"But," he warned, "there will be no story unless the plan is successful."

And, pointing out how premature publicity might upset his plan, he pleaded, "No story, please!"

So there were no headlines about Straus—until that September day in 1939, when the German motorized columns roared into Poland. In the larger headlines of that historic day, the story of Straus was lost. Yet, of all events of that moment, this one held the most significance in terms of American independence.

2

The story of Harry Hans Straus rightfully begins in that tense moment in August, 1914, when World War I began. Until then, Austria had held a virtual monopoly in the production of the lightweight papers which the world needed for cigarettes, Bibles, carbon paper, condenser tissue and paper currency. Source of this paper was flax and hemp fiber. But, before the paper could be produced at prices which consumers could afford to pay, the hand-worked fibers had to be spun into textiles, the expensive textiles had to be used until they had cheapened into rags, and the worn-out rags had to be gathered by trash collectors in the byways of Central Europe, the Balkans and Russia. Thus, despite the high cost of the resultant paper, virtually all of the labor that went into the long and circuitous processing of the stuff was the effort of humans existing on the fringes of human society under almost sub-human standards of life.

Harry Straus knew every step of that devious route by which flax became fine paper. At eighteen, shortly after his arrival in the United States, he got a job in a company that sold cork tips to cigarette manufacturers. A little later he joined the staff of a cigarette-paper importer.

When Austria plunged into war in 1914 and the upheaval shut off the world supply of fine paper, Straus went to Europe and protected his company's American customers by establishing a new paper industry in France.

By 1937 some twenty-six French factories were furnishing seventy-five per cent of the $10,000,000 worth of cigarette paper used in the United States annually. For his part in that achievement, Straus was made Chevalier of the Legion of Honor. But the red ribbon in his lapel was, in his opinion, less a symbol of accomplishment than a warning signal of danger ahead.

Off the record, after he spoke to the assembled chemurgists on that May evening in 1937, he said he was convinced of the imminence of another world war—and a desperate shortage of the linen rags upon which Americans were dependent.

As early as 1933, when Adolf Hitler came into power, Straus had seen the handwriting on the wall. In that year he began his uphill struggle to manufacture his papers in America from American materials. The obstacles were many. France had the craftsmen with the skill required to make these papers which, though thinner than human hair, must be strong enough to withstand the eight-pound pulls of cigarette-making machines, must burn at the same rate as tobacco, and must be tasteless and not stick to the lips.

Frenchmen had the skill; Poland, Russia and the Balkans had the rags; America had the need. What Straus proposed was the question: "Why not make these papers direct from flax fiber?"

The answer was not easy. Thousands upon thousands of dollars had been spent on attempts to combine chemical and mechanical means for removal of the woody core of the flax plant without injuring the fiber. In Europe the use of cheap labor made such separation an inexpensive process. In America it would have to be done mechanically.

Straus appealed to the United States Bureau of Standards, to various government agencies, to the research departments of universities, and to the Forest Products Laboratory in Madison, Wisconsin. Everywhere he met that progress-freezing phrase, "It can't be done," which he came to consider the ugliest alien transplant in this brave New World.

Surrounding himself with research workers with sufficient contempt for the "impossible" to make them dare to try and try again in the face of repeated failure, he supported their investigations financially and morally through seven long years marked with many bitter disappointments.

He faced two problems: the engineering problem of decortication (separation of wood from fiber), and the agronomical problem of producing the required fibrous plants on American acres. Just after his engineers reported success in the development of a secret decortication process, his agronomists reported failure at their end of the experiment. The only flax grown in the United States had been the short-stemmed variety, for linseed oil. For the long-stemmed varieties used for linen, the Straus researchers had combed Europe for seeds of promising varieties. Hundreds of acres were planted in Florida, Alabama, Maryland, the Carolinas, Virginia, the Dakotas, Minnesota, Oregon and California. Some 500 combinations of fertilizers were tried out in one test planting alone. But, no matter where they planted or how they coddled their imported plants, the agricultural experimenters could not get enough straw per acre to compete with Europe's worn-out rags.

They turned to hemp and were making headway with 2,000 acres in Minnesota when a federal law directed at the suppression of marijuana put an end to that experiment.

In desperation Straus ordered his agronomists to try to increase the fiber-yield of short-stemmed linseed straw, hitherto deemed useless.

It worked.

That night in 1937, Straus reported that 20,000 acres of flax planted in California promised the first encouraging answer to his second problem.

"The future," he said, "depends on the result of this year's operation. . . . Next year I hope to be able to submit facts and figures based on this year's experience."

If the promises were fulfilled, he added, an estimated 100,000 acres annually would be required within a period of three to five years. "An American lightweight paper industry," he said, "should be able to absorb from 15,000 to 20,000 tons of fiber per year—unless factors now unknown should develop."

3

Shortly afterward the unknown factors developed. Within six months, the nine-power treaty conference, called in Brussels in an attempt to keep the peace in Europe, adjourned indefinitely. A fortnight later Italy gave the tottering peace a parting kick by giving formal notice of withdrawal from the League of Nations. The Japanese bombed the United States gunboat *Panay,* hissed apologies, and bombed and raped Chinese without apologies. Spaniards slaughtered Spaniards with the active help of Germans and Italians.

As 1937 ended, the furtive gnawings and scurryings of social unrest in the walls of the world were becoming louder, bolder.

Violence is the over-all headline for Eastern Hemisphere events in 1938. Hitler seized control of the German Army and cooing a lullaby, grabbed Austria; and Russians fought Japanese in Siberia.

The Old World, as Straus had accurately foreseen in 1933, was hell-bent once again in pursuit of that business which its leaders have always performed best—mass destruction. And in America, there was a "recession" in the business which Americans like best—mass production. On March 23, 1938, President Roosevelt, speaking at Gainesville, Georgia, said:

"The South may just as well face facts. . . . The purchasing power of millions of Americans in this whole area is far too low. . . . On the present scale of wages, and therefore on the present scale of purchasing power, the South cannot and will not succeed in establishing successful new industries."

On June 2, Frederick Laggett, chief British delegate to the Twenty-fourth International Labor Conference, which was meeting for the first time in the Assembly Hall of the new League of Nations Palace in Geneva, opened the sessions with a sentence that summarized the world unrest. Said he:

"The world's outstanding problem is poverty."

At that moment Harry Straus was beginning construction of an American paper mill, bringing a new industry into a southern state in an area where poverty was an accepted condition.

Straus was now getting help. After Hitler's seizure of Austria, the big cigarette manufacturers of the United States began to realize that Straus was no wild-eyed alarmist. He had taken some American-grown flax to France and had demonstrated that it could be made into fine paper. He had also looked around in Europe for signs and portents. On his return, the cigarette manufacturers, convinced, lent him $2,000,000.

Since most American cigarettes are made in North Carolina, a site was sought there. Samples of water, vital to paper manufacture, were collected and sent for tests to the mills of Straus's French companies, the Société Nouvelle des Papeteries de Champagne and Papeteries R. Bolloré.

One sample was found free of minerals which would give cigarette paper a taste. It came from the Davidson River at a point where that stream rushes out onto the dark Carolina bottomlands from the mile-high, tree-covered Pisgah National Forest. Straus and his associates named the site "Ecusta," the Cherokee word for "rippling water."

Seventeen buildings were constructed, and the training of personnel began. The natives around the new town of Ecusta had never previously worked in any industrial factories. French workers were brought over in May, 1939, to erect the machinery and teach Americans the papermaking arts which had been handed down in French families from father to son for generations. Two French-Canadians and two French-speaking Americans were hired to interpret.

There was no time to lose now. The rumble of revolt was growing louder in Europe. After Czechoslovakia was dismembered some of the Frenchmen in Ecusta were called home for military service. August came, bringing the world-shock of the Communazi Pact, and more French workmen went home. As they left, Carolina mountaineers stepped into their places at the controls of the machines. The test batches of paper were improving daily.

Then, on September 1, 1939, it happened.

As a pseudo-German ex-corporal gave the signal that sent poised ironshod heels thundering into Poland, a German-born American gave the signal that started papermaking machines rumbling in a Carolina mill.

Out of the machinery in Ecusta rolled the first bobbin of perfect paper confected entirely of American materials and American labor. It added something to American independence. To Americans it was unholy that the best use Europe's leaders could make of ragpickers was to fling them recklessly on trash heaps. And it was horrible that the lives of underpaid peasants should be held cheaply, as fertilizer for flax fields. But, though unholy and horrible, these facts no longer constituted an immediate threat to our welfare—thanks to that bobbin of paper.

Hours later, when Great Britain and France declared war, the sea lanes radiating out of American ports began to shrivel.

In terms of fine paper, the shriveling of sea lanes became less important as it progressed. By the middle of 1940, when Denmark, Norway, the Netherlands, Belgium and France had fallen and the Straus mills in Western Europe had been over-run by plunderers, the 900 workmen in Ecusta, having learned in two years the arts which traditionally took ten years to master, were working twenty-four hours a day, manufacturing half of the cigarette paper made in the United States.

These mountaineers were earning wages which were rapidly lifting living standards in the region. Sleepy Brevard, the nearest town, was enjoying a boom. The county's bonds had doubled in value. And the effects rippled across the country, washing up new sources of human well-being in far places.

Every twenty-four hours four railroad cars rolled onto the Davidson plain. Laden with flax fiber, they came from Minnesota and California where men worked gainfully in new decortication plants. For the 147,000 tons of straw required for the first year's operations, flax farmers were enriched two dollars and a half an acre, for they were now getting a dollar for straw which formerly cost them a dollar and a half to remove from an acre.

The openings for productive labor created by this industry extended into laboratories. Research workers in the Universities of Minnesota and California set about the development of new flax strains, new methods of planting, cultivating and harvesting. Federal and state agricultural research workers tackled problems of converting flax into textiles. Engineers at Georgia School of Technology developed a new method of processing flax for spinning.

For, throughout the world, flax for textile fiber had declined steadily after Eli Whitney's gin made cottonseed separation easier than flax decortication. Because cotton is hand-picked and flax is machine-harvested, the explorers of this new frontier were lured by the thought of accomplishments which might again make flax, with its superior durability, the foremost fiber crop.

In flax grown for fiber, the average yield is 300 pounds of linen fiber per acre. The cotton average is under 200 pounds.

The current research is aimed at improving quality and reducing collection costs of flax.

Meantime, the Straus mills expanded and 500 additional workers were employed. Other tissue manufacturers, such as Peter J. Schweitzer, Inc., and Smith Paper, Inc., turned to the use of American flax as European supplies dried up, and domestic production steadily rose to forty per cent of the American cigarette demand. By the end of 1940 Ecusta was supplying a third of the domestic demand, Straus was expanding facilities to turn out enough to fill the full demand upon exhaustion of the imported reserve stocks, and the straw requirements rose to 250,000 tons.

Thus Europe's folly brought a complete new industry to America. Reaching from farm to factory, adding an estimated $10,000,000 of manufacturers' gross annually to the American economy, and contributing no small item to American independence, the achievement of Harry Hans Straus constitutes a perfect example of chemurgy at work.

5

Yet the end is far beyond the horizon.

Beyond cigarette paper there is carbon paper, condenser tissue, Bible paper, and the fine paper used for currency, all derived from flax via the circuitous route through the linen mill and the rag bin.

The flax fields expanded into the Dakotas, Kansas, North Carolina, Texas and other states. Salem, Oregon, became the nation's flax-for-linen center, with four mills working and two a-building. Flax acres around Salem were 7,000 in 1940, rose to 12,000 in 1941, and seemed destined to expand still more when Russia's farmers, once the major factor in production, had to beat plowshares into swords.

For the hand-harvesting of Europe, American farmers substituted combines, aided by a new type of pick-up bailer which, half as heavy as standard types, moves twice as fast and supplies bales "ready-sliced" like bread. For the best pulled straw farmers were paid thirty-five dollars to fifty-five dollars a ton.

The Straus researchers were far from satisfied with their successes. They set out to find industrial uses for the woody "shives" which constitute four-fifths of flax straw. In the laboratory they processed this waste into plastics, wallboard, linoleum, fertilizer and explosives. If the laboratory legerdemain can be moved over into commercial practice, American farmers will have markets for *all* of the flax plant which they once raised for seed only. The mechanization of the processes was advanced by the development of new and improved de-seeders and tow-shakers.

Although Straus was thinking primarily of paper when he launched this project, it soon revealed its bearing on the American defense program. Paul H. Appleby, Undersecretary of Agriculture, estimated that some 18,000 acres of flax would be needed in 1942 to supply such essential defense needs as rope, twine, shoe thread and parachute harness.

Before the war the world's demands for flax required 5,000,000 acres. The acute shortage caused by the war forced even India to adopt cotton substitutes for the jute required by the United Kingdom.

Though America's supply of fiber is still far from adequate, there has already been developed a substitute for jute in osnaburg, a rough cotton fabric which should help diminish the enormous cotton surpluses in government warehouses.

Other substitutes for imported fibers were developed by the chemical industry. Nylon expanded rapidly into fields formerly occupied exclusively by Japanese silk and Japanese-controlled animal hair and bristles. For imported rattan and similar caning fibers, chemists offered substitutes made of extruded vinylidine chloride, a plastic material which soon revealed its ability to serve in hawsers and cables and as a partial replacement of scarce copper tubing.

But these were derivatives of coal, limestone, petroleum and brine—chemicals drawn from the nation's *fixed* resources. And, as rapidly expanding requirements of defense manufacture in 1941 brought increasing threats of shortages of such chemicals, it became more and more apparent to the chemurgists that the nation was moving rapidly toward greater dependence upon the *flow* resources—the wealth of chemicals to be found in the products of forests and field.

Almost daily the defense effort dumped new demands on vegetation. For cordage and textiles, for papers and fiberboards, for plywoods and plastics, for numberless substitutes for metals and minerals, the call went out for more and ever more of the end products of plant growth—cellulose, starches, sugars, gums and formaldehyde; glycerine, oils, fats and waxes; the essential oils, including terpenes and camphors and the chain-polymer caoutchouc known as India rubber; proteins, alkaloids and lignin; and the decomposition products of carbohydrates, ethyl alcohol, methane, and the many products derived therefrom.

Toward the end of 1941, the acceleration of these trends was becoming so pronounced that they were giving point once more to the amazing accuracy of Dr. William J. Hale's predictions. For, in his *Chemistry Triumphant,* written in 1932, Hale predicted that, as the chemical age advanced and machine-age economics gave way to what he called "chemeconomics," the value of sunlit land and water would be enhanced.

"Chemically and physically," he said, "one of the greatest sources of power is sunlight."

And, from his recognition of that basic fact, he foresaw what is now taking place, a growing awareness in the United States of the importance of the sunlit lands surrounded by or touching upon the waters of the Gulf of Mexico and the Caribbean Sea.

Ten years after Dr. Hale predicted it, the Americans of the United States, facing south, were discovering vast but neglected wealth below the Mason and Dixon Line, new frontiers in the Gulf Coast states, and, beyond these, more Americans in more Americas.

Chapter XVIII

TEXAS AND THE SOUTHERN RENAISSANCE

1

One night in 1930 Dr. Herty unfolded his great dream of a Southern renaissance before a little group of men assembled in a small basement room in a Georgia hotel. At the conclusion of the discussion, a short, bald-headed man introduced himself to Dr. Herty as Victor Schoffelmayer, agricultural editor of the Dallas *Morning News,* and observed that eastern Texas contained vast tracts of the pine forests which Herty proposed to convert into new sources of national wealth.

"Yes," said the little Georgian, "you Texans could easily lead the way to a Southern renaissance. You haven't scratched the surface of your potential power. Why don't you get busy?"

From that meeting to which his editors had assigned him, Reporter Schoffelmayer returned to Dallas and got busy. In his paper's columns there appeared regularly detailed reports of the progress being made in the Herty laboratory in Savannah. Among the first Texans to glimpse the significance of these Herty explorations into the newsprint possibilities of the southern pines were Victor's employers, President George Bannerman Dealey and Treasurer Meyer M. Donosky.

As a result of the interest aroused by Schoffelmayer, Dr. Herty was invited to come to Dallas early in 1935 to speak to about 600 men at a luncheon meeting. After addressing these men for the scheduled thirty minutes, the Pioneer of the Pines was subjected to a barrage of questions for three additional hours.

Thereafter, Victor Schoffelmayer was Herty's chief apostle in Texas. It was not exactly a new role for him. As early as 1913, long before Dr. Hale coined the word "chemurgy," Victor had been championing new uses for farm crops in the pages of the *Southwest Trail,* an industrial and agricultural magazine published by the Rock Island Railroad System in Chicago.

Victor's interest in farm problems stemmed from an extraordinary experience in his reportorial career. As a working reporter on newspapers in several midwestern cities he had earned considerable money as a part-time correspondent for eastern newspapers, and, having saved these earnings, had "retired" in his twenties to a farm in Arkansas. On this farm he promptly lost his savings. After a year of farming he returned to journalism and he was the dramatic, music and art editor of a Minneapolis paper when the tale of his fantastic year of agricultural experimentation reached the ears of the late Dr. Henry M. Cottrell.

Dr. Cottrell, who had been director of the agricultural experiment station at Colorado College of Agriculture, had just been made agricultural commissioner for the Rock Island Railroad and was searching for a writer who could supply rural newspapers with reports of agricultural research. He was directed to Schoffelmayer by Alvin T. Steinel, the railroad's industrial commissioner, who had heard of Victor's attempt to become a farmer.

Hired by Cottrell, Victor wrote virtually all the copy and supplied all the photographic illustrations in the railroad's monthly journal which served as a sort of county agricultural agent in almost a score of states. The files of that journal reveal that in 1913, Victor concentrated his attention on one problem each month, writing exhaustively and successively about potatoes, apples, peanuts, Kaffir corn and pit silos (including a page of humorous treatment of the subject over the signature of "Hans Yodler"). And, while investigating causes of conditions responsible for a fall of corn prices to ten cents a bushel in Kansas, he met O. R. Sweeney of Ames, Iowa, who was then striving to convert straw and corn stalks into paper and fiberboard. Sweeney, says Victor, excited him about the possibilities of turning farm wastes into wealth and slanted his agricultural viewpoint into the direction which was later called chemurgic.

"From then on," says Victor, "I saw clearly that no farmer needs to be shown how to get a living out of a farm, but that all farmers must have the help of the industrial kind of research to enable them to get a supplemental income out of the surplus produce of their acres."

The breadth of this former art editor's understanding of farm problems resulted in his hiring by the editors of the Dallas *News* and, later, in this Missouri-born Texan's efforts to interest Texans in the dreams of Dr. Herty.

2

Schoffelmayer's first attempt to infect Texans with his excitement over the Herty ideas was not, however, immediately successful. Indeed, the first promises of success did not appear until several months later, when Victor's friend, Peter F. Lawson, joined the crusade. Like Victor, Pete Lawson was one of those most Texan of Texans, a transplanted "outlander." A native of New Jersey, he had been a salt-water sailor before he became a newspaper reporter in Galesburg and Chicago and in several Canadian cities. He settled in Beaumont as an editor in the early 1920's and was later appointed secretary of the Beaumont Chamber of Commerce. In that post he succeeded in organizing a Tung Oil Conference in Beaumont on October 21, 1935. This conference, co-sponsored by the Beaumont Chamber, the Gulf Coast Council of Agriculture, the Houston Chamber of Commerce and Texas A. & M. College Extension

Service, brought together for the first time the nucleus of those "Men of Texas" whom Garvan lauded at the third National Chemurgic Conference as "American Pioneers of the Twentieth Century."

The direct outgrowth of this conference, fostered by P. B. Doty, Beaumont banker, H. H. Williamson, director of Texas A. & M. College Extension Service, and J. E. McDonald, Texas Commissioner of Agriculture, was the subsequently rapid expansion of tung tree plantings throughout the Gulf States. It brought together for an exchange of ideas such tung pioneers as C. C. Concannon, chief of the Chemical Division, United States Department of Commerce, B. F. Williamson of Gainesville, Florida, J. C. Holton, Mississippi's Commissioner of Agriculture, J. C. Adderley, president of the American Tung Oil Association, Pensacola, Florida, and others, who then organized a tung-oil committee of the National Farm Chemurgic Council. Largely because of interest aroused by this meeting in the Hotel Beaumont, the Gulf States' tung orchards expanded phenomenally from 350,793 trees on 144 farms to 13,000,000 trees on 2,304 farms as Japanese depredations in East Asia increasingly imperiled the Chinese source of this vitally essential industrial oil.

The indirect outgrowth of this Beaumont meeting was a Wood Uses Conference, called by the late Ray Gill, manager of the Beaumont Chamber of Commerce, who worked with the Texas Forest Service in assembling complete factual, statistical and pictorial presentations of potentialities of East Texas forests in a program of growing trees as farm crops. With Banker Doty as chairman, this conference opened on March 6, 1936, in Hotel Beaumont's Sky Room and brought together for the first time Dr. Herty and Ernest L. Kurth, Lufkin lumberman.

This meeting of Herty and Kurth proved to be historic. Kurth had long sought means to make pine trees a farm crop.

The meeting with Herty showed him what he needed. After their introduction on the first day, they spent much time in conversation during the second day, when the delegates inspected the work of the Texas State Forest Service near Kirbyville. Out of these conversations came the first American newsprint mill employing Herty technics and southern pine.

This mill, near Lufkin, began operations shortly after World War II got under way. Texas newspaper publishers insist that it got going solely because foreign suppliers of newsprint pulp raised their prices nine dollars a ton; and these same Texans are convinced that the existence of the mill is the only factor preventing a repetition of the rocketing newsprint pulp prices which World War I produced.

In the first year of operations the Texas newsprint mill shipped more than 31,000 tons, mostly to southern publishers, but some to Puerto Rico and Mexico as well. Faced with a demand for 100,000 tons in 1940, it launched an expansion program, and had to draw twenty per cent of its sulfate pulp from another new mill, built by Champion Paper and Fiber Company near Houston. As director of research, the Lufkin mill employed young Dr. Charles H. Carpenter, who had been Dr. Herty's chief assistant for three years in the Savannah laboratory.

As the spread of Old World conflict into the New World brought increasing danger of paper-dearth to paper-hungry America, more and more mills were built to use the abundant cellulose of the South's quick-growing vegetation. By 1941, when a new Champion mill was manufacturing fine white magazine paper from oak and pine, the total investment in Texas paper mills alone exceeded $17,000,000. And, by the end of 1941, when the bandit nations of the world trained their guns on the United States, the chemurgic pioneerings in the South's pinewoods took on new and greater significance. For, in Fernandina, Florida, one of the South's first sulphite mills had evolved processes for the manufacture of pulp for rayon, and the lessons learned in the development of these and similar processes were now proving their value as contributions to the new and desperate need to convert cellulose into explosives for the defense of the Americas.

Thus, within a few brief months after dreams had become realities, paper from pine proved to be but one small phase of the rapidly unfolding southern renaissance. A complete appraisal would have to embrace a host of chemurgic accomplishments throughout the length and breadth of the South and Southwest. Until World War II has become history any attempt to make such an appraisal is predestined to failure.

One fact, however, which emerges with crystal clarity in any consideration of this southern renaissance is that the Gulf South's discovery of potential economic independence through the adoption of chemurgic practices stems largely from the evangelistic zeal of Schoffelmayer and Lawson. Though they tried to remain in the background, where publicists customarily shun the spotlights, "Vic" and "Pete," as most Texans call them, became willy-nilly the Gulf South's symbols of chemurgic pioneering.

Both men point to the fact that Texan interest in chemurgy was shared at the start by active groups in a number of other southern states—notably Louisiana, Mississippi, Alabama, Florida, Arkansas and Oklahoma, and that regional chemurgic conferences were held in some of these states before Texan interest was aroused. But a consultation of the records of these early southern conferences turns up a wealth of evidence that the rapid spread of this interest was largely due to these two men's deep understanding of the South's peculiar problems. It is fairly easy to determine the weight of their influence by following, in yellowing newspaper files, the widespread rovings of these two journalistic gadabouts. Almost invariably their names appear in the lists of those attending the early regional conferences. Often they showed up as speakers. Almost always they were on hand as reporters. It is said that they played important backstage roles in bringing together at the Southern Chemurgic Conference at Lafayette, Louisiana, in October, 1936, Dr. Henry G. Knight, chief of the Bureau of Chemistry and Soils, United States Department of Agriculture, and Dr. A. B. Conner, director of the Texas Agricultural Experiment Station, whose resultant conversations led to the establishment of the Southern Regional Research Laboratory near New Orleans.

There is no doubt that Vic and Pete were the leavening forces in preparations for the All-East Texas Chemurgic Conference which, scheduled for a hotel dining room in Gladewater in January, 1939, drew such an unexpectedly large attendance that its sessions had to be moved to a school auditorium. So great was the interest that a second conference was necessary in Beaumont a month later.

Though the main topics of discussion at both meetings were cellulose products and vegetable oils, subsequent events showed that these sessions, like the earlier Herty appearances in Dallas and Beaumont, were to have broader effects on history than the planners realized.

As we observed on page 174, it was at this Gulf Coast Conference in Beaumont in February, 1939, that Dr. Leo M. Christensen astonished the conferees by talking about his experiences with castor plants and grasshoppers when he was expected to talk about power alcohol.

This was the first of four events at that meeting which were to have curious relations to one another in the shaping of things to come. The other three: Schoffelmayer's glowing description of "Chemurgic Possibilities of the Trinity River Basin"; the announcement by W. J. McConnel, president of North Texas State Teachers College, that his school at Denton would offer special courses in chemurgy in the summer of 1939; and a report by Dr. H. S. Paine, of the United States Department of Agriculture, on the manufacture of starch from sweet potatoes.

3

By June, 1939, when summer-school classes in chemurgy at Denton were scheduled to start, President McConnel's plan had aroused so much interest in the youth of Texas that similar courses were started at Sam Houston State Teachers College at Huntsville, Stephen F. Austin College at Nacogdoches, East Texas State Teachers College at Commerce, and John Tarleton Agricultural College at Stephenville.

All that summer Schoffelmayer and Lawson were on the move, delivering lectures at the colleges and before members of civic associations, industrial and agricultural organizations, and luncheon and dinner clubs.

Lawson, keeping himself informed about the latest developments in the experiments of Harry Straus, was preaching the virtues of fiber-and-oil-crop agriculture in the Gulf South. "Texas flax acreage," he said, "should be increased from the 25,000 acres planted last November to not less than 200,000 acres this year. The crop which we've been raising for seed and the accompanying product of oil and meal should be looked upon as a fiber crop as well."

Schoffelmayer, for his part, was sandwiching lectures between his attempts to satisfy his readers' increasing interest in chemurgy. By midsummer, the editors of the *News* decided to devote one full page to the subject twice a week, beginning September 1, and kinetic little Victor beamed happily.

Victor's grin was the outward sign that there was a good story coming up. On September 3, the day World War II began, the story came out. Date-lined from Huntsville, it reported the amazing results of chemurgic research undertaken by students at Sam Houston College under the direction of Professor Willis W. Floyd during the summer.

At the school, young Melvin F. Handley, a senior from Livingston, developed a process for separating the fibers from the castor plant and found that these fibers, some of them fifteen feet long and all of them possessing high tensile strength with no weak points at the nodes, could be used as substitutes for imported manila and hemp.

Once more, as unexpectedly as on Dr. Christensen's ridiculous little "farm" up at Atchison, the castor plant had revealed hidden value. Out of a ton of stalks, Handley and his youthful associates recovered twenty pounds of bleached bast fiber.

Then, from the residual 1,980 pounds of vegetable matter, they pulled out more than 700 pounds of pure alpha cellulose which they converted into rayon. Not satisfied, these boys probed the plant for more hidden values. Bob Bratz produced a bleached paper pulp from stalk residue; Handley and Horace Carroll converted castor-oil base into new kinds of soap; Handley and Ruel Donaho isolated some hitherto unrecognized toxic crystals in the leaves; Dayton Drachenberg and Raymond Walley worked out a new process for extracting the oil from the seed; and Harold Odom and Clayton Willis made plastics from the stalks.

In that exciting summer at Huntsville the boys, picking their own projects, probed for chemurgic values in outlandish places. Donaho dug into the south Texas coral bean; Drachenberg made peach seeds yield fine charcoal and cyanide; Wilton Mize plasticized peanut hulls; John Love took sunflowers apart and got fiber, pulp and oil; James Walter Phillips made a palatable flour out of cottonseed cake; Lawrence Cowart and Gus Long succeeded in fireproofing lint cotton for use as insulating material; I. W. Eaves hunted chemurgic values in post oaks and mustang grapes; and Bryan Mayes devised chemical solutions for the preservation of cut flowers.

The Texas educational experiment was bearing fruit. Up at Kansas State College, Dean L. E. Call of the School of Agriculture announced the establishment of an industrial fellowship in chemurgy for the purpose of investigating the economic advantages of manufacturing starch from potatoes.

That investigation was already under way down at Denton, Texas. As his part of the summer courses in chemurgy at North Texas College, young Gilbert C. Wilson studied sweet-potato starch production at Laurel, Mississippi, and St. Francisville, Louisiana, and wrote a report which was published as his school's first of a series of chemurgic bulletins.

Wilson and his youthful classmates at Denton also probed pumpkins for industrial values, and made face powder from bull nettles and long and strong rope fiber from yucca, both common plants in the Southwest. By summer's end, the enthusiastic youngsters from the four schools were able to assemble, for display at the State Fair at Dallas, and the South Texas Fair at Beaumont, a bewildering array of industrial products made from Texas vegetation.

When the regular school year began, Wilson was retained as instructor at Denton and organized the first full course in chemurgy, a nine months' course offering six hours credit for both graduates and undergraduates.

"One of the first projects to be undertaken," he said, "will be further study of castor plants."

"Castor research?" said the boys at Huntsville. "That's our baby! Let Wilson stick to his sweet potatoes!"

And, to show the Denton crowd that their efforts of the summer had not been a mere flash, Professor Floyd's young investigators converted castor plant pulp into paper for use in printing the September thirtieth issue of the *Houstonian,* the student newspaper. Assisted by the Herty Foundation, the Sam Houston researchers developed processes which kept production costs low enough to interest industrialists who found their product to be ideal as filler for book paper.

Since the castor plants used in these experiments had been grown in the lower Trinity Valley watershed, the time had come for Vic Schoffelmayer and Pete Lawson to crow, "We told you so!" For, down through the years, these two had talked endlessly about the "shamefully neglected wealth in the Nile-like watershed populated by some of the most poverty-stricken humans in the fair state of Texas."

Now Vic and Pete had proof that they were right all along about the Trinity Valley. Just beyond the horizon they saw an oil boom, odd for Texas because the oil was not in the earth but some forty feet above ground, in the beetle-like seeds of castor plants. In addition to this oil which the United States normally imports in enormous quantities, they saw plentiful supplies of fiber and pulp which, like this special oil, are normally imported also.

It was September, 1939, now, and things were happening in Europe which threatened curtailment of the normal foreign supplies of these products which, just in time, a group of boys in Huntsville had proved that the Trinity Valley could provide.

Small wonder that Vic and Pete were happy! But, much as it meant to them, theirs was but a faint reflection of the happiness that the proof brought to a Moses-bearded, seventy-year-old giant of a man living deep in the damp heart of that semi-tropical jungle. For that old man, success in the chemurgic exploitation of the castor plant meant one more little triumph in his long, hard, single-handed struggle to "help the poor folks of the valley help themselves toward a higher standard of living."

4

Of fabulous men, the output of Texas seems inexhaustible. But of all the colorful characters the state has produced, there is perhaps none to match Bazil Muse Hatfield. Called "the Commodore" by most Texans, and "the beatinest man in Texas" by the Trinity River folk to whom he is friend and father-confessor, he is the spirit of independence personified.

He was born on Independence Day—July 4, 1870—in the only brick house in Washington, the hamlet in which Texans declared their independence on the banks of the stream that the poetic Spaniards called "River of the Arms of God." His grandfather's name is listed among the heroic dead on the base of the shaft marking the battle of San Jacinto.

In keeping with the Texan tradition of fighting for independence no matter whose the fight, he spent his youth "fighting for his rights" on battlefields in South Africa, Cuba and in a number of revolutions south of the border.

In 1913 he came home to Texas, a bronzed giant of a man with a pocketful of medals from half a dozen governments, a Mexican commission as colonel, and a fine disdain for convention which, he said, "got me into a few very nice jails, including Sir Walter Raleigh's cell in the Tower of London, where I was Queen Vic's guest until I became an international incident."

As Colonel Hatfield, prospector and promoter, the big man with the booming, belly-bouncing laugh acquired additional color and a fat bankroll in Texas oil fields and western mining. When blockade and counter-blockade cut American acres off from their essential supplies of Germany's potash, he played a leading role in finding and exploiting domestic deposits of the valuable material.

But, when the late Dr. Frederick A. Cook, the polar explorer, launched an oil promotion scheme in 1921 which took some $4,000,000 from "investors," the Colonel, though one of the dupes in the swindle, paid for his mistake with the loss of his fortune and a prison sentence.

In the federal jail at Atlanta, he became so deeply engrossed in his job as prison gardener that, when offered liberty at the end of nine months, he insisted that the government stick to its contract and leave him with his roses for the full year and a day.

He was a changed man after that. From his many friends in Texas he was offered scores of opportunities to recoup his lost fortune. "I'm no longer interested in making money," he said. And in the lush 1920's when fortunes were being made overnight, he deliberately remained penniless—a man of mystery. A familiar sight on Fort Worth's streets was his ensemble of white shirt, open at the collar, faded blue cotton trousers and battered hat braided with bear grass, an outfit which he wore summer and winter, in sun and rain or in the icy breath of a howling Texas "norther."

Then, in 1933, he took a new interest in life. In that year, around Fort Worth and Dallas, talk began about a plan to get the Trinity canalized into a navigable waterway to the Gulf. Colonel Hatfield, whose grandfather had operated steamboats on both the Brazos and the Trinity, decided that the proposal to open up the choked waterway was worth working for. When he offered to publicize the idea, the Canal Association officials registered polite but pained disinterest. So, on his own initiative, he scurried around and assembled the materials with which he built a boat to navigate the stream.

The craft, which he and his valley friends built, was a flat-bottomed scow, five feet wide and twenty-four feet long. Christening it *Texas Steer,* he shoved off, with a second-hand outboard motor and a push pole for power, from Fort Worth in August, 1933. His destination, he announced, was Chicago. As an afterthought he added that he would not touch blade to his hair or beard until the Trinity was canalized.

Weeks later the *Texas Steer* nosed into Galveston Bay. The Trinity had been navigated from headwaters to Gulf. On the way down, the skipper's enthusiastic supporters among the valley's poor folk had dubbed him "Commodore" Hatfield.

Pushing on along the Gulf Coast through the Intracoastal Canal toward New Orleans, the doughty Commodore had a few more titles fastened to him. Everywhere, great crowds turned out to see him and hear his lectures on soil erosion and conservation. By the time he was headed up the Mississippi he was "Admiral of the Trinity, Master of the Swamps and First Lord of the Marshes."

Civic authorities feted him. Schoolchildren, his favorite audiences, presented him with pennants for his scow. Skippers of Mississippi tow boats helped him with tow lines and provender. According to one legend, the cook of one of these Mississippi boats complained to his captain that the Commodore ate too much, and the captain, enjoying the company of the genial Texan, listed him as "four guests" for the rest of the trip.

Blazing with pennants, the *Texas Steer* tied up at Chicago at last. But the celebration at the Century of Progress Exposition was paled by the one staged in June, 1935, when the Commodore once more tied his scow to Belknap Street Bridge in Fort Worth. The log book recorded 12,000 miles of travel on thirty-four inland waterways, including trips up and down the Missouri, Ohio and the upper reaches of the Mississippi. The Commodore's hair covered his shoulders and a Santa Claus beard curled down toward his ample paunch.

Having accomplished what he had set out to do, he discovered that his purpose did not square with that of the original proponents of the idea. They wanted the Trinity canalized solely to get cheaper freight rates for their inland communities' commerce, while he had undertaken his stunt in the hope that canalization would bring better living standards to the people living in poverty along the lower Trinity.

"They're my kind of people," he said. "They're living wretched lives in an area of tremendous potential wealth, and I want to show them how to better their lot."

With that, he disappeared into the jungle along the stream.

5

Now, out of the valley came reports of a stout, heavily bearded old man who was going about doing good. River people and tenant farmers told of how he helped them build water filters and septic tanks. They said he helped them nurse their sick and bury their dead, advised them what and how and when to plant, showed them how to select choice seed for next year's crops, and helped them plan and build terraces where gullies were carrying their land into the river.

Deep down in the lower reaches of the valley where poverty was worst, the river people saw the happy old man planting persimmon seeds along the trails, and they decided he wasn't "teched in the haid" after all when he explained:

"If you let the trees grow, the 'possums and 'coons will come and eat the fruit and grow fat, and there'll be food for your families when the fish aren't biting."

The next report out of the forest was that he was planting sunflower seeds in the gardens of his people.

Why?

"Well," he said, "there are times when you folks haven't enough grease to fry your catfish. These seeds will change that. Wait and see!"

And he was off to the neighbor's patch to repeat the performance. Although he was very mysterious about the whole procedure, they helped him plant the seeds. For, by now, in virtually every cabin and hovel in the valley the Commodore's arrival was a home-coming.

When the sunflowers had bloomed and set their seeds, he doubled back on his trail through the bottoms and watershed towns, bringing a meat grinder. Helping his friends harvest the seeds, he ground them, squeezed the pulp between clean boards weighted with stones, and, as the oil trickled out, he exclaimed, "There's your grease—sweet and full of vitamins."

How did he live?

To a banker friend who asked him about that, he replied, "I'm the world's wealthiest man. Up and down the valley I've helped my poor friends plant and cultivate more than five hundred vegetable gardens. Wherever I go, no matter what happens, I'll eat. And I'll sleep, for I'm welcome in hundreds of homes in Texas. My wealth is friends—not engraved paper or figures in ledgers."

He showed his friends how to harvest and cure Spanish moss so that they could use it for mattresses and sell it for upholstery stuffing. He once spent his last cent for thousands of slips of Puerto Rico yams in Beaumont and hitchhiked back to the valley to plant them in his people's gardens "so the kids'll get something to eat besides catfish, corn pone and hog fat."

And, after he had won their confidence completely, he told them about a strange new thing called "chemurgy."

"I've been reading up about it for you," he said, "and I'm going to get you some castor beans to plant."

Pete Lawson and Vic Schoffelmayer were helpful at that juncture of the Commodore's campaign. Several bags of choice seeds were obtained and the Commodore helped his people plant them in spots which he selected. He had an idea that the roots would help hold the rich, black soil which was being scoured off these selected spots by erosion. But when the plants reached the amazing height of forty feet, he was so elated that he called a meeting of his people in the little village of Romayor.

That meeting broke up as the "First Liberty County Castor Plant Association," with sixty families participating in a co-operative planting, harvesting and marketing of ten acres of castor plants.

In April, 1939, the association planted. When the seeds were all in the good black earth, the planters bared and bowed their heads and the minister said, "God, it's up to you now!" And, after that simple prayer, the Commodore went to a little damp room, his Romayor headquarters, and, packing his duffel bag, headed for the lower valley to inspect those persimmon trees.

By now, the rumors of the phenomenal growth of the Trinity

Valley castors had spread far and wide. Experts had investigated and said, "Yes, the Texas Gulf Coast is the proper place to grow them."

Satisfied, the Commodore hurried away to see about the experiments which the boys in the summer classes in chemurgy had launched. For he had been largely responsible for the experiments. The youngsters conducting them were mainly the same schoolchildren whom he had entranced with his lectures on soil conservation a few years earlier when he was skipper of the *Texas Steer*.

6

At Huntsville, the Commodore found Melvin Handley.

"We have some fine castors down Romayor way," he said, "and we need a chemist to show us how to prepare them for industry. Could you come down?"

Handley came down, saw the castors growing to unbelievable heights, and listened to the old man's glowing description of the fabulous wealth lying neglected in these hundreds of square miles of teeming, sun-warmed, water-soaked vegetative fertility.

"We need you down here," said the Commodore. "We can't pay you, but we'll maintain you and build you a laboratory. I've twenty-one dollars for what we need to buy."

Handley smiled. Explaining that he had a wife and two children to provide for, he said, "I'll think it over," and returned to Huntsville.

A month later the Commodore's beaming Santa Claus face appeared at the door of Handley's classroom and said, "I've come to see if you're ready to take charge. Your laboratory's ready at Romayor."

Handley went down to investigate. He found a building, thirty by sixty by twenty-four feet, which the Commodore and his people had built on land donated by a local merchant. A donation of laboratory equipment was on the way.

Though it seemed folly at the time, Handley remained.

Shortly afterward Pete Lawson helped the Commodore's people start a monthly newspaper to publicize Liberty County's renaissance. Called the *Trinity Valley Voice,* it was edited by Lawson's friend, Dean Tevis, Beaumont newspaperman, and was date-lined from Romayor, "the Chemurgic Capital of Texas."

In an early edition Tevis editorialized:

"We are stressing chemurgy, and will continue to do so, for we feel that in this five-hundred-and-fifty-five-mile-long valley in the heart of undeveloped Texas, is the place where chemurgy can be put into practical operation. We want the entire Trinity Valley to be a great pilot plant. . . . We have more than three hundred acres of castors at Romayor, part of a total of six hundred acres in southeast Texas. We have about a hundred acres of sunflowers, the largest acreage in this part of the state. . . . Our purpose is neither personal nor territorial aggrandizement, not by a jugful, but rather the awakening of the valley and Texas to their birthrights."

On June 15, 1940, Romayor inaugurated the world's first all-chemurgic school with the opening of Trinity Valley Applied Chemurgic Institute. Established to provide students with opportunities to develop new uses for raw materials grown in the valley, its classes ran from June 15 to September 15.

To outsiders who questioned him in his damp little room in Romayor the Commodore explained that he got "nothing at all" for his part in the program. "I'm just a self-appointed busybody," he said. "Lots of people don't understand, but my friends of the lower watershed do—and that's all that counts."

After Handley took charge, the old man busied himself once more with the task of getting the Trinity dredged. He talked two Illinois dredgers into bringing their equipment to the river's mouth, started them working by passing the hat among Texas businessmen, and then wangled a federal appropriation. That got the first forty-mile stretch from Liberty to Galveston cleared with two barges using the new waterway to haul valley products out. In 1941 his people urged him to run for the office of United States senator. He campaigned on a platform of "Chemurgy, a five-ocean Navy, and all-out aid for America." A colorful campaigner, he was defeated. But, he insisted, he didn't lose.

"What have I got to lose?" he said with that twinkling smile of his which breaks into a throaty chuckle and then becomes booming laughter.

The Commodore's laughter is a disturbing thing; for he laughs at himself, and, as history has proved on several notable occasions, reformers who laugh at themselves are eminently successful in getting their revolutionary ideas into practice.

Shortly after the senatorial campaign, United States Army engineers put their stamp of approval on the proposal to canalize the Trinity, and the Commodore cut his hair and trimmed his beard.

7

As early as February, 1940, the value of the Texas experiments was becoming apparent. A drought at planting time in India, plus wartime interruptions of ocean transportation, threatened to shut off the castor beans which the United States imported at the rate of about 125,000 tons a year. In a few weeks the price of this commodity nearly doubled.

There were ample reasons for grave concern about the national lack of independence in this matter of drying oils. The young tung groves, planted only a few years earlier in the Gulf States, were now producing about 5,000,000 pounds of tung oil. But, as war in the Orient had reduced annual imports of this preferred drying oil from 200,000,000 pounds to less than 100,000,000, the national shortage was becoming desperately critical.

By the end of 1940 the grim shape of this situation was pondered by a joint committee formed by the National Farm Chemurgic Council and the National Paint, Varnish and Lacquer Association. Meeting in Washington, these men saw little relief for American industry. The only hopeful note was a report that Dr. J. C. Weaver and his research associates in the laboratories of the Sherwin-Williams Company had just perfected a process whereby castor oil could be dehydrated into a drying oil which, mixed with soy oil, could serve in some cases as a substitute for tung oil.

Of soy oil there was an abundance in the United States at last, thanks to the pioneering of the chemurgists. But castor imports from the Eastern Hemisphere were rapidly drying up. Brazil was becoming the principal source; but, with warfare wiping more and more ships off the seas, our dependence on this distant supply was increasingly perilous.

The meaning of the situation was very clear: plant more castors!

Texans jumped the gun on that command by planting 7,000 acres in 1940 and planning a concentration and shelling plant to process them at Brownsville.

True, a total of 216,171 acres would have been required to supply the 237,788,672 pounds of beans imported in 1940, but Texas had at least made a start toward independence. True too, there remained much experimentation to be done in finding and propagating the right varieties of castors for the best oil production; but, though there was considerable skeptical headshaking among Texas adults about the practicability of the ideas, the youngsters, encouraged by the Commodore, continued. At Huntsville, in the fall of 1941, the boys and girls under Professor Floyd were plugging away at castor plants, pulling rope fibers and cellulose pulp from their huge stalks and insecticides from their leaves.

And, down at Romayor, young Handley and the valley children assisting him hit upon an ingenious method of making money to continue their experiments.

They stumbled upon the idea when Mrs. Handley finished a new dress to wear at a club meeting one night and suddenly discovered she had forgotten to buy buttons for it. Her scientist husband came to her rescue with some walnuts that the boys and girls had been examining for hidden values. Sawing the nuts into cross sections a quarter-inch thick, he dipped them in shellac which brought out the soft browns and tans of their delicate veinings, and sewed them on his wife's new frock. They stole the show, launched a fad which spread across the country, and brought increasing batches of orders into the Romayor laboratory. The youngsters made buttons, buckles and costume jewelry from hickory nuts, acorns, pecans, pine cones, chinquapin and cockle burrs. Marketing them, they added the profits to a fund to build a brick laboratory for their Trinity Valley Chemurgic Institute, the school in which more than a hundred potential industrial products were wrested in the first year from such local vegetation as castors, sunflowers, bear grass and wild perilla.

"The best way to get action on a new idea," says the Commodore, "is to get boys and girls excited about it. Youngsters succeed where grownups fail because grownups usually know too many wrong answers to the questions that children ask."

That high evaluation of the native curiosity of children, shared by no less a genius than the great Michael Faraday, is to be tested at Beaumont's Lamar College, where President J. M. Combs and Director John Gray are at this writing preparing to introduce high school and junior college students to chemurgic problems to sharpen their interest in chemistry, physics and other sciences employed in research.

"You can't start too young," says the Commodore. "Even the little shavers have more sense than we grownups. Only the other day a little girl down in the valley came to me and told me not to worry over some people calling me Colonel because they think I'm a nut. 'The kernel,' she said, 'is the goody part of the nut.' "

8

When the Huntsville experimenters concentrated on castor plants, Gilbert Wilson decided to continue his original research on sweet-potato starch. That turned out to be an extremely fortunate decision.

American housewives, textile mills and laundries, bakers, confectioners and brewers use more than 1,000,000,000 pounds of starch a year. Though about half of it is corn starch made in the United States, the rest—more than 500,000,000 pounds—is tapioca flour from the Netherlands East Indies, sago flour from British Malaya, potato starch from the Netherlands and mandioca (cassava) from Brazil.

Four days after the war began, a royal decree restricted export of starch from Holland. Though the decree did not affect the Indies, American dependence on belligerent shipping pointed to potential shortage of transport facilities. This sudden threat brought a rush of orders to a white potato starch mill which foresighted chemurgists had established in Maine's Aroostook County. Also, it brought opportunity to the boys at Denton.

Gilbert Wilson's interest in the chemurgic possibilities of sweet potatoes dated from his fatherless boyhood on a worn-out farm in east Texas. At White Oak High School in oil-rich Longview he and a group of students, encouraged by the Commodore, extracted a host of industrial products from the tubers and took motion pictures of their work and its product. This film, exhibited before many groups in Texas, played a large part in preparing the way for chemurgic research in the schools of the state.

With such a background he was admirably equipped to switch from castor research to a deeper investigation of the sweet potato in September, 1939, when he was made instructor in chemurgy at Denton. Of the subject of his investigation he said to his students:

"We are no longer thinking of the sweet potato as a common garden plant, but as nature's storehouse for a number of valuable chemicals. Its place in industry will be conditioned by the starches, sugars, cellulose, carotenoids, vitamins, fats, proteins, flavones, xanthophylls, pentosans, enzymes and mineral salts that make up its component parts. These component parts do not have to be used as just such, but from them, thanks to chemurgy, there can be synthesized a multitude of usable products."

The starch of the yams, however, presented the most alluring frontier at the moment. Though this starch was long known to be the equal of any of the imported root starches and the superior of some of them in texture, its yellow color had been the chief factor militating against its greater use.

In 1928 the first sweet-potato starch plant in the United States was built at Thibodaux, Louisiana, but its operation was a commercial failure because the market demanded white starches.

The Bureau of Chemistry and Soils, of the United States Department of Agriculture, then undertook research directed toward an attempt to eliminate the objectionable color. The result was a white product with unusually high quality. Through the Federal Emergency Relief Administration, $150,-000 was allotted in 1934 to build and operate a plant for manufacture of this product at Laurel, Mississippi.

In 1939 the Laurel plant, under the management of W. R. Richee, produced about 2,500,000 pounds, extracted from 250,-000 bushels of yams grown by several hundred farmers who were once entirely dependent on cotton for their income. In 1940 the output rose to 3,400,000 pounds.

The processes developed at Laurel were under Public Service patents which permit their use by any United States citizen. Using them, Douglas M. Warriner, the son of the manager of the old Thibodaux plant, started a new factory at St. Francisville, Louisiana, in the fall of 1939. Its operations, however, were limited to ten per cent of its capacity of 1,000,000 pounds a year, because there were not enough sweet potatoes grown in the area.

Then, as this scarcity became acute, Dr. Julian C. Miller, experiment station horticulturist at Louisiana State University, announced the development of a number of new varieties of yams. Earlier he and his associates had succeeded in inducing sweet potatoes to bloom and set seeds, a feat long considered impossible. Allotted federal funds, the Louisiana experimenters bred a number of new varieties with better color, more uniform shape, increased resistance to rot diseases, improved starch content, and productivity as great as 600 bushels an acre instead of the customary 70 bushels.

To Wilson and his north Texas associates who had studied operations at Laurel and St. Francisville in the summer of 1939, these revelations were electrifying. They drew up tables showing that annual starch imports had grown from a little more than 100,000,000 to 500,000,000 pounds in five years; that the value of the current imports exceeded $8,000,000; and that southern agriculture, now linked to a dying cotton economy, could help itself appreciably with about 200 starch factories each producing 2,500,000 pounds a year.

"Visualize if you can," said Wilson, "the number of farmers and industrial workers that could have had gainful employment in the South if we had manufactured the 1,631,864,310 pounds of starch imported between 1932 and 1938 at a cost of $29,314,398."

With such an alluring vision to keep them steamed up, the young men at Denton set out to discover all they could about starch.

They were thorough. They found that sweet-potato starch is actually the aristocrat of starches. Textile mills, they learned, preferred it because it penetrated easily instead of merely coating surfaces and then flaking off, and because this better penetration made it more economical to use.

Next, commercial laundries tried the product, found they needed twenty per cent less than of ordinary starches, and that the better penetration made ironing easier.

Then bakers and confectioners tried it and reported that it possessed the very desirable quality of retaining moisture longer than sago and tapioca starches and therefore kept baked goods fresh for a longer time.

Another favorable attribute was found in the fact that this starch gelatinizes at lower temperatures than other commercial starches, thus requiring less heat in its preparation and providing easier control of viscosity.

Finally, the Denton boys examined the by-product potentialities and were engrossed in their findings. For, after the starch is washed out of the yams, the pulp, pressed and dried, can be stored and, soaked in water, used as stock feed for winter feeding of dairy herds or fattening of beef cattle.

Now for years the lack of abundant feed had forced Texas ranchers to ship their cattle north for fattening in the corn country, an expensive process which whittled down the profits of cattle ranching. The feeders were getting more and more of the profit and the time was ripe for the discovery of means whereby Texans could fatten their own cattle and pocketbooks. To Wilson and his associates, the dehydrated pulp looked like a partial solution of that problem.

According to the findings of the young men at Denton, the new industry should be one of many small and widely scattered plants in order to guarantee each factory a supply of raw material. Then they saw that some method would have to be devised which would enable each plant to operate throughout the year, instead of only about a hundred days as was then the practice.

Year-round operation seemed impossible because sweet potatoes, being very susceptible to molds and rot, are almost impossible to store for long periods. Furthermore, since the tubers are rich in amylase, the conversion of starch occurring during storage reduces their starch value.

The chemists at the Laurel factory developed a laboratory procedure for the dehydration of the tubers for long storage, but the process had not gone beyond the laboratory stage.

Here, young Wilson decided, was the opportunity for some real chemurgic pioneering. The more he thought about it, the more he realized that the sweet-potato dehydration industry could become a greater industry than the starch industry.

"There's no good reason why we of the South should be so dependent on other sections of the country and on imports for our milk and meat supply," he said. "Though the South is notably deficient in supplies of fattening feeds, there is no section of the nation which could compete with southern production of carbohydrates in dehydrated sweet potatoes."

Pointing out that southern sweet potatoes have two to three times the carbohydrate content of middle-western corn, he launched an extensive research program to find ways and means of permitting the South to utilize all the values of this expanding crop. In this work, he was aided considerably by Everett Scoggins, a graduate student working in the college's department of chemurgy on a Freeport scholarship.

These young men eventually developed a dehydration process which was capable of being used on a commercial scale. In doing so, they developed a method of trapping, during dehydration, a valuable concentrate of vitamins, carotene and fats which, added to the pulp after starch extraction, raised the value of the residue as stock feed.

At the 1941 Chemurgic Conference in Chicago, Wilson appeared on the program of a special session for young people from high schools, colleges and universities. He announced that the first commercial dehydration plant was being built.

To the hundreds of eager youngsters who attended this "Forum of Opportunities for Tomorrow" in the Stevens Hotel's huge ballroom, youthful Gilbert Wilson said:

"This little plant, which will serve as a pilot plant for other, larger plants now planned, will use processes that were worked out and tested mostly by Texas youths in high schools and colleges."

On November 5, 1941, the machinery, designed and built by Wilson and his boyhood associates, began operating in the first sweet potato dehydration and processing plant in Texas. The $20,000 invested in the project represented the combined savings of the young men, a $1,500 donation from the Denton Chamber of Commerce, and money which they had borrowed in small sums from their families and friends on their personal notes.

Earlier in the year, when it became apparent that not enough money could be secured to build or rent a factory building, the young men rolled up their sleeves and built their own factory on Wilson's farm two miles south of Denton. Salvaging lumber from an unused and dilapidated poultry house, they built the first unit of their factory, a drying room, twenty by fifty feet, in which they assembled the gas-fired rotary dryer which Wilson had designed and built. Needing another building to house the Wilson-designed grinding and pressing machinery, they stripped off their shirts, assembled shovels, wheelbarrows and tamping tools and built a rammed earth unit, thirty by sixty feet, alongside the frame building.

All summer these boys and young men labored happily under the hot Texas sun, scooping the topsoil from a pasture, pounding it into wooden forms and shaping it into the fourteen-inch-thick walls of their factory building. By autumn, the reports of their amazing ingenuity and dauntless enterprise had spread so far that they had to build a fence around the plant to keep sight-seeing visitors from interfering with their work.

By October 16, the preparatory work was done and experimental operations were started to test the equipment. Wilson wanted to resign his professorship to devote his full time to the supervision of the factory, but the college officials, recognizing his value as a teacher and leader of youth, retained him and lightened his teaching schedule.

Because of the widespread interest aroused by the summer's activities, it had become easier for the young men to borrow money for their Gilbert C. Wilson Laboratories. After they had converted a two-story residence adjacent to their factory into an office and chemical research laboratory, they added a graduate dietitian to their staff of four full-time workers. Thirty-odd part-time employees, boys and girls earning their way through the college, completed the working personnel.

The student helpers were paid not less than thirty cents an hour for their work. Operations were intermittent. Though the plant was able to process fifty tons of yams a day, its average consumption in the first month was only five tons a day.

There were many limitations on the activity. One day it would be lack of funds, and, while the machinery stood idle, Wilson and his young associates would scurry around Texas trying to borrow money. Next day it would be a shortage of yams, and the youngsters would have to comb the countryside for farmers who had grown enough of the tubers to make up a worth-while shipment to Denton.

From the beginning, the products of the mill found ready markets. Main product was a flour-like commodity which, rich in pro-vitamin A, quickly became popular with bakers, confectioners and housewives. Distributed throughout north Texas by Monroe-Pearson Company, wholesale grocers, of Denton, it was named "Vita-Yam." A secondary product was an absorption flour which became popular with meat packers.

On their laboratory shelves, the young pioneers had a dozen additional products, including starch, syrup, pectin, stock feed, mucilage, dyes and vitamin concentrates, which they were prepared to manufacture whenever sufficient capital and raw materials might become available.

The difficulties encountered by these young Texans have been many and complex. Changing world conditions have rapidly shifted the emphasis of demand from one yam product to another. First there was a pressing need for starch. Then demands for stock feed overshadowed the starch requirements. And finally wartime blockades produced great needs for dehydrated food products and vitamin concentrates.

Facing these constantly shifting demands while the manufacturing processes were in a formative stage, Wilson and his associates had to alter their plans dozens of times before they began production. Then, having secured markets for their products, they had to find capital to keep their plant going.

On top of that, the young men had to show Texas farmers how to plant and cultivate yams for industrial use. That was extremely difficult, for the farmers, having raised yams for years in their kitchen gardens, thought they knew how to grow the tubers. To prove that they were mistaken Wilson leased a farm of 400 acres from the county as a demonstration tract. The county's operations of this farm had resulted in a deficit of $1,500 in 1940. Under Wilson's direction, the first year's operations produced a profit from the sale of hogs, beef cattle, poultry and dairy products through the use of factory wastes and by-products as feeds. On this farm the young experimenters have worked out planting, cultivating and harvesting methods designed to produce maximum yields of yams.

In the first season of operations, Wilson steadfastly refused to pay less than fifty cents a bushel for sweet potatoes, even when on several occasions he was offered lots at lower prices.

"I don't want this business to succeed at the expense of the farmer," he said. "I can't forget the hard years of my boyhood on that Van Zandt County farm of my father's where the whole family worked hard all the time but there was never enough income to meet expenses. So I'll shut down rather than pay less than fifty cents a bushel. I'm positive that we can pay a dollar a bushel if and when we attain year-round full-capacity production.

"If we were operating a million-dollar processing plant, such as this new industry will easily support, we could be producing many other commodities which are only hinted at now."

Wilson foresees the day when the South will support many large factories for the processing of yams. And the young people who share his vision of the future include dozens of boys and girls who attended his science classes at White Oak High School and followed him to Denton, where he washed dishes in a restaurant and worked in a grocery store to put himself through college.

Among these young associates are Everett Scoggins, James Jones, Alfred Davis, Perry Brown and Virgil Little, all of whom remember that time back in 1936, when their teacher Gil Wilson, then twenty-five years old, heard Victor Schoffelmayer make a speech at Marshall, Texas, and came back to Longview full of enthusiasm about sweet potatoes as chemurgic raw material. They remember, too, how Gil Wilson's visions fired their imaginations and how the bearded Commodore fanned the fires with his talk about chemurgy and castor plants until about ninety of the town's teen-age boys and girls organized a pin-money-financed science club to conduct experiments for which the high school's laboratory equipment was inadequate.

That club, started by children, was the mother of the busy little factory near Denton.

9

An astonishing series of agricultural discoveries is now transforming the entire South. The effects of that southern renaissance will certainly be far-reaching.

With the South discovering its ability to surpass the Corn Belt in the production of carbohydrates, a drastic series of changes in American agriculture is inevitable. The end of the practice of fattening Texan beef cattle on northern acres is already in sight.

Curiously, that change stems from the huge stores of natural gas under Texas.

For many years the principal source of industrial alcohol in the United States was molasses which, imported from the lands with low standards of living, was cheap enough to prevent distillation of American crop surpluses. Then, a few years ago, petroleum chemists developed a pressure process of distilling alcohol from natural gas, and imported molasses became a drug on the market. Seeking new uses, molasses importers learned it was regularly mixed with silage to fatten cattle in Scandinavian countries. Bringing molasses to Texas Gulf ports in tank ships, they tried to interest ranchers in its use as feed. The ranchers scoffed at the "cow candy" until 1939, when, a drought having burned up the range, a few desperate cattlemen timidly tried it. The results were so amazing that, before the year was over, a total of 700,000 cattle had been fattened with more than 4,000,000 gallons of molasses. A year later Texans were feeding 2,000,000 cattle on molasses-flavored mixtures of local grains and grasses, cottonseed and citrus pulp, sweet-potato pulp—and even ground oyster shells from Corpus Christi beaches! By 1941, a Texas market for 12,000,000 gallons of Cuban molasses a year loomed as a better builder of Pan-American co-operation than all diplomatic conferences and good-will tours combined.

Then, from the fabulous million-acre King Ranch in south Texas, there came a strain of cattle which will further alter the future of agriculture in the United States.

In the hotter, more humid sections of the South, the standard breeds of cattle, derived mainly from species imported from Europe, could not thrive because they do not sweat. Around 1915 the owners of the King Ranch imported from India a few head of the Brahma species which thrive in the hottest, most humid climates. Crossbreeding of Brahma and native beef breeds produced a hybrid type of beef cattle able to stand prolonged heat and humidity.

With this new breed, cattle promise to become important in southern agriculture. The trend is being hastened by the new feeding practices adopted in Texas, by the recent discovery that the sensational synthetic drug, phenothiazine, is an effective weapon against the intestinal parasites that scourge cattle in the South, and by the introduction of such soil-building and gully-stopping forage crops as Asiatic Lespedeza, the sand-loving tropical Crotolaria and the prolific Japanese Kudzu vine.

These, in combination with the rapidly spreading recognition of chemurgy's values, are signals of great changes that must come as the South recognizes that sunlight and rain falling on acres constitute a natural resource which northern states cannot match. Out of that recognition, now shaping up, the future, if intelligently handled, promises food-crop surpluses beside which our recently glutted granaries will seem symbols of scarcity.

"Food," says Secretary of Agriculture Claude Raymond Wickard, "will win the war—and write the peace." But, as Wickard, the Indiana corn-hog farmer, has indicated he fully realizes, there lies beyond that time of peace, after America has served as charitable greengrocer to an exhausted and hungry world, another prospect of glutted larders—unless the chemurgists succeed in expanding the non-food uses of the vegetative abundance produced by the alchemy of sunlight and rainfall on American acres.

Against that day of reckoning, the four regional laboratories, set up by the federal government and supervised by Dr. Henry G. Knight, are now building buffers with chemurgic research directed toward the opening of new frontiers ten and twenty years from now.

Chapter XIX

RESEARCH PAYS OFF

1

"You are so tight-fisted that God himself couldn't pry your hand open to put a blessing in it," said Francis Garvan's plain-talking father to a neighbor who had refused a mite for charity.

In the years when he and Herty were urging American industrialists to spend more money for research, Garvan told that anecdote often to illustrate his conviction, proved by his own experience, that "the open hand gets filled first."

His argument worked. In the two decades between 1918's armistice and the resumption of hostilities in 1939, more and more heads of American industries came around to better understanding of the Garvan principle—and more and more hands participated in the blessings with which research paid off.

By 1940 the benefits were obvious. Thanks to industrial research we were not quite so hopelessly dependent on other nations as we had been in 1914. But there were serious gaps in our armor. One of the serious faults was the fact that in agriculture American policy was still too tight-fisted to grasp blessings.

To high-light that fault, Larry F. Livingston, manager of agricultural extension of the du Pont Company, cited some shocking comparisons of research expenditure before a House of Representatives committee on chemurgy in January, 1940.

As a whole, he said, American industry spends each year about one-half of one per cent of its gross sales revenue for research. In every industrial field, he pointed out, leadership is very clearly falling into exactly the hands which are most open in subsidizing scientific investigation.

"Nobody I know of ever went broke doing research work," he said. "If you will make a study of the successful industries today, you will find that those that advanced all through the depression years are those that conducted big research programs, and were willing to spend money and wait for results."

He sharpened his point by citing the chemical industry's amazing record of growth during the depression and asked the legislators to ponder the fact that this industry's average research expenditure was two per cent of its gross revenue, with some of the more successful companies spending as much as four per cent.

"But," he added, "if you put down all the funds spent by the federal government, add all the funds spent by state experiment stations, all the money going into the four federal regional research laboratories, and all the money allocated for work done by groups interested in agricultural development, you find the expenditure on research in agriculture amounts to only one-seventh of one per cent of the value of all agricultural products in the United States.

"In other words, to put the farm on a par with the factory, three and one-half times as much should be spent on agricultural research as is now being spent."

Adding that he believed the establishment of the four regional laboratories to be one of the wisest moves the federal government had made in a long time, Livingston cautioned the lawmakers against expecting results too soon. The du Pont Company's forty years of experience, he said, indicated that from six to ten years is required for a laboratory project to become a marketable product.

"The time may be shorter," he said, "but more often it is longer."

Warning that this snail-like emergence of results all too often fosters a fatal temptation to strangle a promising experiment by tightening the purse strings, Livingston cited, as proof that research pays handsome dividends, Lammot du Pont's statement that fully forty per cent of the company's revenue from sales in 1938 was derived from articles which were either non-existent in 1928 or which had been improved beyond recognition in the decade.

Before the year was over, American acres themselves supplied the proof that, on the farm as well as in the factory, the "patient money" of research eventually comes back to the open hand wondrously enriched.

The "wonder crop" of 1940 was a million dollars' worth of soy beans. Its existence was the rich reward reaped by American agriculture largely because of the patience of two men: Augustus Eugene Staley and Henry Ford.

2

In the lives of Staley and Ford there are many strange similarities. Both were farm boys who hated farming. Both devoted their later years to improvement of living conditions on American acres.

At seventeen, Ford left his father's Michigan farm to become a mechanic in Detroit. At the same age, Staley shook the red clay of a North Carolina hillside farm off his boots to become a traveling salesman. The engine of a threshing machine inspected by a fascinated little boy was the germ of the Ford career in the automobile industry. The soy beans which a missionary brought home from China and gave to a seven-year-old boy was the beginning of the Staley career as "Soy Bean Pioneer." World-wide fame came to Ford when he was fifty. At the same age Staley, considered the world's most successful starch salesman, put away forever the sample cases of the stuff which he, a diabetic, couldn't eat, and became the great salesman of the soy bean.

"Many discoveries," says Charles Kettering, "have been accidents, the result of stumbling on one thing while searching for another. But no one ever stumbled while standing still. You only stumble while you are moving. So unintelligent stumbling is more important in reasearch than intelligent standing still."

Staley stumbled on soy beans in 1912. Having sold other people's starch successfully enough to make other people rich, he had gone into starch manufacture on his own with a factory in Decatur, Illinois. Because his factory was a handy market, the surrounding acres were being rapidly "corned to death." Watching the soil depletion with mounting alarm, Staley remembered the beans he had planted as a child, remembered chiefly that a two-ton crop of those Oriental bean plants, plowed under, was reputed to add as much nitrogen and organic matter to the soil as seven tons of manure. So he read all he could find about the beans, and he sent away for seeds which he planted and studied.

Then, after he had learned all he could, he called on farmers on Sunday afternoons and talked beans, urging them to plant the seeds he supplied. "Crazy!" said the Illinois farmers among themselves. But they liked this fellow Staley and they planted the seeds and reported to him on the results.

So it went for five years, this groping and stumbling missionary work of Staley's. And, by 1917, in a constantly widening area centered on Decatur, you could hear more and more of the close-mouthed Corn Belt farmers praising Staley for bringing them the plants they were using increasingly for hay and forage and fertilizer. The area of interest spread as far as Bloomington, where E. D. Funk, the seedsman, began importing the seed beans from Manchuria for his farmer customers.

The awakening interest was especially gratifying to Dr. W. L. Burlison of the University of Illinois; for as early as 1908, when he was a graduate student at Urbana, the soy bean had caught the attention of this former Oklahoma farm boy who had turned to chemical research. When Dr. Burlison began investigating the beans, only one bulletin and one circular had been issued on them in the United States, and the state experiment station was recommending their cultivation as "a hard-time hay crop and soil-builder." When Dr. W. J. Morse of the United States Department of Agriculture returned from China with a few new varieties, Dr. Burlison experimented with them at the university and persuaded about forty neighboring farmers to grow them experimentally.

"We were utterly foolish dreamers," said Burlison, years later.

For the beans themselves there was then no American market. That fact bothered Staley, who knew that the nation was importing 15,000 tons of the bean oil, cake and meal every year. So he built a processing mill alongside his starch factory and told the farmers, "I'll buy all the beans you can raise." The mill began grinding in the fall of 1922, producing a little oil and meal. One year later, though the Illinois farmers were still growing the plants mostly for hay and fertilizer, the mill crushed twice as many beans as the farmers had harvested in 1922.

Then Staley decided to become really open-handed with research. He worked with seed firms to improve strains, with farm implement manufacturers to get planting and cultivating and harvesting machines perfected, with Burlison of the University of Illinois chemistry department, and with the Illinois Central Railroad which ran a soy-bean demonstration train throughout the state.

By 1924, the Illinois acreage had multiplied four times in three years and other processors began operating. By 1926, Glen G. McIlroy, "bitten by the bug," launched a missionary campaign among Ohio farmers from his farm at Irwin, Ohio, and finally got his neighbors so stirred up that the American Soy Bean Association was formed with McIlroy as the head of it.

In 1928, H. J. Atwood of Allied Mills established an industrial market by contracting, with the support of Seedsman Funk and the Grange League Federation, for the output of 50,000 acres at a dollar and forty-five cents a bushel. Farmers in Indiana and Ohio joined the Illinois pioneers. Plant breeders and agronomists at Purdue, Ohio State, Wisconsin, Iowa and Missouri Universities launched soy research.

The circle of interest then reached as far as southeastern Michigan where Henry Ford, troubled by the widening gap between farm and factory, was talking about bringing the two closer together with something which was tentatively called "agrindustry" but which Billy Hale was calling chemurgy.

Inscribed prominently on the walls of the Ford rotunda at Dearborn is the quotation: "There is nothing permanent about this organization except change." That expresses the spirit which spawned and nurtured what Ford now set out to do. The agricultural experiments were to have sociological effects which are even now unassayable by agronomic prognosticators, and technological effects which are currently making that rotunda inscription a fitting motto for the whole industrial world.

For, discovering Staley's beans, Ford launched a many-sided research program to fit the Chinese visitors into the American way of life. He set out to improve their agricultural production. He strove to simplify their processing for industry. He put Dr. Ruddiman to work sleuthing down their nutritive values. He began to build little factories in the fields. He built and staffed schools in which the normal curiosity of children was encouraged no matter into what peculiar bypaths it happened to probe. And out of these schools he piped the most persistently inquisitive youngsters into a laboratory to discover new industrial markets for soy oil and protein.

Before Pioneer Staley died in December, 1940, he had all the proof he needed that research pays off. His $20,000,000 industry, which had started stumblingly as a sideline of a starch factory, had become the largest of its kind in America and the prototype of several new similar plants. It had nurtured a host of new industries. It had launched a series of breath-taking changes—explosive changes, the sputtering fuses of which the Ford-trained, inquisitive youngsters had lighted and were still lighting.

On September 25, 1941, the University of Illinois feted Dr. Burlison and his associate pioneers, the "utterly foolish dreamers" who had grown soy beans before 1914. Reminiscing, Dr. Burlison expressed his belief that the soy had done more than any other single crop to bring scientists, farmers and industrialists together around the chemurgic conference tables.

In passing, he told how two Japanese officials visited his office one day in 1936 and, manifesting deep interest in the work of thirty young researchers in the two big rooms of the United States Soy-bean Laboratory at the other end of the hall, admitted that their government was worried about the potentialities of many of the 660 new varieties Americans had developed in the past twenty years.

Good reason had the Japanese for worry; for, coveting Manchuria's soy-productive acres, they had embarked upon a national program of pillage which was threatening their nation with destruction, while Americans were peacefully expanding abundance of soy beans by applying to the crop all their peculiar genius for mass production.

3

At the end of 1939, soy beans had been tested agriculturally and had proved themselves. In a drought that burned up pastures and meadowlands throughout the northeastern states, the tough Orientals alone emerged victorious. About one-half the nation's 9,000,000-acre crop that year was harvested as hay to become belly-filling and bone-building meat and dairy products.

In 1940 the acreage topped 11,000,000 for the first time. The 100,000,000-bushel crop put 75,000,000 earned dollars into farmers' jeans. The United States became an exporter of the beans.

By 1941, domestic production had multiplied seventeen times in six years. The United States was growing a third of the world crop, and it would soon overtake Japanese-grabbed Manchukuo as second only to great China in production. Yet, despite this enormous increase, prices rose steadily to one dollar and seventy-five cents a bushel, enabling this recently introduced crop to surpass in value every other crop save the subsidy-bolstered big four: cotton, wheat, corn and tobacco.

Instead of the few varieties available when Staley had started to distribute seeds, there were now some 2,500 kinds grown in the United States. There were varieties for every soil and climatic variation. The South grew them mainly for fodder and fertilizer—fodder for beef and dairy cattle which the South needed desperately, and fertilizer for the South's cotton-starved, erosion-gutted acres. West of the ninetieth meridian, farmers found them hard to raise because of the prevalence of rabbits which turned up their noses at carrots and such to forage on the tender young shoots of the soy.

Recognition of their values spread to South America and Europe. Brazil and the Argentine found varieties that were suitable. Europe planted them with success below the Danube, and Germany, getting set for a plundering expedition, had stocked up with about 40,000,000 bushels a year from Manchukuo for several years before Hitler's hoodlums marched with soy-enriched rations under their belts.

Yet, despite the beans' recognized superiorities as human food and despite the well-known fact that they have no insect, fungus or virus enemies, few edible varieties had been introduced into

American agriculture by 1941. The adoption of the versatile bean was clearly a chemurgic triumph.

At least fifty-six per cent of 1941's crop went to pressing mills for oil extraction, an operation for which du Pont chemists developed a special solvent, trichlorethylene, a derivative of common table salt. Three-fourths of the oil was refined, deodorized and used for edible fats of which imports were cut down by the war. The rest, unrefined, went to industry, with paint manufacturers taking most of it after chemists learned that, like castor oil, it could be dehydrated as a dryer to stretch the dwindling supply of tung oil. Soapmakers turned to it increasingly with the discovery that soaps made of it lathered richly even in salty sea water.

Of the meal residue, about ninety-five per cent went back to the farms as animal and poultry feeds.

At the University of Illinois Soy Bean Day celebration, Dr. Burlison said he wanted to see the soy take up the slack between American vegetable oil production and use. He added that the use of high-protein soy meal as winter feed for western cattle might easily cut down production costs to a point at which beef and veal produced in the United States could compete anywhere with Argentine or Australian meat.

Although three-fourths of the oil and ninety-five per cent of the meal produced in 1941 were destined for the human stomach via circuitous routes, the dramatic possibilities bulked large in the small but enlarging proportions that were clearly industrial in application. In them lurked the promise that the next twenty soy-bean years in the United States would be more incredible than the last twenty.

4

To evaluate that promise you begin with the date, September 25, 1931, the tenth anniversary of which was celebrated at the

University of Illinois. That date marks the birth of the first American soy-bean industrial product—a paint. It was not a very good paint, said the men who assembled to celebrate its birth. But it was the ancestor of some of the best of all paints now in use.

About the time that birthday was being celebrated the members of the American Soy Bean Association held a convention at Dearborn Inn where Ford's young researchers took them in tow and showed them what had happened to the soy bean in the factory in the intervening ten years. They were shown the soybean enamels with which most automobiles are now coated. They saw soy meal treated with organic solvents and become light, durable, waterproof, weatherproof and rotproof plastics for many automobile parts.

Then they were shown samples of man-made "wool" which had been extracted from soy protein. Unlike the wool of sheep, this stuff was produced to fit specific needs. In one form it served as automobile upholstery padding. In another it could be spun and woven into upholstery fabrics, carpets, wearing apparel. In another process it emerged with the springy texture of rubberized curled hair. In still another process it came out not as fiber but as a powder base of paper sizing, plywood glue, leather finish and paint pigment.

But by far the most dramatic prospect which the Ford researchers pulled out of the hat in 1941 was the proof that Henry Ford's predicted automobile-from-the-soil was no pipe dream.

In actual production on the assembly lines of the Ford River Rouge Plant, the visitors saw plastic material, a mat-like combination of cellulose fibers and soy protein, pressed into finished seats for Ford-Ferguson farm tractors. And, in the laboratories, the experimenters were producing similar non-metallic plastic panels out of preformed masses resembling papier-mâché, popping them, smooth-surfaced and pre-colored, from the hot presses which molded them into shapes suitable for bathroom and kitchen fixtures, refrigerator and automobile panels, airplane wing and fuselage sections, and panels and slabs and shapes for houses.

Here, at last, was tangible evidence that Shen Nung's "Little Honorable Plant" may one day feed us, clothe us, put a roof over our heads and give wheels and wings to our wanderings.

Like the Staley research, the Ford research was beginning to pay off. And, like that chemurgic triumph of the Straus attempts to make paper from flax, success was achieved at the exact moment when the nation needed it most. For, in the mad scramble for alternates and substitutes for metals that became dangerously scarce when the American re-armament program got under way, plastics turned a corner in the American economy. Almost overnight it happened. Interesting and amusing gadgets yesterday, the myriad products of the American plastics industry were suddenly thrust by wartime emergency into strange new roles as elements of vital necessity.

Historians, recording that epochal shift, will doubtless include in their list of plastic pioneers Robert Boyer, one of those inquisitive youngsters who came up through Henry Ford's world-wide school system into the Ford soy-bean industrial laboratory.

Chapter XX

THE FARM-GROWN AUTOMOBILE ARRIVES

1

When Henry Ford began to build Edison Institute and Greenfield Village, it was generally assumed that the technological museum and its neighboring collection of early American buildings were mere expressions of an antiquarian's hobbies. Of the hundreds of thousands who visited the institute and village annually, few suspected they were roaming around a campus. For not until comparatively recently was it revealed that this popular tourist attraction in Dearborn was the nerve-center of a novel educational experiment with outlying schools as far away as the Brazilian jungle and the countryside of England, and that there were in the world some 10,000 humans to whom Ford is primarily not an automobile manufacturer but *their* schoolmaster.

And, when Ford built a barn-like laboratory for soy-bean industrial research near the Greenfield Village re-creation of Thomas Edison's Menlo Park headquarters, the juxtaposition seemed odd and haphazard. Actually, as was revealed in 1941, the seemingly whimsical placement of that laboratory beside a collection of historic buildings was part of a well-laid plan. Oddly, even the Ford purchase and restoration of the famous Wayside Inn at Sudbury, Massachusetts, dovetailed itself into that plan.

When Robert Allen Boyer was a boy, his father became manager of the old tavern on the Boston Post Road which Long-fellow immortalized in *Tales of a Wayside Inn.* Bob, who was born in Toledo, Ohio, in 1910, was then just a normal American boy, serious enough to get by in high school but not too serious to let studies interfere with athletics. He was thinking of going to Dartmouth College when Ford visited the inn. The man and the boy were attracted to each other and talked a long time. Upshot of their discussion was Bob's decision to attend Henry Ford Trade School instead of Dartmouth.

On December 4, 1930, Bob got a second push toward his vocation. Thomas Edison was puttering happily in his re-created Menlo Park laboratory which his friend had picked up in New Jersey and set down in Michigan with a fidelity to detail that included even the transportation across country of New Jersey's red clay and the Edison plant's rubbish dump. Bob, earning his way through school as a student guide in the museum, met the old gentleman and listened to his reminiscences. At the end of a long talk the famous inventor handed the boy a piece of notepaper upon which he had written in that type-like script of his:

"When you experiment, put nature to work and it will answer you."

Edison died soon afterward and Bob put the treasured note among his souvenirs. He followed advice so well that Ford singled him out as a potentially good researcher.

One day Ford brought him a clipping from a technical journal describing experiments with chemicals derived from soy beans. When Bob manifested interest in it, Ford built that barn of a laboratory and put him in charge.

"Find out everything there is in a soy bean and what it can be used for," he said.

The first piece of equipment supplied to Bob was a thousand-gallon still in which the beans were made to reveal their secrets. In time, as their classroom work under Ford instructors revealed special aptitudes and insatiable curiosity, additional youngsters joined young Boyer. Finally there were thirty of them digging away at the bean's secrets. Their average age in 1941 was only twenty-four!

"We were chosen," says Bob, "because we were not too sure that certain things were impossible."

One by one, the soy revealed its industrial values to these boys. First, the enamels. Then the plastics. And, as these laboratory findings showed promises of adaptation to commercial practice, full-scale soy processing plants were built. The first were little factories in the fields, reconditioned grist mills in little Michigan towns that had been slowly slipping into decadence. Then, in August, 1939, the expanding uses of the bean's oil and protein necessitated construction of a six-story processing factory as an integral part of the great, sprawling Ford Rouge Plant. Within six months this mill's facilities were taxed to such an extent that a second extractor had to be added. And, at the end of 1940, the Ford plant included one of the largest plastic-molding plants in America. In that year it had converted 21,375 tons of beans into plastics for Ford cars.

2

By 1940, all the large automobile manufacturers were operating their own plastic-molding plants; for, since 1905, when a single-cylinder seven-horsepower Oldsmobile runabout was supplied with a storm front curtain whose celluloid "windshield" was the first automotive application of a synthetic plastic, the use of the man-made resins had increased progressively in motor cars. Without Baekeland's thermosetting phenol-formaldehyde resins, Inventor Kettering has said he could not have perfected the electric starting, lighting and ignition system with which he revolutionized motoring in 1911.

From these beginnings the automotive applications of plastics mounted annually—into steering wheels, horn buttons, control knobs, electrical parts, glove compartment doors, instrument panel assemblies, accelerator pedals, radio cases and grilles, tail lamps and lenses, gear wheels, plastic layers in safety glass and the plastic coatings of the bodies. By 1940 the average automobile had fifty different plastic applications.

Indeed, the automobile and plastics industries were closely linked from the start. Hyatt, who invented the thermoplastic cellulose nitrate "celluloid" in 1869, also invented the roller bearing which, provided with a large-scale market by the automobile, was instrumental in bringing Alfred P. Sloan, Jr., from the Hyatt factory into General Motors Corporation.

The two industries grew up together. Before 1911, when Kettering put Baekeland's new thermosetting resin "Bakelite" to work, automobiles were still "horseless carriages," and their manufacture was called "the automobile game." Of plastics there were then only Hyatt's celluloid, a shellac composition, a bitumen composition and Bakelite.

In 1921, when the building of automobiles had become an accredited industry with an annual production of 1,682,365 cars and trucks, plastic production of all kinds reached 1,600,000 pounds, and casein and coumarine had been added to the list.

In 1927 automobile production reached 3,580,380 units, and plastic output totalled 13,500,000 pounds, with phenol furfural, alkyd resin and cellulose acetate added.

In 1930 plastic production climbed to 31,000,000 pounds, with urea formaldehyde, vinyl ester and styrene added.

Though car production fell to 1,985,909 in 1933, plastics, with acrylic resins and cellulose acetate butyrate added, topped 45,000,000 pounds.

Up went the production of both cars and plastics in 1936, with 4,454,115 vehicles and 133,000,000 pounds of plastics, of which the expanding list included ethyl cellulose and methyl methacrylate.

In 1939 plastic output reached 213,000,000 pounds. With the addition of vinyl butyral, lignin, cellulose acetate propionate, vinylidene chloride and methyl cellulose, the list of basic plastic materials had reached twenty distinctly different kinds. The United States was now leading the world in their production.

Many of these newer forms of plastics were seized at the start by automotive engineers and designers. Ranging in price from ten cents to more than two dollars a pound, each type possessing different properties and presenting different advantages, their diverse potential applications presented constant challenges to inventive ingenuity in the automobile industry.

But, in all the long list, there was neither one plastic nor any combination of plastics which seemed to hold the answer to Ford's search for the "farm-grown automobile." The idea was deemed fantastic—outside the Ford laboratory.

3

Inside the laboratory, new problems were coming up. Wartime curtailment of vegetable oil imports increased enormously the demands imposed on the oil of the soy, shooting the price of it sky-high, and threatening to turn the residual meal into a troublesome surplus. Boyer and his associates worked like beavers, trying to find more industrial uses for the solids. The wool-like fibers came out of that effort.

Boyer himself concentrated on the search for that plastic automobile body about which the wiseacres were scoffing openly now. The lessons he had learned in plasticizing soy protein he now applied to other vegetation. He tried all sorts of combinations which he plasticized into rear compartment panels for a Mercury sedan. And, as fast as he finished them, Ford took them out and whacked them with an ax until he succeeded in smashing them. Then he brought the cracked or nicked panels back, and Bob tried again.

Finally, after hundreds of experimental panels had been belted by blows such as nothing less than armor plate should be expected to resist, he turned out one that bounced the Ford-wielded ax off again and again.

"We've got something!" said the jubilant ax-swinger.

To make this panel, Boyer matted long and short fibers obtained from field straw, cotton linters, hemp flax, ramie and slash pine. To the fibers he added a filler of soy meal. Then he impregnated the mass with a liquid resin binder and color and plasticized it in a hot press. That was a long and laborious process—all right in a laboratory but hardly suited to a mass-production factory.

But it was a triumph. It was at last the material Ford had been seeking. It had an impact strength at least ten times as great as the traditional sheet steel panel which it replaced. Though its tensile strength was less than that of steel, that weakness was easily remedied by molding it on a tubular steel frame. Even with that frame, it was a third lighter than a comparable steel panel. And when it popped out of the press it was finished, requiring no painting or polishing, and presenting a smooth surface from which the color could never be removed.

4

Yes, it was something. The word of it leaked out and, in January, 1941, the United States Junior Chamber of Commerce awarded Bob Boyer a medal as "America's Number One Young Man of the Year." He was just thirty-one years old.

The ceremonies finished, he ducked back into the laboratory. He was a happy young man, for Ford had given the order that he be supplied with all the presses, dies and equipment needed to mold an entire automobile body out of his fibrous material. He worked out a method of matting the cellulosic mass by floating it on water and lifting it out on screens which preformed it into a rough approximation of the finished panel as the mass dried. Then he figured out a way to increase the production rate of the molding presses by squeezing six panels at a time. Engineers and designers developed new principles of automobile construction by building a tubular steel frame of adequate strength to serve as a durable skeleton for a body whose "skin" would be an assembly of fourteen plastic panels.

The result was exhibited for the first time on August 14, 1941, at the fifteenth annual Dearborn Home-coming Day celebration. It was an experimental, cream-colored automobile. Its body was seventy per cent cellulose and thirty per cent resin binder. Differing little in appearance from the conventional type of car, it weighed exactly 1,000 pounds less. It required no painting or polishing. Its color was integral, not superficial, and its surfaces were as smooth as the polished dies of the 1,000-ton presses that had squeezed the panels under heat and at pressures up to 1,500 pounds per square inch. Because its impact strength was greater than that of steel, it offered greater safety in collisions. In a bad crash there would be no jagged edges of torn steel to slash human flesh. In such collisions, fenders might be broken, but minor bumps which would dent or tear steel fenders would leave these undamaged because the plastic, unlike steel, does not "take a set," and therefore springs back into shape. Because the walls were composed of cellular organic matter, the interior proved to be cooler in summer, warmer in winter, and no sound-deadening "dope" was necessary to eliminate the drumming noises of vibration. Pound for pound, the plastic raw materials were more expensive than steel, but fewer pounds were necessary. Besides, fewer fabricating and finishing operations were required. For example, the rear-compartment panel when made of steel required no less than seven stamping operations, while only two were necessary for the same panel made of plastic.

The long-awaited plastic automobile was an accomplished fact at last. Discussing the effect which possible widespread adoption of the practice would have on American agriculture, Boyer said:

"If we made a million cars a year with plastic bodies, we would consume at least one hundred and seventy thousand tons of farm products and fifty thousand tons of synthetic chemicals."

The farm products, he explained, would include 100,000 bales of cotton, 500,000 bushels of wheat, 700,000 bushels of soy beans, 500,000 bushels of corn. The wheat, corn and soy beans would be interchangeable.

"We could use one of them or any combination of them," he said.

Other domestic materials required in smaller quantities, he added, would include flax, pine pitch, sugar cane, glue, lard, hides and alcohol. The import needs would embrace cork, rubber and tung oil.

"But," he warned, "this is merely an experiment. Any substitution of it for the present steel body is a long way off."

How long?

"Your guess," he replied, "is likely to be as good as mine."

Proud of the youngsters whose efforts had advanced his ideal toward reality, Henry Ford said, "I wouldn't be surprised if this laboratory comes to be the most important building in our entire plant. These young men working here, always on their toes, always enthusiastic, working hard because they love their work, feeling they are doing really useful things, looking forward always—there is the stuff that makes America great!

"It's a shame," he added, "that nations are at war again. . . . But they will never quit warring until they learn how to use the soil. There's not a country in the world that could not support itself easily if its people knew how to use the soil. That's what we are learning here in this laboratory. .

"Because we are learning it, the United States can become strong enough and wise enough to be the big brother to the rest of the world and show other nations how they can keep out of war—and why they must. If nations could learn to make proper use of the productivity of their soil there would be no incentive to crowd each other."

5

The last step between the laboratory and the factory remained to be taken. The length of that step, as every researcher knows full well, is most unpredictable. In times that are called normal, the step is usually a long one. But, when times of crisis make many minds emerge from the comfortable ruts of habit, the step is often a frightened leap.

The dynamic forces of wartime emergency were at work when that step was ready to be taken. In the weeks and months which followed, the shocks of their hammering accelerated progressively in tempo and impact. The demands of defense manufacture, superimposed on the mechanism of peacetime production, created critical shortages of aluminum, nickel, copper, zinc, chromium, magnesium, tungsten, tin and an ever-lengthening list of the common things which automobile manufacturers use in huge quantities. Facing grim prospects of ever greater curtailment of normal production, those manufacturers neglected no ideas which might provide alternate materials. Already accustomed to the technics of fabricating plastics, they turned to these new materials for alternates for metals formerly used in fuel and water pumps, carburetor bowls and door handles, and virtually all articles used as trim and ornamentation.

Plastic automobile bodies? Even those who had scoffed at the idea only yesterday could see today that such an innovation would relieve many worries. But it would not be easy to get the new presses and tools and dies. Moreover, as the demands of defense piled up, more and more of the chemicals required in the manufacture of plastics were themselves becoming scarce because their uses in the fabrication of war material were taxing the American chemical industry's facilities.

Plastic bodies? Feasible, perhaps—in normal times, said those who scoffed yesterday. Minds were changing now. That was the major significance of the development. The thing which Ford and Boyer launched in 1941 might easily become the opening gun in a technological revolution whenever other guns fall silent.

Plastic automobiles? The engineers yawned and began to fidget in their chairs when Plastics Designer George William Walker of Detroit stood up to speak about that topic at the 1941 convention of the Society of Automotive Engineers at White Sulphur Springs. The engineers had heard this kind of "Sunday Supplement Science" before. This is where we came in, they said, straggling out. Walker, who had designed more than $500,000,000 worth of industrial products from clocks to airplanes, was about to face an empty hall. To pull himself out of a bad situation, he hastily announced he would exhibit some important new plastic shapes, made of transparent acrylic resin panels no more than a quarter-inch thick but capable of withstanding wind pressures of 400 miles per hour.

"They are now in mass production," he said.

Mass production? At the sound of that familiar combination of words the engineers straggled back.

Onto the stage Walker moved a collection of the huge transparent "blisters"—nose pieces, gunners' turrets and observers' cupolas—with which military airplanes are equipped.

By the simple device of exhibiting a familiar thing in a new light, Walker made the engineers think about this plastic material's potential application to something besides the ornamentation for which it has been used. Then a page of Walker's daring designs for plastic automobiles appeared as illustrations for an article about the war-induced spurt of interest in plastics among automobile engineers. Written by Clyde Vandeburg, of Packard Motor Car Company, for the October, 1941, issue of *Esquire,* this article revealed that Packard's Designer Edward Macauley took his vacation in 1941 in a car whose roof was a transparent plastic panel through which he got the benefits of a healthy sun-tan without discomfort.

"The day of the plastic car is almost here," said Walker. "The events of 1941 have merely served to step up the program by forcing us to search for new and better materials to replace the ones denied us."

6

This kind of thinking was given additional impetus in the automobile industry when fears arose that a steel famine might result from the demands of national defense. Even before the engineers began to worry about sheet steel shortages, the plastic applications in the average automobile had increased from 50 in 1940 to more than 120 in the early editions of the 1942 models. One Chrysler car had 232 individual plastic parts. Applications of the optically clear methyl methacrylate resins, developed in 1936, increased from 8 in 1938 to 70 in the 1942 automobiles.

In electric refrigerators, too, the race for materials accelerated the shift to plastics. An average of 39 plastic parts in 1941 models jumped to 50 in 1942, with one of the manufacturers turning to the use of plastic panels for interior linings.

As the tempo of defense manufacture quickened, one could scarcely pick up a serious periodical without reading of some new and startling adaptation, process or material. The number and variety of things that could be made out of these protean materials seemed suddenly endless. For example, when a copper curtailment order was issued from Washington, Dow Chemical Company's engineers offered, as substitute tubing, the extruded vinylidene chloride resin their chemists had produced for the first time in 1939.

For the manufacture of this resin, however, as well as for magnesium metal, ethylene glycol engine coolants, aviation fuel, synthetic "rubbers," many plastics and all white papers, a prime need was chlorine, the poisonous greenish gas which, though a relative of common table salt, has many wartime uses. Just when these wartime demands threatened a shortage of chlorine, two Columbia University scientists, Dr. Arthur Warren Hixson and Dr. Alvan Howard Tenney, brought out a new process for producing the chemical.

On top of that, Vice-President R. L. Murray of Hooker Electro-chemical Company announced that research begun in 1925 was now paying off with an improvement of the famous Hooker Cell process of chlorine production.

Then, from the laboratory of Dr. G. P. Vincent of the Mathieson Alkali Works, Inc., came the announcement that many years of research had finally developed, for the first time in more than a century, an entirely new heavy chemical. This was known as sodium chlorite, and apparently was capable of assuming some of the multiplied tasks recently imposed on sodium chloride derivatives.

These announcements, all made within the brief span of a few weeks, indicated clearly that, under the spur of emergencies, more and ever more minds were coming up out of the deep canyons of old habits and roving onto the open horizonless plains of research.

Would this altering mental attitude bring those plastic automobiles into existence at last? Before 1941 was three-quarters down in history, the affirmative answer was so plain that the scoffers were falling silent. Just before the Axis attacks on the United States beclouded the view, it was easily possible to discern on the horizon of some far post-war tomorrow the signs and portents of a dazzling future.

7

That future—when we reach it—clearly contains not only plastic automobiles, but plastic airplanes as well. Already, in every fighting plane there are hundreds of plastic parts. In the United States, airplanes with plastic wings and fuselages were made experimentally as long ago as 1937, and, at this writing, are all still in active service. The first successful one was a five-place, Fairchild Model 46, built by Haskelite Manufacturing Corporation and Duramold Aircraft Corporation at Hagerstown, Maryland.

This plane, like ones built by Hughes Aircraft Division of Hughes Tool Co., Aircraft Research Corporation, Timm Aircraft Co., and Glenn L. Martin Co., was molded of phenolic-resin-bonded cellulose, a new product stemming from years of plywood research at the Forest Products Laboratory in Madison, Wisconsin. This government laboratory, founded in 1910, focuses the collective ingenuity of 200 inquisitive researchers on one subject—new uses for wood. Under the impact of their curiosity, plywood, a formerly shoddy substitute whose many faults made it the perfect American variant of German *Ersatz,* has become, through the addition of fabrication technics borrowed from the plastics industry, one of the strongest, toughest, most durable and most abundant of the construction materials used by mankind.

It is common knowledge throughout the aviation industry that this material is the long-sought ideal material for airplane construction and that the mass-produced airplane of tomorrow will be made of it. Since small boats were being successfully built of it in 1941, the mass-produced watercraft of tomorrow will doubtless be plasticized plywood also. With its applications expanding rapidly in the field of shelter under the pressing need of housing for defense workers, it represents the introduction of plastics into the almost limitless frontier of human shelter.

Almost thirty years after O. R. Sweeney began trying to convert corn stalks and straw into wallboard panels out in Ames, Iowa, American researchers attained signal success in the conversion of cellulosic wastes into building material. In 1941, Dr. J. F. J. Lynch, the head of the Southern Regional Research Laboratory at City Park, New Orleans, developed a tough and hard plastic panel material called "Kanex" which began as bagasse, the formerly useless fiber of sugar cane.

The original Lynch experiments, subsidized by a sugar company seeking new values in the 1,680,000 tons of dry bagasse annually produced on Louisiana's 563,000 acres of caneland, were launched in the government laboratory in Ames—the community in which Sweeney began his experiments three decades earlier.

Essentially, the process of plasticizing fibrous material differs little from the process of manufacturing phenolic-resin-bonded plywood. The methods vary but the principles are the same. Both products are chemical transformations of cellulose which, once it is impregnated with synthetic resins, can be molded into any kind of shape under heat and pressure.

The late William H. Mason started his process by exploding wood into mattable shreds. Ford's Boyer starts with mechanically shredded fibers. The Madison wood wizards slice wood into thin cellulosic sheets. In all three processes the next step is basically the same—chemical transformation of cellulose, by the action of heat and pressure on some latent or added plasticizing agent, into a synthetic structural material with qualities surpassing any that nature put into the things from which it was made. The latest such material is "compregnated" wood.

The stores of raw materials, lying around and waiting to be employed for such ends, are fabulously enormous. Ignoring entirely the annual production of such material which is generally wasted on American cultivated acres, the stores are tremendous in the annual wastes of forestry. It has been estimated that, in the northwestern lumber states alone, there are some 50,000,000 tons of stumps, treetops, sawdust and slabs which might be used but now serve only as constant threats of destructive forest fire.

8

That vegetation can be chemically transformed into materials utterly unlike the stuff from which the materials originate is a source of constant wonder to the average human. Yet it should not be. In millions of forms, nature has been making these transformations in plain view of all human eyes right down through the ages.

The silkworm, doing the trick in one way, provided man with the ideas for today's synthetic textile fibers. The wasps probably taught ancient man how to make paper, another transformation of cellulose. The lac bugs, as we observed in Baekeland's story, provided the hints which were the starting points for those feats of modern alchemy, the production of thermosetting resins and synthetic enamels. Cows and sheep and elephants, as Dr. Barnard remarked in the introductory chapter of this book, employ their own peculiar methods of grass-transformation which, improved upon by restless man, enable him to convert the cow's milk into a reasonably close copy of the elephant's tusk or the sheep's wool.

Indeed, all living creatures—mankind included—are not only constant practitioners of the processes, but products thereof. Animal bone and horn and the carapace of the tortoise are some of the commonest products of nature's engineering in plastics.

Thus, there is at bottom no sound reason for the skepticism and the scoffing which greeted the early Ford predictions of the coming of the "farm-grown automobile."

All that was required to remove it from the realm of fantasy was a group of young minds "not too sure that certain things were impossible."

Chapter XXI

COFFEE, COTTON, CASEIN AND CHEMURGY

1

In his fascinating little book, *The Devil of the Machine Age,* Dr. J. Russell Smith, the famous economic geographer and authority on tree-farming, shows with disturbing logic how the spreading revolution rocking the foundations of modern society is the outward manifestation of a conflict raging in every human mind. As consumers, says Dr. Smith, all of us desire abundance ardently; but, as producers, we are constantly striving to maintain a condition of scarcity.

No human, he adds, can stand on the outside of our economic system and throw pharasaical stones at it without hitting himself, for all are equally guilty of planning for scarcity while helping machines make abundance.

Among a wealth of case histories with which Dr. Smith sharpens the barbs of his convincing indictment, the case of Brazilian coffee is cited as one example of how the farmer has had to veer around finally and belatedly to the Devil's corner as a champion of the cause of relative scarcity.

Brazil produces more than half the world's coffee. Because coffee can be stored for years and because coffee trees produce for years, the accumulating abundance of coffee ultimately forced its producers to seek relative scarcity or face economic ruin.

So, collaborating with their government and acting in strict accordance with the basic tenet upon which economic theory rests, Brazilian coffee growers set out to create that element of scarcity without which, as David Ricardo, the famous economist, pontificated in 1817, "there is no value."

The first assault on coffee abundance was storage and price control by governmental decree. It failed. Next, ships, loaded with coffee, steamed out to sea and crews spent hours tossing coffee overboard. Some 6,000,000 bags of abundance were wiped out in this way before the method was abandoned because it used too much labor. Then the surplus coffee was sprayed with creosote to keep it out of coffeepots. That method was abandoned when some ingenious Brazilian hit upon the less wasteful idea of mixing the coffee with tar and pressing the mixture into briquettes for use as fuel.

And, while all of these onslaughts on abundance were being made in Brazil, other nations expanded their coffee acreage until they were able to come into the market. Like the later attempt to create cotton scarcity in the United States, the Brazilian coffee-control scheme collapsed, a dismal failure of man, the producer, to stave off the abundance which he, the consumer, constantly strives to attain.

2

In 1941, after the Brazilian government had bought and destroyed more than 70,000,000 bags of coffee in a decade, there appeared the first ray of hope that the surplus might have chemurgic value. Instead of briquetting and burning the abundance, Brazilians happily contemplated using it as a plastic, and were lauding, as the United States' best ambassador of good will to Brazil, the young chemist who had found a chemurgic solution for their perplexing problem.

Herbert Spencer Polin was Brazil's favorite North American in 1941. A Californian, he interested himself in coffee in 1936, when he, then only twenty-seven years old, was hired by the

Atlantic & Pacific Tea Company to conduct research on improved roasting methods.

Polin had studied science at a number of universities without ever having bothered to pick up a degree. An ingenious experimenter, he has had patented about a hundred inventions, including a remote-control device for radio receiving sets and oil-burning furnaces, and ultra-high frequency telephone equipment used on United States naval aircraft.

Around 1938 he began to think hard about those millions of bags of coffee being destroyed annually. Being young and, therefore, inquisitive, he took some coffee beans apart chemically and found they contained *all* the chemical components of plastics. Quietly, on his own, he set out to develop a process for shuffling these chemicals around and combining them.

The method he finally hit upon was to grind the green beans, extract part of their oil and all of their soluble alkaloids (notably caffeine) with solvents, and cook the residual meal mixed with water and selected fractions of the distilled oil, in the presence of a catalyst in a high-pressure autoclave. After washing to remove the catalyst and other soluble material, the end product was a plastic powder, ready to be dyed and molded, under pressures of 2,500 to 5,000 pounds per square inch and at temperatures of 325 to 375 degrees Fahrenheit, into a plastic which Polin called Cafelite and pronounces ka-fay-lee′-tee.

Polin's findings were spectacular. The coffee bean, he discovered, uniquely contains not only the plasticizers and the bulk materials required, but also the dyes to color the finished article! At will, he drew greens, tans, browns and black from them. Other colors he found, but discovered that their extraction drew on chemicals needed for other qualities of his plastic. With the addition of dyes he ranged through the spectrum. The only color he could not attain was pure white.

Then he found that this miraculous stuff could be converted into both of the two distinct types of plastics—the thermoplastic resins which can be melted and molded as often as desired, and the thermosetting plastic which, once molded, remains permanently hard. Moreover, he found he could make it opaque or transparent, though never crystal-clear, and either rubbery or hard.

His findings were so startling that Brazil's President Getulio Dornelles Vargas dispatched a scientific mission, headed by Dr. Paulo Carneiro, head of the Technological Institute of Brazil, to his laboratories in Manhattan's Chrysler Building to investigate his claims.

From a 132-pound bag of coffee, Polin produced almost a hundred pounds of plastic material, a pound of caffeine, two gallons of oil, and small amounts of other by-products, including cellulose, furfural and vitamins D and E. Impressed, the scientists invited the young chemist to Brazil to try commercial production. Under the terms of an agreement which he signed, Polin leased his patents to the Brazilian government for fifteen years, during which time he is to serve as technical adviser at the plants built and operated by the government.

In September, 1941, the first plant began operations. A five-story factory at São Paulo, it can convert 50,000 bags of surplus coffee into 4,250,000 pounds of cafelite annually.

Early estimates were that cafelite could be sold in the United States for from seven to ten cents a pound, a price which would easily enable it to compete with many traditional materials now used structurally. As cafelite is the only cheap plastic which can be made without the use of chlorine derivatives, the wartime demands for chlorine contributed to its advantages.

Within a few weeks after operations started, the Brazilians were so well pleased that they awarded tentative contracts to a Pennsylvania company for machinery for a planned $3,500,000 main plant capable of converting 5,000,000 bags of coffee into 350,000,000 pounds of cafelite annually.

The magnitude of that proposed production moves into focus when it is remembered that the total current world consumption of plastic powders is somewhere between 500,000,000 and 750,000,000 pounds per year, or only about twice the planned output of the scheduled plant.

Neither Polin nor his Brazilian employers are worried about a possible glut of the plastics market; for until defense priority demands created a world shortage of plastics, consumption was increasing at the rate of thirty per cent a year. The only limiting factor on the horizon may be the chemical solvent which Brazil must obtain from the United States.

An entrancing aspect of this chemurgic triumph is that the new industry emulates the highly successful chemical industry in its ability to shift its productive emphasis to a number of several potentially valuable by-products.

The proposed plant will be able to produce, as a by-product, 5,000,000 pounds of caffeine a year. Though this is twice the world's present consumption of that soluble alkaloid, there is at present a war-induced shortage of caffeine, and larger markets are on the horizon because of recent discoveries of new uses for it.

As Dr. Hale has often pointed out, the mild and harmless stimulating effect of caffeine, plus the aroma of coffee, are the sole reasons for man's fondness for coffee. As Hale's Midland associates demonstrated, the aroma or flavor of coffee can be attained with any roasted cereal by adding roasted furfuryl mercaptan. Hence, if caffeine becomes plentiful enough, the coffee of the future might very well be a synthetic product, made of surplus cereal crops roasted, caffeinized and flavored but not containing the compounds trigonellin and potassium salt of chlorogenic acid which, present even in de-caffeinized coffees, are the real poisons in the brew.

The coffee oils extracted in the Polin process represent another rich store of valuable by-products. Their fractions can be used in soaps, paints, lacquers, polishes, waxes, food products, medicines, insecticides and vitamin sources. In the tin-plate industry they can serve in place of palm oil.

In his new laboratory in Rio de Janeiro, Pioneer Polin and his assistants plan for a future in which a troublesome surplus of coffee beans may alleviate, as plastic panels, a troublesome shortage of decent human shelter.

While he is busy making plans for the future, his Brazilian friends are well satisfied with his past achievement—an achievement which promises to convert a $50,000,000 annual waste into a profit.

3

The conflict between man the producer and man the consumer, though ancient and world-wide and cataclysmic, remains obscure because man manages somehow to maintain an egregious self-delusion that producers and consumers are two distinctly separate and different sets of people. That concept, though rooted deep in the human mind, is sheer nonsense. It clots all human thinking, especially in the field of economics where its prevalence constitutes the bed-rock of this most unscientific "science."

Thinking of themselves as producers, Brazilian coffee growers naturally brought only ruin upon themselves with their attempts to create relative scarcity. Just as naturally, salvation came only when their problem was examined by the open mind of a young man with the rare ability of thinking of himself as a producer-consumer, which, in reality, is what every human is at all times.

The same kind of thinking was responsible for an experiment which, launched in Mississippi, promised to provide as effective a cure for the ills arising from the South's cotton surpluses as Polin's remedy for the evils of Brazil's one-crop economy. Here, too, the solution came from a man with the rare ability to think of himself as both producer and consumer, at one and the same time.

4

As a trouble-shooter, D. Howard Doane of Saint Louis brought to the cotton problem the same kind of mental equipment that Herbert S. Polin brought to bear on the coffee problem—an open mind.

Unlike Polin, Doane is young only under the silvery thatch that frames his sun-tanned, grandfatherly face. No cotton farmer, he is currently showing cotton farmers that the proper first step toward profitable production of cotton is to shuck the mind of the constricting notion that "cotton is just cotton."

As head of Doane Agricultural Service, an association of farm management, appraisal and consulting engineers with headquarters in Saint Louis and branch offices in Nevada, Missouri, Quincy, Illinois, and Fergus Falls, Minnesota, Doane acquired intimate familiarity with most of the farm problems in the Middle West. Attending the first conference of agriculture, industry and science at Dearborn in 1935, he expanded his interests and became an active chemurgist.

As an expert in farm management, he had first-hand knowledge of all the dismal aspects of deposed King Cotton's crumbling domain, but the causes were somewhat obscure in his mind until he heard Dr. Herty expound his famous heresy: "Cotton isn't cotton. It's cellulose. And, under conditions as they prevail in the cotton business, a spruce tree or a pine tree is a better source of cellulose than a cotton boll."

In 1936 Doane set out to discover cotton—with the consumer side of his mind. What he discovered was that man the consumer was reducing his uses of cotton but increasing his uses of cellulose. Says he:

"When manufacturers found they could get cellulose fibers of uniform strength and quality year after year from rayon and similar synthetics, they turned away from cotton.

"They lost interest in this form of cellulose because of the mess created by the accepted belief that 'cotton is just cotton.' Clouded by that misconception, the crop moved from the grower to the middleman, who, destroying producer labels and identities, graded the product with flexible yardsticks of varying human opinion instead of using scientific measurements of quality, durability and uniformity."

Under such conditions, Doane adds, a manufacturer of, say, tire cords was unable to order a particular kind of cotton which his research department had tested and found exactly suited to his specific need.

"The cotton brokers just didn't know where those particular bales of superior fiber came from," he says. "And even if they had known, the odds were against the possibility that the grower could repeat the lucky freak."

So, ignoring entirely the productive aspects of the cotton business, Doane skipped around the country asking cellulose-users what they wanted.

One of the most amazing things he learned was that nobody wants pretty cotton, despite the fact that all planters have always striven to produce pretty cotton by sunning their crops to whiten them. So here was the ridiculous figure of man the cotton-consumer wanting strong fibers and not giving a darn about their whiteness, in conflict with man the cotton-producer wanting white cotton and letting the sun bleach the strength out of the bolls.

"Anybody who has ever used an awning," says Doane, "knows very well how oxidation and sunlight sap the strength of cotton."

Next he found that, from the consumer side of the problem, cotton is cottons. For tire cord, cotton is a fiber which can be spun into smooth, tough and resilient threads. For hosiery, it is a smooth, long, silky fiber that resists the destructive acids of perspiration. It is another and a different thing to the manufacturer of fire hose. Something else in a bath towel, a bed sheet, a sugar sack, a pair of overshoes. It is protean stuff—this cotton which cotton men have been calling "just cotton."

Then, after he had the answers for all the questions bristling in the consumer side of his mind, Doane went to a Mississippi plantation and opened the producer side of his mental tool kit.

The results, fully described at the 1941 national chemurgic conference in Chicago, were:

Five years of Doane's double-barreled thinking have put some 15,000 Mississippi Delta acres back into profitable cotton production by the simple device of growing cottons for specific uses.

Simple device? With the huge accumulation of human knowledge about genetics that has piled up since Friar Gregor Mendel officiated at the weddings of the peas in his monastery garden almost a century ago, it should have been simple.

But it wasn't. It didn't even look simple when Doane first looked at it in 1936. His first look encompassed vistas of ruin on the 7,000-acre Robertshaw Plantation, ten miles east of Leland, Mississippi. The plantation owners had called him in for ideas, his specialty. Before W. J. Godbold, the plantation manager, he laid out, one at a time, the ideas he had collected on the hooked question marks with which he had fished in the minds of cotton manufacturers. The two men sat for a long time contemplating the ideas. Result: agreement that they were good ideas.

Then Doane set out to find one of those youngsters who are "not too sure that certain things are impossible." The search brought him to John Oakley, a Starkville farm boy who was so bent on becoming an agronomist that he had put himself through Mississippi State College by working seven hours every night in a bakery while carrying a full college course. Doane knew that Oakley was his man when he learned that the youngster had piled up this accomplishment while contributing to the support of his widowed mother—and that he had saved $150 besides!

Oakley went to Robertshaw in June, 1936, and spent the rest of the summer examining each and every plant on the plantation's 3,000 acres of cotton. By fall, he had 1,400 of them tagged and described in a card index file. When picking time came, the black faces of the field hands framed wide, white crescents of laughter when he brought them their picking sacks—little paper bags!

Each ticketed boll went into its own marked bag. All that winter Oakley and Godbold were busy, opening bags, pulling bolls apart, classifying, reclassifying. Sometimes Doane joined them. In the cabins, their conduct was the chief topic of discussion, sometimes with laughter, more often with awe.

Old Lon Applewhite, Godbold's house servant, became an authority on the daffy doings up at the big house. But even Lon was puzzled. "I dunno," he said. "Dey poke 'n smell 'n poke some mo'. . . . Hit look lak dey makin' taffy."

By spring of 1937 each boll had been separated into seeds and fibers in a miniature gin, and the fibers had been tested here and in the laboratory of a government researcher who had developed special character classifications for cotton.

What followed was standard plant-breeding practice. Planting of identified seeds in marked areas of an experimental plot. Hand pollination. Prevention of crossbreeding by protection of buds with paper bags. Repeated inbreeding until individual characteristics were clearly evident. Crossbreeding to bring out dominant and desirable traits.

To satisfy the demands of tire cord and awning manufacturers Doane and Oakley bred a cotton with a tensile strength of 80,000 pounds per square inch. And, by fall of 1941, when they brought into market fibers with a strength of 101,000 pounds, there was no dearth of customers for their product. Moreover, these experimenters are producing bales of cotton with a uniformity of staple-length far greater than any market has ever demanded.

Throughout the United States South, wherever "cotton is just cotton," the labor is still being put into this crop for which the demands have been diminishing. It goes into overstuffed warehouses, and the people of the United States, who might consume it but do not, continue to pay for the labor incorporated in it—pay for it, in a roundabout way through taxation, while depriving themselves of the benefits it could certainly bring to them as consumers.

In sharp contrast to this ridiculous condition is the case of the 15,000 acres of tailor-made cotton grown in Mississippi's central Delta region in 1941 from Robertshaw seed. Hauled to the Robertshaw gin, classified, baled and marked with one of the four "Bobshaw" brands, it moved to the compress of the Staple Cotton Co-operative Association at Greenwood, Mississippi, and thence out to the mills and into consumption. The labor incorporated in it is *used,* not wasted. The product of that labor moves steadily and constantly from producer to consumer, who—remember!—is one two-sided human. It moves. And the fact that it moves fits it into the economy of abundance which—unlike the hard-dying but definitely decadent economy of scarcity with which it is in conflict, interposes no circuit-breaking warehouses between man the producer and man the consumer.

The lessons which Doane and Oakley and the men of Robertshaw learned are being studied in the South. Studied and put into practice. Neighboring planters, studying the Robertshaw methods, noted that soy beans were planted between the cotton rows. They emulated that and learned the reasons. They saw Oakley experimenting with castor plants, and they didn't laugh. They watched a new laboratory being built on Robertshaw

Plantation and learned it was to house Oakley and his research assistants' experimental attempts to turn out at least twenty-five distinctly different cottons for as many individual uses.

And Howard Doane, whose idea this all was, is not quite satisfied. He foresees the possibility that the experiment will help lift the South out of its sorry plight, but he will not be satisfied until it actually does just that.

"It has given the southern farmer a long-needed chance to do some long-range thinking," he says.

5

Long-range thinking is being aimed from many directions at the South's one-crop economy. More and more Americans are looking quizzically at those government warehouses bulging with cotton produced and paid for, but not consumed.

It is natural that people, being in a quizzical mood, should try to dovetail a surplus into a shortage; so it is not astonishing that surplus cotton should slowly and steadily gravitate toward the housing shortage.

The classic example of such gravitation is the idea developed by J. Harris Hardy, another Mississippi cotton planter, who perfected and patented a cotton-cement roof shingle which is ideally suited to use in the South because it is best manufactured right on the building site.

Unlike many substitutions, Hardy's product replaces nothing which is already in use, but merely adds to existing materials cotton's ability to make them more satisfactory.

Hardy's shingles are thin concrete slabs with cotton fabric cores which hold the cement together. Dyed in any color or combination of colors desired, and capable of many modifications of surface texture, they are applied to the roof immediately after they are made and while still wet, and thus shape their own perfect bearing surface. Nails not only bond with the cement, but the shingles bond together.

Within a few months after the idea was patented, exhaustive tests proved its values so thoroughly that, after the first commercial application in Jackson, Mississippi, in June, 1941, it was proved that the process could be used to make floors, wall tiles and sheathing. It was estimated that the use of the shingles alone could absorb 1,000,000 bales of cotton annually.

Cotton duck is increasing constantly in use as building material. As early as 1934 the New Uses Division of the United States Department of Agriculture built, at Northport, New York, a demonstration house with an outer coat of duck over conventional wood sheathing. Hundreds of houses now incorporate cotton fabric in their structure. One of the latest developments of the idea is the use of fire-resistant canvas, bonded to plywood or tongue-and-groove sheathing with a thin layer of bedding cement, as an exterior surface.

Steel wire-mesh lath with cotton fabric backing is the least expensive base for plastered partition walls. The steady trend toward prefabrication of larger and larger building-units has produced resin-bonded plywood-cotton panels, fire-proofed cotton quilting for insulation, and a panel material which, being a three-layer bond of steel, canvas and plywood, combines the best qualities of the three materials.

All over the country the cotton mats, which were developed by the United States Bureau of Roads and the Texas State Highway Department, are being used to cure concrete in highway construction, and another kind of cotton fabric is used to hold soil in place on fresh embankments until vegetation can take root and check erosion.

Such trends were of course stimulated enormously by the multitudinous and pressing needs of the American defense effort. The chemurgic investigations of cotton mesh as binder for bituminous roads, for instance, provided emergency highways in a hurry. A rubber company, having developed a self-sealing inner-liner to prevent gasoline leakage from airplane fuel tanks punctured by bullets, found that the flared metal of the tanks, when hit by .50 caliber projectiles, prevented the sealing material from closing. The chemists solved the problem by perfecting a sheet material composed of cotton duck and rubber. Lighter than aluminum, it was formed into fuel tanks which sealed themselves perfectly.

Though the threat of war was far from the minds of the chemurgists when they assembled for the first time at Dearborn in 1935, there obtruded from the complexities and confusions of the world scene seven years later a thousand and one sharp bits of evidence that almost every chemurgic step taken in those seven eventful years had been helpful to the defense of America in war.

And when war finally came to America, the deluge of emergency demands threatened to engulf the long-range objective of the chemurgists—the persistent, perhaps pathetic, hope of a pacific world of independent nations striving to find the more abundant life for their peoples through mastery of nature's secrets for man's peculiar purposes.

At the close of 1941, man's peculiar purposes seemed to work as much as possible at cross-purposes in a deepening fog of confusion twice and thrice confounded.

6

Ironic was the war's effect on some of the chemurgic developments.

Take, for example, the case of the surplus casein which had been the subject of years of study by Dr. Francis Clark Atwood and his Atlantic Research Associates at Newtonville, Massachusetts. Backed by National Dairy Products Corporation, Dr. Atwood finally developed, in 1940, a good use for the billions of pounds of casein wasted annually in the United States.

From this milk-waste, he and his associates derived a protein fiber called "Aralac." The product arrived just in time, for it proved to be a perfect substitute for the rabbit fur which, used in felt hats, was then unable to reach America from war-blockaded foreign sources.

In World War I, hat fur prices rose rapidly from one dollar and fifty cents to ten dollars a pound. By 1941 they rose to five dollars, and the resultant shift to the casein fiber, which proved to be equivalent to the superior beaver fur, moved the Atwood research project out of the laboratory and into manufacturing practice in a new factory in Taftville, Connecticut.

The casein fur having been used in 50,000,000 hats in 1940, the Taftville factory was equipped to produce annually 5,000,000 pounds of the fiber—the casein equivalent of 160,000,000 pounds of skim milk. The outlook for ending the notorious waste of skim milk brightened still more when in the spring of 1941, the fiber was found to combine well with wool, cotton, rayon and fur, and, passing all dry-cleaning, dyeing and wear tests, was snapped up by the cloak-and-suit trade in the fall of that year.

Then the irony emerged.

The federal government suddenly ordered all available skim milk in the United States to be turned into milk powder for Great Britain. That order cut the base from under this chemurgic development. The project, undertaken to find a use for a surplus, was left suspended in mid-air because the surplus had been wiped out by fiat.

Just before it happened, another use for casein was developed. At Long Beach, California, Sterling P. Hart succeeded in converting casein into plastic walls for oil-well bores by dispersing the milk-waste in muds circulated through the bores during drilling operations and then subjecting them to a second mud bath containing formaldehyde. The plasticizing action of formaldehyde converts the soil-embedded casein into a solid wall impervious to water at pressures up to 5,000 pounds per square inch.

But this, like many another chemurgic achievement in the conversion of waste into wealth, seemed destined to be shelved "for the duration" after the Axis powers aimed their program of mass destruction at the nation whose peculiar genius is mass production.

To keep their infant chemurgic industry going as a preparation for that distant day when America's mass-productive ability may again produce surpluses, the Taftville pioneers imported casein from the Argentine. Only a few months earlier the stuff was so abundant in the United States that the best use that could be made of it was to hand it back to nature as fertilizer dumped on America's prolific acres.

Almost overnight, war's tremendous destructive force turned huge surpluses into vital necessities.

The breath-taking speed with which such changes swept upon us engender the alarming realization that the superabundance of food which troubled us only yesterday can very easily vanish overnight, throwing us back once more to that grim day-before-yesterday when the specter of famine troubled the dreams of all humankind.

The margin of abundance between ourselves and the condition of continuous scarcity under which our ancestors lived in fear for thousands of famine-scarred decades, is not, we now discover, as stout a bulwark as it seemed only a few months ago. Like those "great, wide oceans" which Americans contemplated with such heart-warming self-assurance yesterday, these accumulations of abundance, heaped up by the accidental population of an extraordinarily fecund land by an exceptionally productive people, are shrinking fast under the impact of the mass-destructive forces of the Old World.

Can we save the slim margin of security?

Out of this clash—this suicidal revolution against scarcity, will the long-range objective of the chemurgists emerge strengthened?

The signs are hopeful.

Speaking to his troops on the eve of battle in North Africa, British General Sir Archibald Wavell asked:

"Have you ever thought what a world we could make if we put into peace endeavors the energy, self-sacrifice and co-operation we use in the wastefulness of war?"

If such questions can trouble the minds of men trained in the business of destruction—trouble them at the very moment when they are concentrating their whole attention upon their grim business—then there is reason for hope.

Nothing now is distant. The nations, once distant, are being pulled together. There can be no isolation now. The huge melon-size planet upon the surface of which we humans crawled laboriously until yesterday, began to shrink when we took to wings. Tomorrow it will be a pea-size world. Whether the human inhabitants remain masters of that shrunken world depends on how the majority of those humans answer the outraged question which the race's earliest recorded destroyer asked:

"Am I my brother's keeper?"

Until now, Americans have tried to ignore the question. Now they know they must answer it. That discovery is part of their discovery of America.

THE END

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