JANUARY - 1945

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# Scientific American

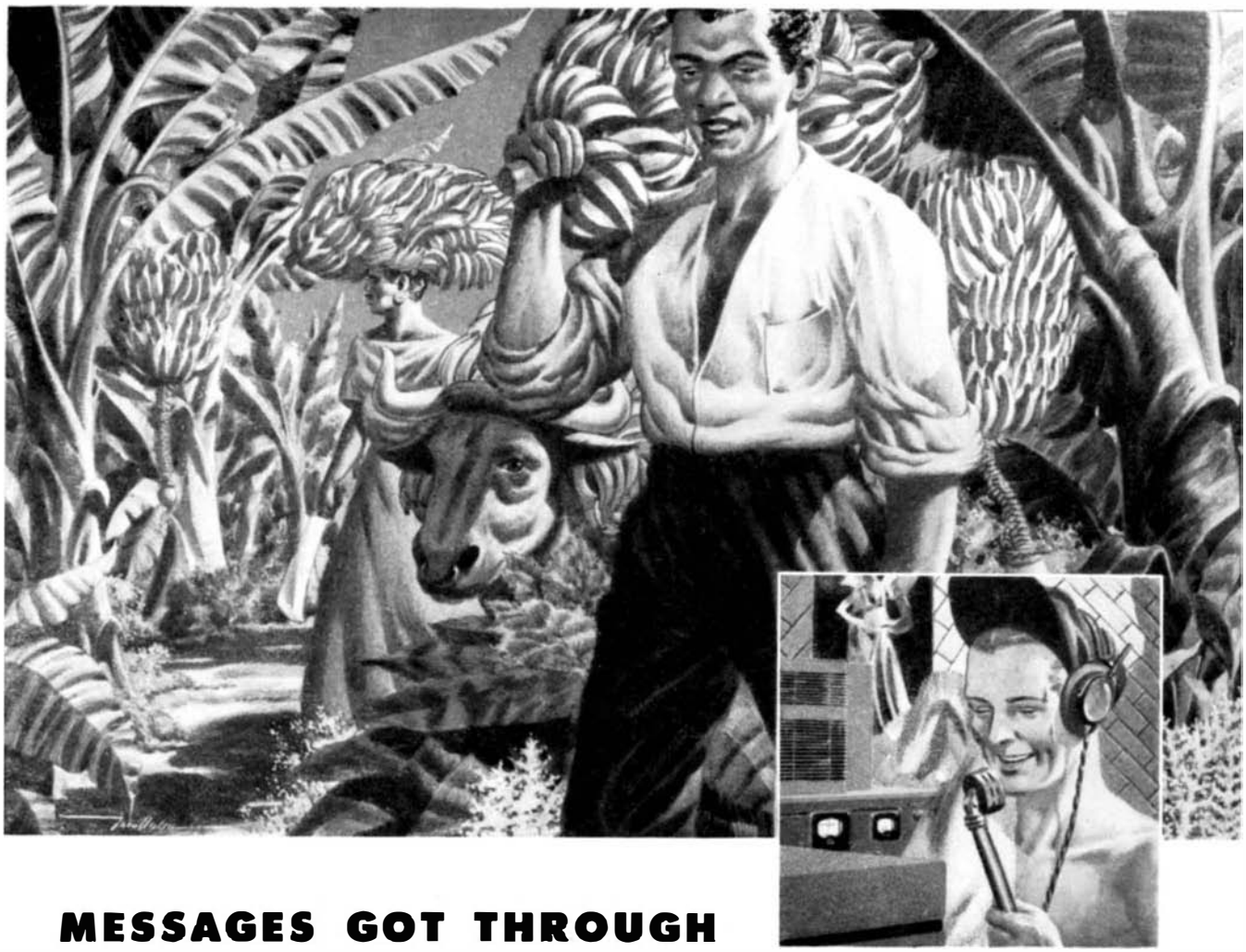
★ 100th Anniversary Year ★

REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY

Exploring New Paths for Industry . . . See page 1

## The Story of INDUSTRIAL RESEARCH

Anniversary Issue No. 1



# MESSAGES GOT THROUGH ON THE "BANANA NET"

THERE is many an exciting story about how amateur radio operators now in the services have helped extend the lines of victory around the world. There's the one about the "Banana Net"—the name the boys gave to the radio network down in the Panama jungle. As the G. I's have it, "it rains continually during the rainy season but only once a day in the dry season". The "Banana Net" is just one link in the vast network set up by the AACS—Army Airways Communications System. The AACS safeguards tens of thousands of lives by relaying weather reports, coordinating information on enemy movements and by bringing home or locating flying ships that are down or in trouble.

The ranks of the far flung AACS are filled with one-time amateur radio operators. Amateurs have always found in Hallicrafters equipment the perfection they themselves have been seeking. For these exacting technicians Hallicrafters made superior equipment long before the war. As a matter of fact thousands of pieces of privately owned Hallicrafters equipment were drafted into the services right along with the amateurs who once operated them. After the war Hallicrafters will have a new kind of radio ready. Discriminating listeners will want the radio man's radio—the radio that has an amazing range and performance on all bands, short wave and regular broadcast.

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# Scientific American

Founded 1845

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**Our Cover:** Taken in one of the research laboratories of the Aluminum Company of America, this photograph graphically illustrates the dependence of many industries on chemical research. It points up in particular the article on page 35.



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# Previews of the Industrial Horizon

*By A. P. Peck*

SINCE THIS number of Scientific American, the first of 12 100th Anniversary Issues, is devoted to reviews and previews of the past, present, and future of industrial research, it is fitting that this month's Industrial Horizons be scanned through the eyes of outstanding men of science and industry. The following quotes fit neatly into the integrated pattern of things to come out of the research laboratory and of the increasing consciousness of industry's stake in society.

### COMPETITION AND NEW INDUSTRIES

"IT IS ALREADY evident," says Dr. Harvey N. Davis, president of Stevens Institute of Technology, "that there is going to be in the post-war industrial world an unusual amount not only of inter-company, but also of inter-industry and even international competition. New industries, such as television and civilian radar, will be fighting for places in the industrial sun. New raw materials such as the light alloys and the plastics will be available to supplement or displace the more familiar materials of pre-war industry. New production processes such as hyper-milling, high-speed broaching, precision casting, and powder metallurgy will be competing with the more familiar machine-tools and process of pre-war production. All this welter of possibilities will necessitate a vast amount of industrial research if a firm or an industry is to remain or become prosperous. And there must also be intensive study of foreign lands both as markets and as sources of imports as a basis for post-war trade."

### ROCKETS IN THE FUTURE

"WITH MILLIONS being spent in the development of jet-propulsion engines and airplanes," according to G. Edward Pendray, assistant to the president of Westinghouse Electric and Manufacturing Company, "we can no longer look upon rocket power as a dream of the future. It is already big business.

"New post-war industries will spring from this enormous war-time development of rockets, rocket motors, jet-propulsion planes, and gas turbines," continues Mr. Pendray, saying further that "the effect upon us, as civilians, will be enormous. Jet propulsion and rocket power will provide new altitudes, new velocities, new power for aircraft, and new devices as important and revolutionary to human life as the invention of the airplane itself. The gas turbine, close relative of the thermal jet engine, is maturing so rapidly that, in a very few years, we may see it driving planes, locomotives, ships, and electric generators."

### GOVERNMENT AND RESEARCH

"THE JOB of normal peace-time research," says Hon. Robert P. Patterson, Under Secretary of War, "is a private job, not a government job. Those branches in which the government will continue in the principal role are well known: in no way do they conflict with the scientific functions of industry or university. What the government may do, if it is called upon, is to furnish information and financial support. It may furnish counsel, even leadership. It must not, in the normal researches of peace, assume control."

### A NEW KIND OF INDUSTRIAL COMPANY

"I BELIEVE quite simply that the small company of the future will be as much a research organization as it is a manufacturing company, and that this new kind of company is the frontier for the next generation." So said Edwin H. Land, president of the Polaroid Corporation, speaking at a recent forum on "The Future of Industrial Research," sponsored by the Standard Oil Development Company.

"Internally this business will be a new type of social unit," continued Mr. Land. "There will be a different kind of boundary between management and labor. All will regard themselves as *labor* in the sense of having as their common purpose learning new things and applying that knowledge for public welfare. The machinist will be proud of and informed about the company's scientific advances; the scientist will enjoy the reduction to practice of his basic perceptions.

"Basic research" in these companies of the future, as visualized by Mr. Land, "will be so thorough that the equipment required for manufacturing will be light weight and automatic, requiring relatively small capital investment and relatively few operators. The essential technique for increasing the amount of work to be done during the next generation should be the multiplication of fields of activity rather than the multiplication of operators required in any particular activity."

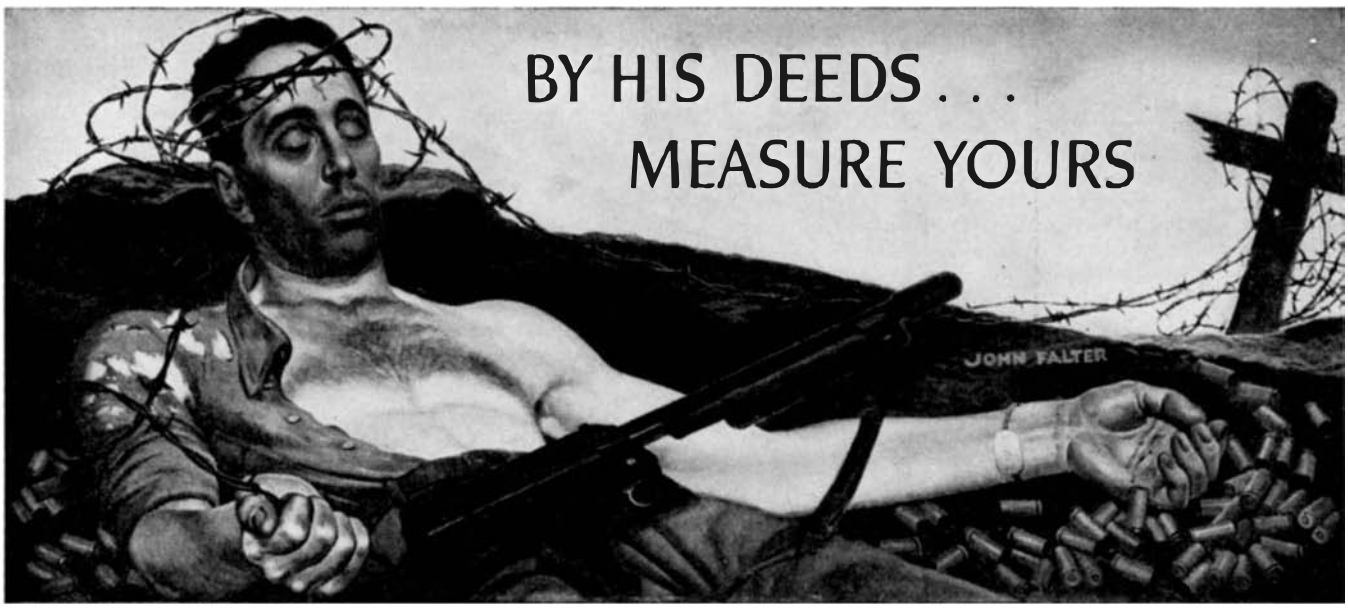
### MANAGEMENT AND RESEARCH

"WISE MANAGEMENT," says Dr. Frank B. Jewett, retiring vice president of the American Telephone and Telegraph Company in charge of development and research, "will see to it that those who direct its research and development organization are an integral part of its policy-making group. Such participation imposes a grave responsibility on the directors of research and development. They must be more than able scientists and technologists—they must be industrial statesmen capable of viewing the problems and accomplishments of the laboratory not only as scientific achievements but as part of an economic and social structure. They must be capable of discarding work—no matter how interesting technically—whenever it is clear that it does not fit into that structure. On the other hand, they must be prepared to support to the limit those undertakings which they are convinced *do* fit into the economic and social structure, even though their less informed associates in management think otherwise."

### SCIENTISTS ARE PEOPLE

IN DISCUSSING the oft-proposed thought that placing all industrial research under governmental direction would result in accelerated progress, Thomas Midgley, Jr., then president of the American Chemical Society said, just before his recent untimely death: "I have read the various Kilgore Bills and the arguments for and against; but I must confess that I simply cannot understand the logic involved. Somehow, it seems to me, the proponents of this and similar proposals assume that research scientists are going to work largely for the purpose of presenting the results of their labors to society free gratis, without any desire for rewards for themselves. It is quite true that scientists, as a group, are more willing to work for the sheer joy of satisfying their inquiring minds than are most other people; but it is also true that scientists have wives who want new automobiles and fur coats, quite like physicians' and lawyers' and judges' wives do, and scientists have children, just as other folks do, and scientists like to feel that they can raise and educate these children, like other folks do, and to do it they are deserving of an opportunity to obtain a financial reward that is somewhat proportional to the services they render society. I have never been able to figure out where they get it under the Kilgore proposal."

IT is not pleasant to have your peaceful life upset by wartime needs and restrictions and activities.... It is not pleasant to die, either.... Between you who live at home and the men who die at the front there is a direct connection.... By your actions, definitely, a certain number of these men will die or they will come through alive. If you do everything you can to hasten victory and do every bit of it as fast as you can... then, sure as fate you will save the lives of some men who will otherwise die because you let the war last too long.... Think it over. Till the war is won you cannot, in fairness to them, complain or waste or shirk. Instead, you will apply every last ounce of your effort to getting this thing done.... In the name of God and your fellow man, that is your job.




The civilian war organization needs your help. The Government has formed Citizens Service Corps as part of local Defense Councils. If such a group is at work in your community, cooperate with it to the limit of your ability. If none exists, help to organize one. A free booklet telling you what to do and how to do it will be sent to you at no charge if you will write to this magazine. This is your war. Help win it. Choose what you will do—now!

***EVERY CIVILIAN A FIGHTER***

CONTRIBUTED BY THE MAGAZINE PUBLISHERS OF AMERICA

# 50 Years Ago in . . .

## SCIENTIFIC AMERICAN

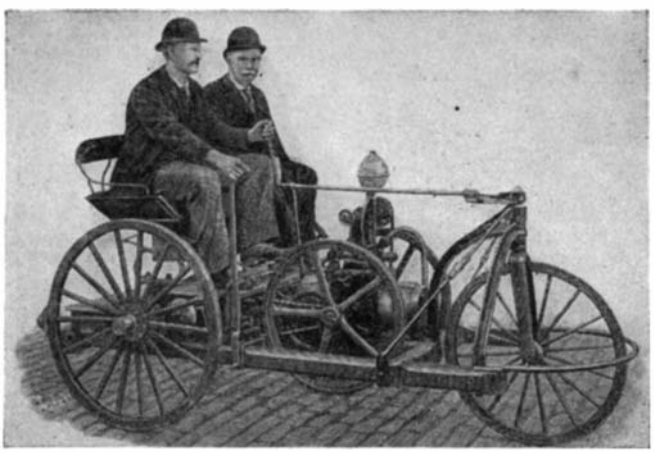
(Condensed from Issues of January, 1895)

**PNEUMATIC TIRES** — "An interesting series of experiments have been made recently to test the difference between the road friction of a carriage with and without the modern pneumatic-tired wheels. . . An obstruction 5/16 of an inch high was placed in front of each carriage, and it was found that 25 pounds was required to haul the steel tired carriage over the obstruction and but 11 pounds to draw the pneumatic tired carriage."

**ANESTHETIC** — "The fiftieth anniversary of the first use of anesthesia for the purpose of relieving pain was commemorated recently."

**CANALS** — "It has long been proposed to enlarge and generally improve the canal routes connecting New York with Philadelphia and Chesapeake Bay, and it now appears that this work is to be accomplished. . . The latest report of the surveyors of the Delaware and Raritan Canal stated that the full length of their proposed new route would be 32 miles. . . It is, furthermore, proposed to make connections with the Dismal Swamp Canal, and to widen and deepen this canal."

**GAS ENGINE TRICYCLE** — "The accompanying illustration shows the latest improvement in adapting the gas engine to the running of wagons on ordinary roads. This tricycle is



propelled by a two horse power Golden Gate balanced gas engine. . . It carries twelve hours' supply of gasoline, or two and one-half gallons, and can easily attain a speed of from ten to twelve miles per hour on favorable ground."

**BUILDING CONSTRUCTION** — "The Real Estate Record commented some time ago upon the immense reduction that has been made within the last decade, in the cost of building. Office buildings that cost $1.50 per cubic foot, and even more, can be produced by modern methods for 30 or 40 cents a cubic foot. This reduction in cost is due in no slight measure to the employment of mechanical devices in building operations. . . The employment of steam power in the mechanical operation of building has, however, by no means reached its limit."

**HYDROELECTRIC POWER** — "An ambitious plan for utilizing the waters of the Susquehanna River as a means of generating electric power is about to be carried out. . . It is proposed to dam the Susquehanna River near Conowingo, Maryland, and erect a large electric power house, similar to the one now in operation at Niagara Falls. The power obtained in this way will be supplied to Philadelphia, Wilmington and Baltimore, and other intermediate points. . . It is understood that the Westinghouse Electric Company are behind the project."

**TIME SIGNALS** — "Every day at noon a signal is sent to various parts of the country by telegraph, so that all operators and railway men who hear that signal can set their clocks at noon within two or three seconds. People who live near railway stations can thus get their time from it, and so exact time is diffused into every household of the land which is at all near a railway station."

**ELECTRICITY** — "The influence of electricity upon the vital forces of plants and of animals is not well understood. Its effect upon chemical changes and transformation is only partly comprehended. An electrical current destroys, disintegrates and decomposes. It also builds up, develops and perfects chemical combinations. . . The development of electrical science has been so rapid that an expert electrician would find it difficult to keep informed in regard to its new applications to industrial art in all lines. . . It has been recently discovered that caustic soda is cheaply produced by passing an electric current through a solution of salt."

**COPPER** — "The largest copper smelting property in the world is at Anaconda, Montana. During the past eleven years the magnitude of this plant and its results have been steadily increasing, till now the employes are numbered by the thousand, and the business aggregates over a million of dollars a month. . . From 1885 to 1892 inclusive the Anaconda Mining Company has extracted from the mines in Butte district over 450,000,000 pounds of copper."

**TELEPHONY** — "Despite its novelty, since the establishment of the first telephone lines dates back scarcely more than fifteen years, there are few industries of which we have had to record so numerous and so radical transformations as that of telephonic communications."

**FISH FARMS** — "The practice of raising food fish for market has become of late a very profitable industry, and in some parts of the country is being carried out on an extensive scale. The equipment of a fish farm, as it is called, is a very simple and inexpensive operation. Land which would be valueless for ordinary farming may be used for the purpose, the only requirement being a plentiful supply of good running water."

**GRADE CROSSINGS** — "The blindness of city officials to the great and daily dangers to which citizens are exposed by the practice of permitting street railways to cross the tracks of steam railroads at grade is becoming so serious a matter that some kind of a surgical operation seems necessary to restore their sight."

**BICYCLES** — "In cycle construction the reduction in weight has reached a startling point. Twenty-pound road wheels are plentiful, and the manufacturer who is carrying anything over 28 pounds is the exception and not the rule."

**TELAUTOGRAPH** — "The long-expected test of Gray's telautograph over the long-distance telephone line between Paris and London came off on the night of December 15, and resulted in a great success. . . The distance over which the writing was electrically reproduced was 312½ miles, and all agreed that it was a wonderful spectacle to watch in Paris the instantaneous reproduction of the movements of a pen in the hands of a man writing in London. Of the 312½ miles of line, 23 miles is submarine cable and 5½ miles consists of buried conductors at Paris. All of the English land line is overhead."

**NEW RAILROAD CONSTRUCTION** — "According to the records of the Railroad Gazette there has been much less railroad building in the United States during 1894 than in any year since the Civil War. Some 1,761 miles of new track have been laid in the year, which makes an addition of less than one per cent to the railroad mileage of the country, which at present is 177,753 miles."

# WAR *STILL* NEEDS THE WIRES THIS CHRISTMAS

**Please help keep LONG DISTANCE circuits clear for necessary calls on December 24, 25 and 26.**

BELL TELEPHONE SYSTEM

# THE DOUGH YOU BLOW —will bring U.S. woe!


**What a boom** we were handed by World War No. 1! Money came easily—went easily. Everybody was splurging on everything—from silk underwear to diamond sunbursts. Prices went skying. Sugar eventually hit 28¢ a pound!


**Bye-bye, boom.** Factories closed; men laid off. Prices and wages sinking fast. Wish we'd banked some of that dough we'd blown a few years back! With jobs scarce, that money would have come in mighty handy, then.


**Prosperity.** Stocks up fifty points in a week. Again everybody was buying everything—yachts, jewelry, stocks, real estate, regardless of cost. Depression? Phooey... we thought we'd found a way to lick depression.


**Or had we?** Bread lines, apple venders. WPA. "Brother, can you spare a dime?" No jobs. Prices dropping. Wages dropping. Everything dropping—except the mortgage on the house. "What goes up must come down."


**We're splurging again.** Americans have been earning more money. But even today there are fewer goods to spend it on—so naturally prices rise. We must keep them in check. DON'T LET *IT* ALL HAPPEN AGAIN!

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## 4 THINGS TO DO to keep prices down and help avoid another depression

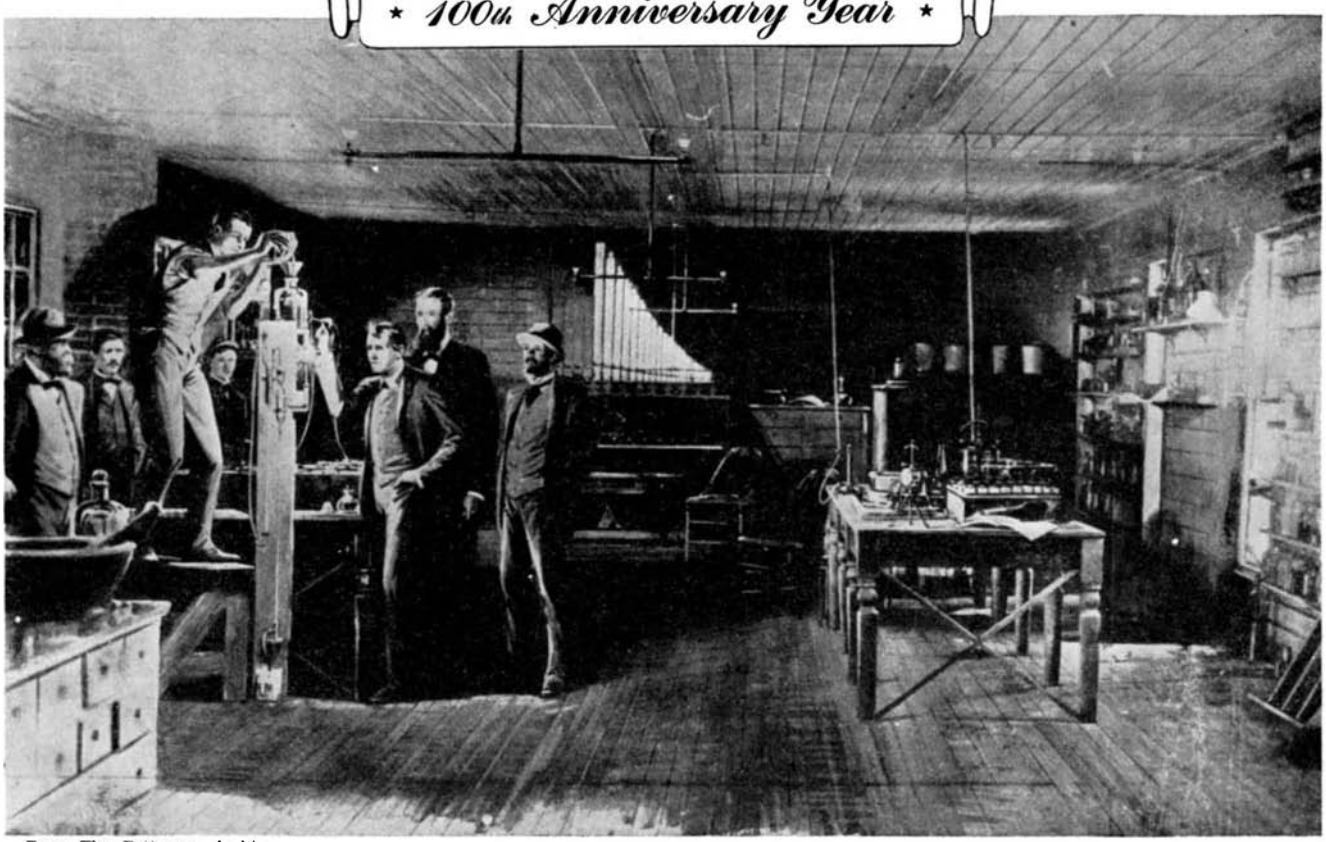
1. Buy only what you really need.
2. When you buy, pay no more than the ceiling prices. Pay your ration points in full.
3. Keep your *own* prices down. Don't take advantage of war conditions to ask for more—for your labor, your services, or the goods you sell.
4. *Save.* Buy and hold all the War Bonds you can afford—to help pay for the war and insure your future. Keep up your insurance.

EVERY
WAR BOND
YOU BUY
WILL HELP
US
KEEP
PRICES DOWN

A United States War message prepared by the War Advertising Council; approved by the Office of War Information; and contributed by this magazine in co-operation with the Magazine Publishers of America.

Scientific American
JANUARY • 1945

* 100th Anniversary Year *



From The Bettmann Archive

**The dramatic moment when Edison's first successful electric lamp was lighted**

# Research Opens The Door

***How Industry Has Developed the Philosophy of Research, Changing the Picture from that of the Lone Inventor Struggling Against Tremendous Odds to the Broad Teamwork Programs of Today. Present Applications of Industrial Research Point the Way Toward Solving Some of Tomorrow's Important Problems***

*By* **CHARLES F. KETTERING**

*Vice President of General Motors and Directing Head of General Motors Research Laboratories*

IT WOULD hardly be fitting to begin an article dealing with the historical aspects of American invention and research without repeating Patent Commissioner Ellsworth's oft-quoted statement:

> "The advancement of the arts from year to year taxes our credulity and seems to presage the arrival of that period when human improvement must end."

Ellsworth has been credited with making this observation in the year 1844. Inasmuch as he was United States Commissioner of Patents at that time, he certainly should have known whereof he spoke. Personally, in the face of this statement, I would have thought twice before embarking on the publishing of a magazine to be called "Scientific American"—that is, if I expected it to have a bright future. But, since Scientific American has been published without interruption for 100 years, it is obvious that Ellsworth overlooked some pertinent facts.

Let us take a look at Ellsworth's America from our vantage point of 100 years later and see if we are able to uncover some of the facts which led Ellsworth to make such a sweeping statement. Let us suppose, for example, that in the year 1840 or thereabouts we lived in Cincinnati and we wanted to travel to the heart of American progress—New York. Would we board a plane and arrive there in a couple of hours or so? No, indeed. To get there we would have to use canal boats, horsecars, steamboats, and the then new-fangled railroad. And it wouldn't be a matter of hours: it would take anywhere from seven to ten days, depending on the limitations of each mode of travel.

When we arrived in the metropolis, would we be amazed at the sight that would meet our eyes? There would be Broadway, for example, a street of three- or four-story houses—no office buildings or elevators in those days because people lived and conducted their business in the same buildings. On the street would be quite a few brightly colored horse-drawn buses—no taxis or subways. We would see a man drawing water from a well and taking it into a

From The Bettmann Archive

**Charles Goodyear discovers vulcanization of rubber**

house, and the street-cleaning department apparently consisted of a drove of wandering pigs whose chief secondary function seemed to be getting in the way of the not-so-teeming traffic.

If we happened to look into one of the homes at night, we would find the only light coming from a whale-oil lamp or perhaps a gas fixture. The cooking in those days was all done in open fireplaces and on crude stoves, and all communication was by horse or shanks-mare.

As we look on these concrete evidences of "the advancements of the arts" to which Ellsworth referred, we can't help wondering just what he had in mind. People had been cooking in fireplaces for thousands of years and even the Romans had aqueducts—they didn't confine themselves to wells in the streets. The mail had been carried for centuries by the horse, which was almost as fast as the train or boat of Ellsworth's day. Where were these new things that indicated the end of human improvement?

Commissioner Ellsworth may have had in mind, as one example, Morse's telegraph, because it was in May, 1844, that the artist who tinkered with coils and batteries first sent over the wires from Washington to Baltimore the message "What hath God Wrought?" But I am pretty sure that Ellsworth didn't visualize at that time the Atlantic cable, Bell's telephone, Marconi's wireless, De Forest's electron tube, or television.

**SETTING THE STAGE** — That period of 100 years ago is one of the most interesting ones in the history of American invention. Things were beginning to happen all over the country that were destined to open the way for the tremendous American progress that was to follow. Up in Boston, Elias Howe had been working on a machine to sew seams mechanically to make clothes; in 1845 he entered his machine in a contest against five girls sewing by hand. Howe and his new sewing machine won because, as the judges said, his machine work was "neater and stronger."

A few years before, down in Connecticut, a bankrupt inventor by the name of Goodyear had smeared a piece of rubber with sulfur and left it lying overnight near a hot stove. It the morning he found the rubber had taken on entirely new properties; he had at last found the secret of vulcanizing rubber after a six-year heartbreaking search.

In 1847 a young man named Cyrus McCormick moved from Virginia to Chicago to set up a business there. Sixteen years before he had successfully demonstrated at the village of Steele's Tavern, Virginia, a machine that would mechanically reap grain faster than could be done by hand and with only a fraction of the labor. But it wasn't until 1840—nine years after he had invented the reaper—that he was able to sell one. By 1844 the McCormick homestead was a small industrial center, but McCormick moved his business to Chicago because he felt that the agricultural empire of the future would be on the plains.

Down in Kentucky, an ironmaster named William Kelly made a peculiar discovery when melting some iron to be used in casting maple-syrup kettles. He found that if a blast of air was blown through the molten iron, the carbon in the iron would burn itself out—in other words, the cold air would apparently heat up the metal. His young wife thought he was crazy and called in a doctor because every one knew you could cool coffee by blowing on it. But Kelly went on refining iron by this process and over in England, Henry Bessemer, who was working on the same process, invented the Bessemer converter. The age of cheap steel was born.

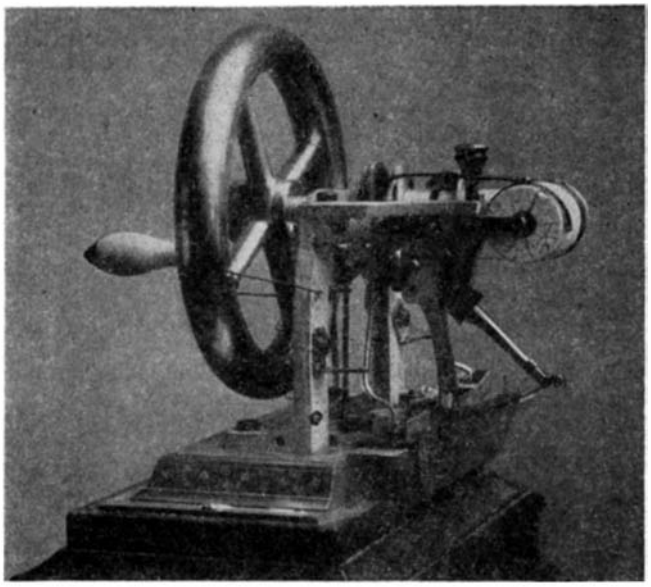
Looking back at that period, we now appreciate the fact that, simultaneously with the birth of Scientific American, men all over this country of ours were setting the stage for industrial America. Morse was laying the foundation for communication—McCormick was establishing the basis for our agricultural empire—Elias Howe was solving the clothing problem—Kelly had found a way to make cheap steel which, together with Goodyear's rubber and Col. Drake's oil, still to come, made possible the automobile industry that started some 50 years later.

**WHY MEN INVENT** — It is interesting to note that these men were all individualists just as were Sholes, Mergenthaler, Bell, the Wright brothers, Hyatt, and many other of the early inventors. These men, I believe, invented for one of several reasons: the problem became a religion to them, like Goodyear's search for rubber; in the case of Howe and the sewing machine, there was a belief that the inventor would make a fortune; or, in many cases, the inventors had a great desire to do a certain thing, like the Wrights who "just wanted to fly."

All these inventors had their troubles—financial, inexperience, lack of facilities, and, in nearly all cases, an outstand-

From The Bettmann Archive

**Otto Mergenthaler demonstrating the operation of the "blower machine," the first successful linotype, for Whitelaw Reid in the plant of the New York Tribune**



**Above: A working model of the sewing machine developed by Elias Howe and patented in 1846. Right: Howe, reproduced from an excellent daguerreotype**

ing lack of sympathy and understanding on the part of their contemporaries. We must remember also that, in spite of Ellsworth's conviction that "the arts" were highly advanced, some of the basic facts of physics, chemistry, metallurgy, and thermodynamics were just being uncovered—they were almost starting from scratch.

But such men as these set into motion forces of great magnitude and complexity. The nation mushroomed. Transportation and communication became global. Great industries covered the country. Education became almost universal and science made important advances. The problems of the individual inventors were becoming more and more complex, were calling for new methods of attack. The entire pattern of American life was beginning to change. Along with improved transportation and communication came increased industrial output—and competition. And along with these changes we see a gradual change taking place in the method of inventing—the lone inventors, suffering hardships and making sacrifices, gradually became fewer in number.

It is difficult to state definitely just when this change started to take place. Some people say that Edison was the link between the old school and the new school of invention and research. Be that as it may, I believe Edison did make one discovery which was not assigned to him by the Patent Office. In carrying on his many investigations involving the electric light, the phonograph, and the motion picture, he found that whenever he uncovered a fact in any one of these new fields it was just as though he was opening the front door to a whole house of facts. Facing him were scores of other doors crying for opening and investigation beyond.

All of these unopened doors which he faced in these many fields forcibly impressed upon him the limitations of individual investigation. One man could not hope to explore all these channels in a lifetime. So he hit upon a logical solution: he would hire assistants skilled in each line of endeavor to open these doors for him and to explore beyond. The result was, as a friend of mine describes it "the 'drafting' room of 50 years ago grew into the engineering department which in turn gave birth to the research laboratory." Industrial research as we know it today was born of this revolution.

Along with the necessary developments of modern industry have come a multitude of problems that would completely baffle an inventor of the old school. To appreciate this fully, let us take as an example a single improvement that was made in the suspension system of the automobile some years ago—independent wheel suspension, better known to some, perhaps, as knee action. This, as we know, involved replacing the front axle and leaf springs, heritages of the old-time buggy, with coil springs held between individually pivoted arms or "wish-bones." This arrangement not only allowed each front wheel to move independently of the other but more important, made possible the use of softer springs in front, thereby eliminating the uncomfortable "pitching" of the car when travelling over a rough road.

**INVENTOR AT WORK** — Now, it is quite conceivable that an idea such as this might originate with an individual (actually, the general idea is nearly 50 years old), but let's see what our lone inventor would have to do in order to have it materialize from the idea stage to the point where it becomes a feature of a standard car on the salesroom floor.

First he would have to do the paper work, as we call it. In other words, he would have to be a mathematician of a high order because the accurate calculation of spring rates, centers of oscillation, and so on, call for the generous use of mathematics. Then comes the matter of steering geometry, which means an accurate lay-out on the drafting board. But our inventor is a versatile man: he has worked this out and is now ready to build a model.

Since this model must be accurate in every detail, he had better be an A-1 tool and die maker with a well equipped machine shop handy, or be prepared to spend several thousand dollars to have it made. Let us assume he has crossed this bridge and that the model is ready for test. As is usually the case, it doesn't work, so he has to go through the whole thing again. Change this, change that. More time, more money. After doing this any number of times, the model finally acts as he planned it should.

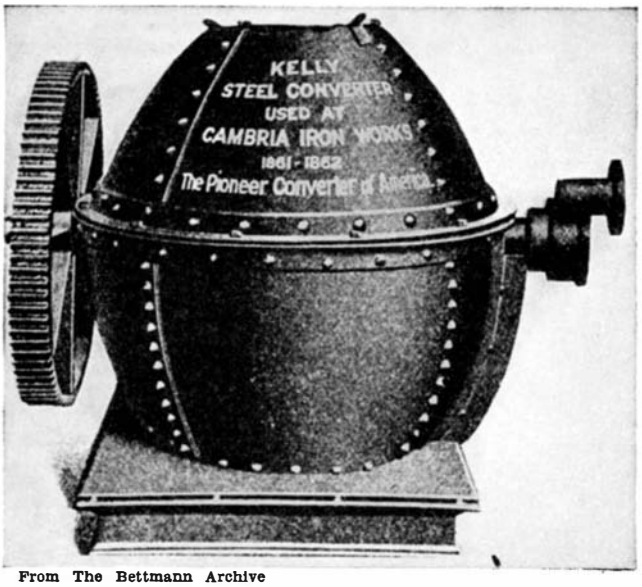
From The Bettmann Archive

But wait a minute; hasn't he forgotten something? Maybe someone else has had the same idea and it is covered by a patent! So he has a patent search made, which consumes more time and dollars and, if he is lucky, he finds the field is clear. So he has drawings made, and a lawyer draws up a patent application for him.

Now he has a model and has taken steps to protect the idea legally. It has taken time; perhaps a year or more has passed. But he is ready to make a working sample. So he selects a car which he feels would be suitable and proceeds to have the conversion parts made. His machine shop is inadequate for this larger work with its required forgings, castings, and so on. So he has to make new drawings, new calculations, and start at the beginning again. And that takes more time, more money.

Months roll by and he is ready for a road trial. But the working sample doesn't function like the model—a spring breaks, the wheels shimmy, or a hundred other things may happen and each one has to be ferreted out and corrected. To do this he has to be a metallurgist, a mechanical engineer, a mathematician, an optimist, and a very well-to-do man.

But we can readily assume that our mythical lone inventor is all of these, so the great day finally arrives when he is




From The Bettmann Archive

**The age of cheap steel was born when it was discovered that air, blown through molten iron in the Kelly "steel converter" would burn out the carbon**

to demonstrate his invention to the automobile company which he has in mind as the purchaser of his brain child. He proudly demonstrates the superior riding qualities of the "knee-action" car over a very rough road and awaits the reaction of the company's engineers. The engineers suggest that they return to the office at the plant; then they proceed to ask some very embarrassing questions such as: "How many thousand miles have you put on the suspension?"; "How does it work in hub-deep mud or water?"; "What is the effect of slush freezing on it in the winter?"; "What is your estimate of the additional cost of the new construction over the standard construction in car quantities of two million or so?"; "What is your financial proposition?"

Our friend is bewildered. He can only guess at the answers. The experienced engineers know that his estimates are far wide of the mark. But they agree that they should test the car on their proving ground in an attempt to try to find some of the answers. The results they eventually get are usually most discouraging to the inventor. If they find, though, that the idea has some merit, they make an arrangement with him and the whole repetitive cycle of design and test, production design and test, night and day, summer and winter, has to be gone through. This work involves scores of men—researchers, metallurgists, design engineers, chassis engineers, production men, test engineers, and lastly, the sales force.

There are many places for the inventor to become hopelessly lost in this process. He must have the faith of Goodyear, the creative ability of the Wrights, the patience of Edison, the business ability of Robert Fulton, the production knowledge of Ford or Knudsen—and, in addition, sufficient thousands of dollars to see the thing through.

**METHODS HAVE CHANGED**—Please don't misunderstand me when I paint this rather dark picture of the lone inventor's chances of succeeding in this modern world of ours. Don't get the impression that the chances of doing a new thing are impossible today. On the contrary, the chances are better than they ever were because we have a broader base upon which we can build. All I am trying to do is to point out that our methods of attack on the unsolved problems are quite different from those of a hundred years ago.

Perhaps I can better illustrate this fact by an actual example. Over 50 years ago Rudolph Diesel saw a Malayan fire syringe in a museum and hit upon the idea of using the same principle of compression-ignition as the basis of a new type of internal-combusion engine. After many unsuccessful attempts to apply the principle he at last produced a working engine. From the standpoint of thermodynamics it was a very efficient engine—in fact, the efficiency of the so-called Diesel cycle surpassed that of the Otto cycle commonly employed in the ordinary gasoline engine.

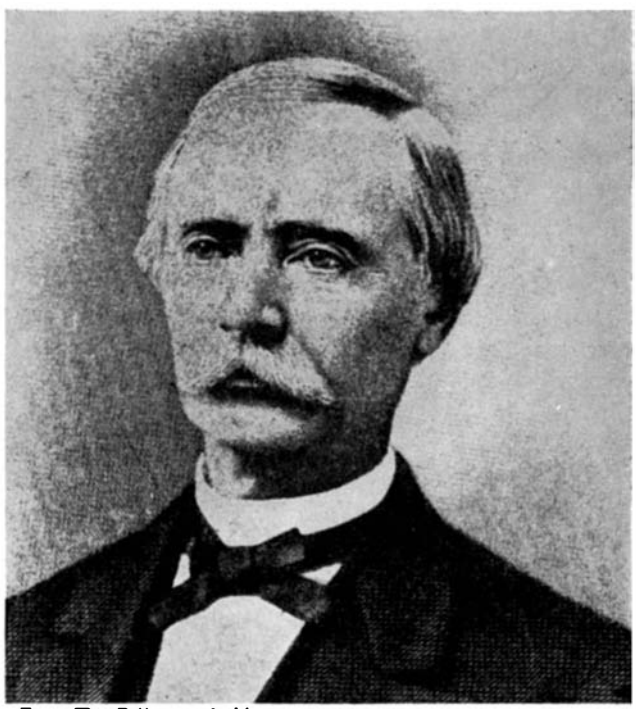
Unlike gasoline engines, however, Diesel engines were afflicted with several handicaps—they were large, heavy, and ran at slow speeds. In these respects they resembled steam engines more than gasoline engines. As a consequence, they were used principally in stationary power-plant installations and on ships. As time went on, the weight of the Diesels gradually came down as some of the structural features and materials used in the rapidly improving gasoline engines were incorporated in compression-ignition engine designs. But they still couldn't approach the gasoline engine on a power-weight ratio basis.

This was the situation in the 1920's when our research laboratories decided to take a fresh look at the compression-ignition engine. The first thing we had to do, of course, was to divorce it from the steam-engine and gasoline-engine schools of thought. We decided to attempt to design and build a compression-ignition engine like it wanted to be built and not like any other type of engine.

**PRODUCTION DIFFICULTIES** — To begin with, we started on the fuel-injection system, and after several years experimentation we arrived at the high-speed unit injector. Then we ran into the production fellows. The heart of the injector was the plunger which, in order to function properly, had to be fitted to the pump cylinder to an accuracy of a quarter of a tenth of a thousandth of an inch—less than one hundredth the diameter of a human hair. This is a far cry from the accuracy James Watt boasted of when he fitted a piston to a cylinder of a steam engine with a clearance of the thickness of a shilling. The production engineers threw up their hands, so we started our own precision injector department and solved that one.

In order to take full advantage of the compression-ingition cycle, we designed the new engine to operate on the two-cycle rather than the four-cycle principle. In other words, we would get a power stroke every revolution of the crankshaft instead of every other revolution. Theoretically this would give us twice the power from an engine of the same size. But this necessitated a blower to force in the fresh air. But this necessitated a new type of blower having spiral vanes. Again the production engineers were hesitant. So we had to develop at the same time a new machining operation. I bring out these points just to show how many angles there are to doing any new thing.

After these years of work we thought we had our problems just about licked but in reality we were just starting. This time it was the pistons which had a bad habit of seizing under the heat and high loads. So we began on the period of piston research and months and months passed



From The Bettmann Archive

**William Kelly, inventor of the "steel converter"**

before we finally hit on one that would run satisfactorily. However, after about 10 years of experimentation on the part of scores of engineers, designers, metallurgists, chemists, and production men—all working with every facility available, from electro-limit gages to dynamometers, milling machines, stroboscopes, and thermocouples—we had an engine to exhibit at the 1933 Century of Progress in Chicago. We ran it during the day and repaired it at night, but out of it all came a new, light, high-speed engine which the next year was installed in the first of the modern, high-speed, Diesel-powered streamlined trains.

**MODERN RESEARCH GROUPS**—The foregoing, I believe, gives a rough idea of how modern group research works. The man with the ideas, the man with the patience and persistence, the man with manual skill, the craftsman, and the man with ingenuity — each has his place in this picture.

From The Bettmann Archive

**Bell inaugurating the New York-Chicago telephone line in 1892. Right: A view of lower Broadway, New York City, in 1889, showing the vast maze of overhead wires just before they were placed underground**

Working as a group, they can do things that it would be practically impossible for them to accomplish individually.

From this little picture of a research project which I have given, you might draw the conclusion that the time, money, and effort expended is rather large just to get an engine for a streamlined train. But let's see what happened to that engine in the ten years after 1934. From the sleek, streamlined trains, it went into switching engines and then into freight service. A smaller version is being used in power generating units; it is being used also in both city and inter-city buses and trucks. On the water the use of the compression-ignition engine has spread in tugs and other boats. When World War II came along it powered submarines, and nearly all our landing craft, as well as many of our tanks and other heavy-duty land vehicles.

That is one thing that is certain: once a new idea is drawn out of oblivion, no one can predict just what will become of it or who will apply it to new uses. Take, for example, the case of F-12, or Freon. To get the background for this, it is necessary to take a look at the mechanical refrigerator at the end of World War I. It was in the kindergarten stage of development but we did recognize one fact about it. The gas refrigerant of those days had some very unpleasant properties: it was toxic and caused irritation and when the system sprang a leak in the home or in a hospital, the

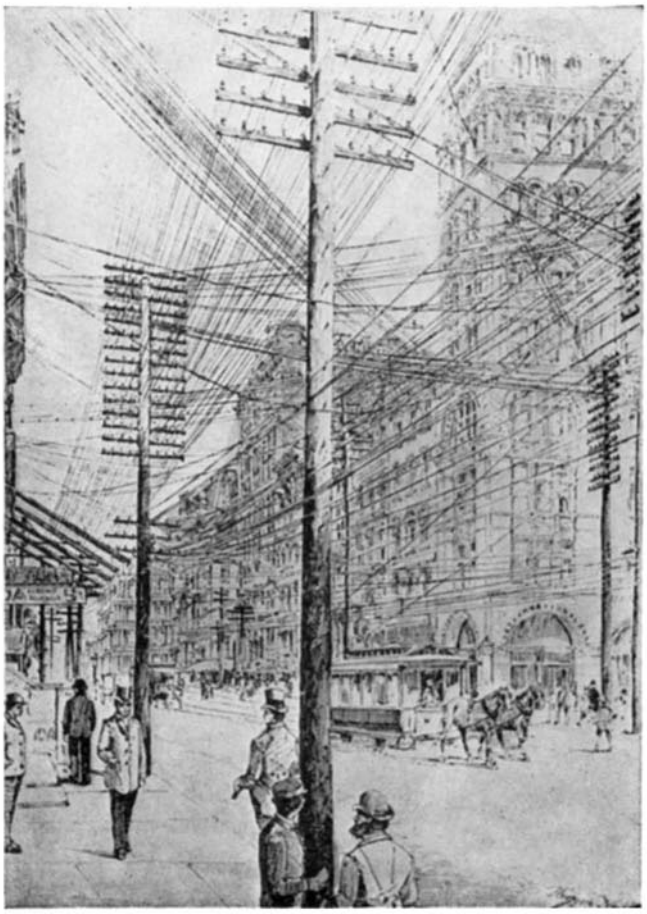
Copyright Edwin Levick

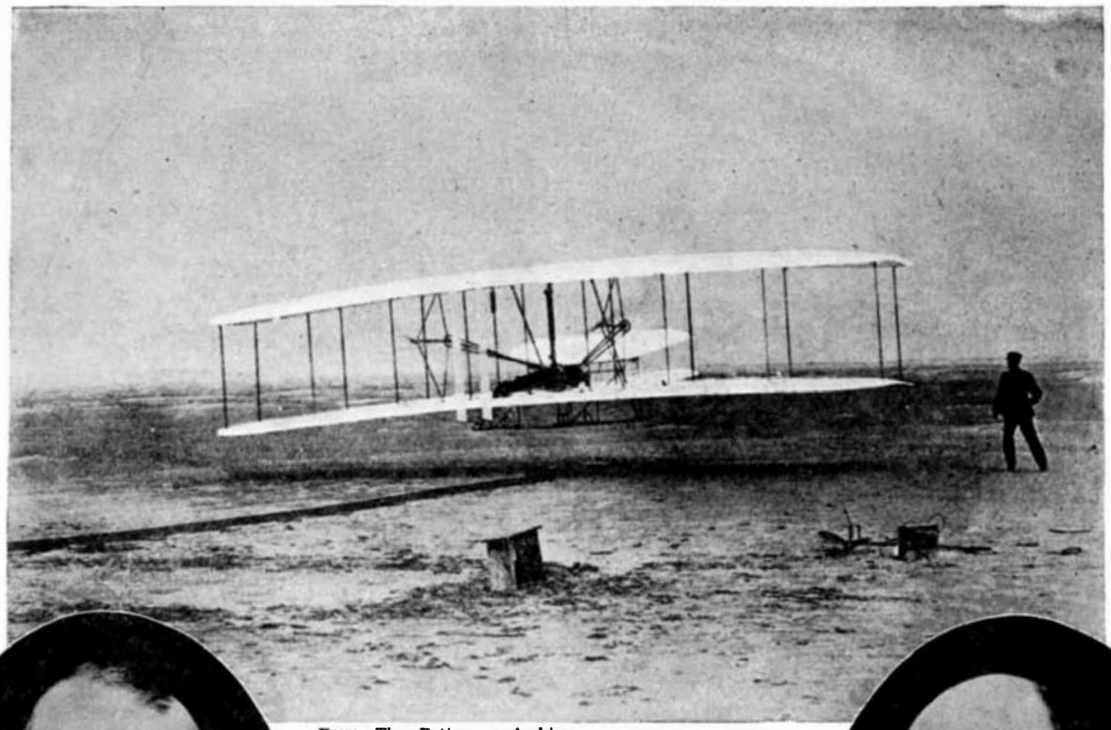
**Rudolph Diesel, who saw a Malayan fire syringe**

resulting effects could be quite harmful to human beings.

So our Organic Chemistry Department was assigned the job of doing something about this unhealthy situation. In other words, they had to find a new gas that would be non-flammable and non-toxic. After studying all available scientific tables and data it was found that only a few things would meet the specifications which had been set up, and that each one of these had some objections.

The most promising group of chemicals contained fluorine which, as every high-school chemist knows, has a bad reputation. Despite this, all the compounds were investigated in the hope that some fluorine compound could be found in which the bad qualities would neutralize each other. Thomas Midgley described this investigation in these words: "We





From The Bettmann Archive

**At 10:37 A.M., on December 17, 1903, the first powered Wright plane soared over the sands at Kitty Hawk, North Carolina. The take-off was from a wooden track seen at the left. Orville Wright was at the crude controls; Wilbur Wright, on the ground, guided the plane by running along on the sand**

**Left: Orville Wright**

**Right: Wilbur Wright**

plotted the boiling points, worked slide rules, brushed away eraser dirt and pencil shavings, and did all the other formalities that take the place of tea leaves and crystal balls in the life of a scientific fortune teller." After this had gone on for a long time, the search focused on one compound which, for simplicity, was called Freon.

To make this unusual compound, the research team found that in this country there were only five one-ounce bottles of the starting material which they wanted to use. One was selected at random and a few grams of Freon were prepared. A guinea pig was placed under a bell jar with it and, much to the surprise of a physician present, did not gasp and die—in fact it was not even irritated. When samples from the other four bottles were tried, the experiment did not work. By sheer luck the researchers had picked for the first experiment the only bottle containing a perfectly pure chemical.

As the result of the development of Freon, all risk of toxic harm was removed from household and hospital refrigeration and air conditioning equipment. But when World War II came along and our soldiers invaded the malaria-infested islands of the South Seas, Freon was called upon to do a new job. It was found to be the most effective carrier for the insecticide used to destroy the malaria-bearing mosquito. Still later it was also found to be a most efficient insulator for certain very important electrical equipment used by our armed forces.

Here, within the short span of less than 15 years, a gas designed as a refrigerant also plays the parts of an insecticide carrier and an electrical insulator—two uses which, by no stretch of the imagination, could possibly have been foreseen by the research men who originally produced it.

**INVENTION AND RESEARCH**— I believe that nothing better demonstrates the change which the world has undergone in the past century than a comparison of methods used by man in uncovering new facts a hundred years ago and today. Yet there is no sharp line of demarcation between Invention and Research, except for this distinction—Invention has to do with a specific result, while Research is concerned with the determination of those factors which may be necessary to the development of that result.

Today many people are confusing our geographical frontier with our mental frontier. When the first edition of Scientific American made its appearance, America was still a country of undeveloped resources, unexplored wilderness, and millions of uncultivated acres. Today these physical frontiers are practically gone and some people say we have no future —that we, as a nation, have reached our maturity.

But just as Morse, McCormick, Fulton, and Stevenson gave our forefathers the means of developing the frontier of a hundred years ago, modern science and research are putting into the hands of today's explorers the means of unlocking innumerable doors to undiscovered facts. It is easy to look back and marvel at our accomplishments of the past hundred years, but I had rather look ahead to the next hundred because there in the future the frontiers are limitless; or, to put it another way, as I have often said, there will always be a frontier where there is an open mind and a willing hand.

# Better Metals Through Research

**Outstanding War-Time Research-in-Metals Development is the Sharing of Data and Efforts by Manufacturers. The Inevitable Result is Better Materials and Methods for Peace-Time Products. These Will be Converted into Applications of Importance to Industry and the Public Alike**

DESPITE all the dramatic records established by our metal-working industries in boosting the production of existing plants and expanding the capacity of whole industries by new building and the use of efficient production methods, the war-time metals development of most potential significance to this country is what has been learned about metals research. It is metals research that has made possible war-winning materials, and metals research that has laid the foundation for the conversion of those materials into peace-time applications of importance to the industrialist and the ordinary consumer alike.

This war evolved something heretofore unknown in our history—an integrated non-governmental organization for carrying out and correlating industrial research in metals that blueprinted our conservation, alloying, capacity-expansion, and new-product developments on a scale beyond anything our enemies have approached or we ourselves had previously imagined.

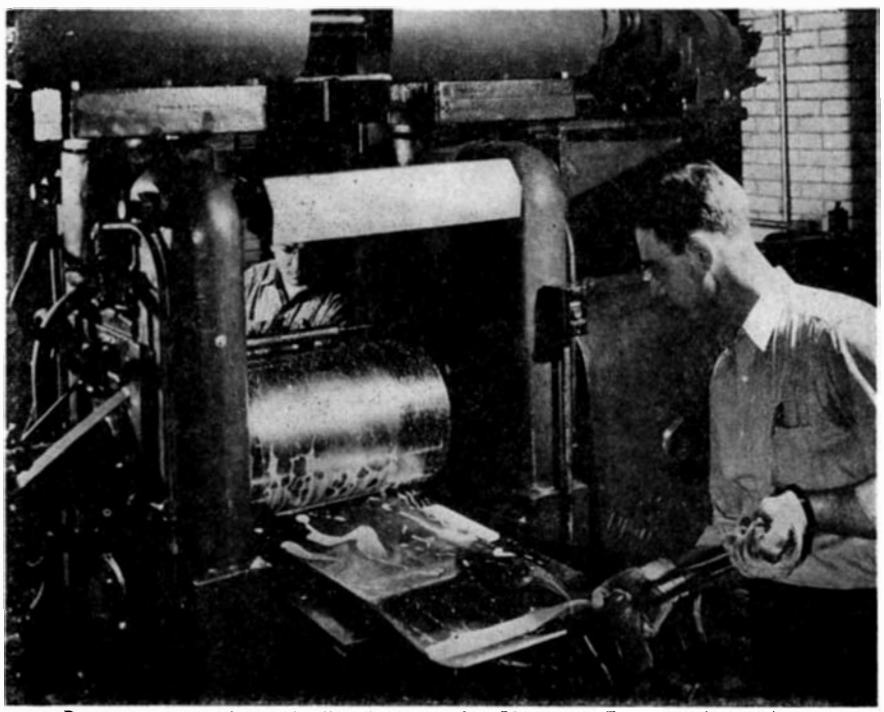
This organization, the War Metallurgy Committee, is a creature of the National Academy of Sciences and the National Research Council. It serves the functions of organizing and conducting specific research on metallurgical problems for the War Production Board. It also advises war-production agencies and the Armed Services on problems of conservation and use of metals and alloys. More than 100 research projects completed or now underway throughout the country are directed and supervised by the War Metallurgy Committee.

Without certain accomplishments of this group of metal researchers, victory in this war would not be possible, according to some authorities. Thus it was the War Metallurgy Committee that pushed the research that ended in the development of the low-alloy National Emergency steels, without which demands could not have been met for the large tonnage of alloy steel required for tanks, machine parts, aircraft equipment, motor vehicles, and so on.

The same Committee promoted the use of methods for making magnesium which increased production 300,000 tons or nearly 100-fold; it developed processes for making alumina from domestic bauxite or even from clay ready for use should the situation demand it; it supervised the planning and metallurgy of the only American tin plant to ease the tremendous pressure on our tin supply. In addition, it developed high-temperature alloys and precision manufacturing methods that made possible the efficient operation of turbo superchargers and gas turbines now in regular use on many of our high-flying heavy bombing planes. Other achievements of the Committee were to work out countless processes for making a little metal go a longer way, for speeding the production of badly needed metal products, or to permit use by the Armed Services of non-critical materials once considered incapable of munitions application.

The chairman of this committee is Clyde Williams, Director, Battelle Memorial Institute, (itself a metals research organization that has grown astonishingly during the war); the vice chairman is Dr. Zay Jeffries, Technical Director of General Electric's Lamp Works and one of the fathers of scientific metallurgy in this country; the members include dozens of metallurgists and engineers in industry, colleges, and research institutes. But more important than who is on the committee is the fact that it represents a bank of metallurgical know-how in which is deposited, without fear of competitive advantage, the full store of metallurgical knowledge accumulated in recent years by our research staffs and out of which is drawn their tested technical knowledge and experience, for the most efficient use of materials in munitions.

**PURE AND APPLIED RESEARCH**—Not all the research on metals conducted for war purposes has been under the auspices of the War Metallurgy Committee, but the committee has had its irons in so many fires that it is difficult to determine where its inspirations and activities begin and end. In the vast panorama of war-time research in metals, the



Rolling an experimental alloy ingot at the Aluminum Research Laboratories

strongly scientific or pure theoretical aspects have been pushed into the background. Practical research, nevertheless, is certain to unearth many data that eventually will be utilized by the pure scientists when they return to their academic pursuits.

Similarly, the products of this war-time research have direct peace-time implications. The high-temperature materials mentioned previously will make possible a new gas turbine industry which will eventually supply units for transportation and other equipment in what is now the established domain of Diesel and gasoline engines. The work on aluminum from low-grade domestic ores means that the development of light-metal applications may be continued without fear of an eventual loss of raw material supply. The precision casting methods evolved for the manufacture of supercharger blades, buckets, and so on, will be applied in the post-war period to the manufacture of countless intricate parts to close tolerances on a mass-production basis.

**MATERIALS**—In the field of materials, recent research in metals has evolved new aluminum alloys, much stronger than anything available before the war and combining qualities of strength and corrosion-resistance certain to find broad peace-time use in aircraft, railway cars, busses, automobiles, and even machinery of certain types. Systematic studies of beryllium-copper have resulted in methods of treating and working this material that make it best for many kinds of fine precision springs. Research on the effect of low temperatures on metals has not only given better materials to withstand the embrittling effects of sub-zero temperatures on aircraft parts but also provided information on how to improve tool steels by refrigerating them during their heat-treating cycles—the last a development that should save American industry thousands of dollars in its machining operations in any post-war year.

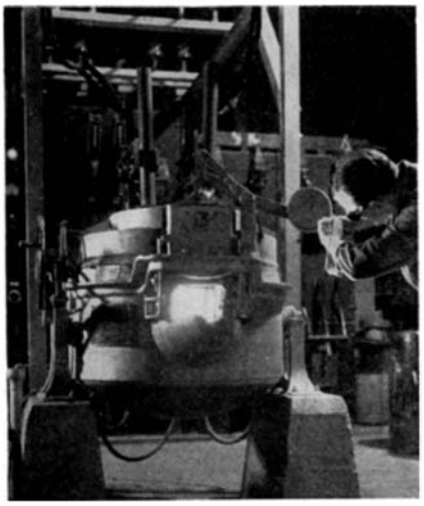
**Creep tests being conducted in the research laboratories of the United States Steel Corporation. Such tests as these are part of the development program that has given rise to new heat-resistant alloys for gas turbine and supercharger components**

**METHODS**—Nor has research on metal-working methods lagged. Industry-wide coördinated research attacked the problem of producing steel cartridge cases that would perform satisfactorily in place of brass. The real sticker was the drastic forming operation. Research finally licked it through suitable modification in the conventional deep-drawing steel, and painfully developed heat-treating and forming methods. The result was enough steel cases to relieve the pressure on brass during the most critical shortage period of the war. And the practice that war-time research has evolved will permit the post-war manufacture, once considered impossible, of drawn parts in steels as strong as those that can now be used.

Similarly, the heat treatment of steel has been the subject of a vast amount of research replete with peace-time potentialities. The most important of these researches, reviewed in the December, 1944, issue of Scientific American, include the development of drastic quenches to bring out the full hardness of steel with a minimum of alloy—a combination that reconversion engineers are already planning to utilize for technically controlled mass-production of low-cost machine and engine parts, general hardware, and so on; isothermal treatments to permit the crackless and distortion-free hardening of irregular-shaped parts; electronic induction heating to provide ultra-thin hardened cases without carburizing; and many others.

Modern research in metals has increasingly centered around certain causes of failure or service problems whose solution will vastly enhance the performance of metals in many situations. Those conditions that have received most attention are creep of metals or gradual flow under sustained stress; the fatigue of metals or their failure in vibration at relatively light loads; corrosion of materials in marine, industrial, or just ordinary environments; and the wearing away and galling of bearing surfaces.

These researches have been in some cases spectacularly successful. Here, for example, is the telescoped story of the fatigue-of-metals problem and its practical solution based directly on research. The preoccupation of a small group of men with the conditions that hasten the failure of auto and railroad axles, compressor shafts, bearings, reciprocating machine parts, bridge cables, and so forth, gave, first, dependable methods of testing the endurance of metals. These in turn helped a larger group of engineers to understand the importance of improved endurance; of avoiding surface discontinuities and roughnesses, sharp concentrations of stress in service, and the like; of designing for dynamic balance; and of prestressing or otherwise placing the outer metal layers of a metal part in a state of compression.



**A pilot plant at Jones and Laughlin Steel Corporation includes a 375-pound electric melting furnace used to prepare test heats of steel**

Finally, practical methods such as the prevention of decarburization of steel (which hastens fatigue failures), the superfinishing of parts to "roughnesses" measured in micro-inches, the use of balancing machines and techniques to locate and correct fatiguing unbalance in rotating parts and—most recently—the application of shot-peening blast treatments to cold-work metal surfaces, were developed and are now widely used to combat fatigue failures or to increase the loads that a product can withstand indefinitely under vibration, without failure.

**THREE SIMILAR STORIES**—The stories of creep, corrosion, and wear research are similar. Creep studies produced the high-temperature alloys previously mentioned. Corrosion work has tremendously increased the utility of many alloys by showing what corrosives and what "galvanic couple" combinations should be avoided, and has stimulated the development of more corrosion-resistant alloys and of durable protective coatings.

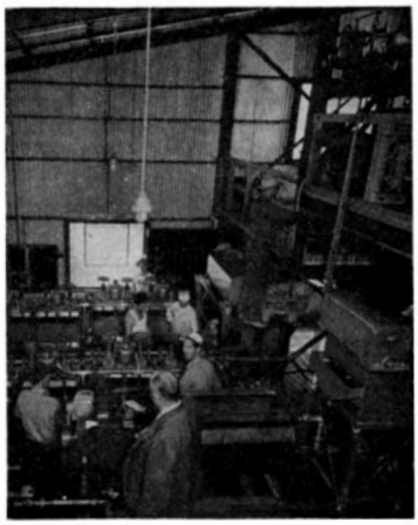
Bad boy Wear and his father, Friction, are currently undergoing some of the most intense investigation. Bearing-wear problems were usually attacked empirically—by trying various bearing-shaft combinations, bearing alloys, lubricants, operating conditions, and so on—until the best set-up was evolved. Now the scientific brains of the automotive, railroad, oil, and bearing alloy manufacturers are probing the abstruse realms of intermolecular forces and behavior for the secrets of metal-to-metal wear.

The outcome is certain to be longer-lived bearings for hundreds of uses and therefore more efficient machines and engines, plus a host of by-products. Already recognized as a related development is the new technique of high-speed milling of steel, the direct result of coördinated research on the mecha-

nism of wear in metal-cutting operations. A well-known manufacturer of friction parts (brake disks, clutch faces, and the like) made by powder metallurgy has decided that a scientific investigation of the nature of friction between metals would not only help his own product development but might illuminate the whole field of powder metallurgy, which is itself engrossed in the consideration of particle-to-particle bonds from other points of view.

**TOOLS OF RESEARCH**—Many research tools of relatively recent development have been essential factors in the accelerating pace of metals research. The electron microscope, capable of magnifying metal structures 100,000 times, will hasten the development of new, highly hardenable steels and alloys, and will solve many research problems in powder metallurgy. X-ray and electron diffraction help us to understand the atomic structures of metals both far below and exactly on metal surfaces. Electronic micrometers permit the measurement of tiny movements in delicate specimens without imposing an extraneous load from the instrument—a valuable contribution to spring research and to studies on the cold flow of metals within the "elastic" range.

Hardness testers that measure the hardness of microscopic areas of metal surfaces, ultra-high-speed photography



**Part of the flotation unit of a manganese-production pilot plant, operated by Bureau of Mines in Nevada**

for studying metal-to-metal impact behavior, and photomicrography in color are but a few of the new weapons of the metallurgical scientists in their campaign for better materials and methods.

Metals research men look for no end of problems for them to tackle in the months and years ahead. The coming competition among materials will be preceded and fanned by intensive alloy development and announcements of new products of alloy research. Among the still unsolved problems or those now undergoing study are the discovery of brazing alloys that melt somewhere between the 700 degrees, Fahrenheit, of the highest-melting soft solder and the 1100 degrees, Fahrenheit, of the low-melting silver brazing alloys; the development of corrosion-resistant or stainless steels that machine as easily as screw-stock; the establishment of important uses for magnesium powder aside from pyrotechnics; the economical production of iron or steel parts by powder metallurgy that have mechanical properties comparable to those of the strongest cast, forged, or rolled steels; and that old perennial, the low-cost manufacture of aluminum from clay.

Writing recently in *Metals and Alloys,* Dr. Jeffries declared that "the most important metallurgical engineering development of the war is the opening up by industry of its great bank of metallurgical know-how to competitors and non-competitors alike with little regard for post-war consequences." Actually those post-war consequences are certain to be better materials and methods for all of industry and better peace-time products for the ultimate consumer.



## MAGNESIUM POROSITY

### Being Corrected by Use Of Organic Impregnants

POROSITY exists in magnesium alloy castings, as in other metals, to varying degrees, depending on alloy composition, casting conditions, and gas content. An unavoidable feature of magnesium aircraft castings, porosity is being widely corrected in that field on a production scale by impregnating the castings with specially developed organic compounds in an autoclave after extracting air from the pores by a vacuum treatment.

Originally sodium silicate was used and then tung (or China-wood) oil, until the supply of the latter available for this use disappeared. The compounds that are nicely filling the gap, with results promising their continued use when tung oil returns from the wars, are alkyd resin fatty acids, modified by and reacting with monostyrene.

From a cost standpoint the old and the new materials would be approximately on the same level. Castings impregnated with the new compounds have successfully withstood pressure tests of 1000 pounds per square inch and treated aircraft-engine cylinder heads have passed service tests of more than six months' duration, according to the records.

## SHOT PEENING

### Improves Mechanical Properties of Metals

AMONG metal-working's fastest-moving trends is the growth in use of the shot-peening process, whereby the surfaces of steel parts are bombarded with metallic shot to improve the mechanical properties of the parts, especially in vibration service.

Peening is a cold-working operation that produces a shallow layer of surface metal which is harder, stronger, and less ductile than the underlying metal. The chief advantage of shot peening is that, through the formation of this surface layer of metal in a state of compressive stress, it increases the "fatigue strength" or "endurance limit" (resistance to cracking or breaking in repeated-stress or vibrational service) of the part and either lengthens its life or permits the use of heavier fatigue-loads than can be used with unpeened parts.

To a certain extent shot peening can replace heat treating or surface hardening if distortion must be avoided. It is being applied to finished parts, such as springs; to specific areas, as fillets on structural or machine parts; and to the bodies of shafts to resist pitting-corrosion or "corrosion-fatigue." Shot-peened gear teeth have improved resistance to pit-corrosion and to wear. It has also replaced polishing, for shot blasting has long been used for cleaning parts. Furthermore, the blast intensities used for peening have a distinct polishing effect.

The machines used are similar to those conventionally employed for blast-cleaning by the shot method, the shot being thrown against the work by compressed air blast or, without air, by centrifugal means. They usually embody automatic and conveyorizing features for incorporation in mass-production systems.

## STRONG ALLOY

### Made With Aluminum, Magnesium, Zinc, and Copper

RECENT months have seen the introduction to industry of two new strong aluminum alloys—75S of Aluminum Company of America and R301 of Reynolds Metals Company. Now a third has appeared, also of outstanding interest to post-war designers and materials engineers.

After nearly two years of laboratory tests and development of fabricating processes, "the strongest aluminum alloy yet available for commercial use" was recently announced by Mr. Paul P. Zeigler, Reynolds Metals Company chief metallurgist.

This aluminum alloy, known as R303, is made with magnesium, zinc, and copper. It is described as the first combination of this type to possess such strength and at the same time to be free of defects—susceptibility to corrosion and stress cracking—which for years have made similar alloys impractical for use in the construction of aircraft.

The new alloy has almost three times the compressive strength of structural steel. Tests have shown this alloy to be over 50 percent higher than structural steel in tensile yield strength and 70 percent stronger than the other older type high-strength aluminum alloys.

When peace comes, the new alloy will be available for railroad equipment, automotive parts, and heavy machinery, as well as for baby carriages, furniture, and appliances and other light household articles.

# Railways Roll On Research

**Many Problems Became the Subjects of Research Early in the History of the Industry. Some of These Have Been Under Almost Continuous Investigation Since. Practially No Industry Employing Research in the Development of its Products Has Not Made its Contribution to the Railways**

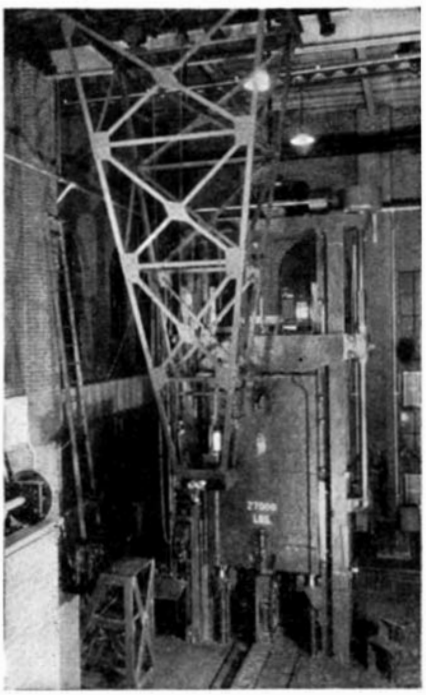
THE RAILWAYS of America have been the beneficiaries of a greater variety of industrial research extending back over more years than perhaps any other industry in America. Indeed, there are few industries whose research development has not contributed to railway progress, for the reason that railroads are large purchasers of the products of almost every industry.

Why has the physical progress of the railways depended so largely on sources outside themselves? Because the railways are a service industry and produce no physical product for sale. Furthermore, through most of their history the unsatisfied demands for capital to improve and expand facilities involved directly in the conduct of transportation have left little opportunity for the railroads to undertake the development of manufacturing facilities that would supply their own needs. Consequently, they have provided a large and diversified market which enterprising manufacturers have not been slow to exploit.

This has resulted in the development of the so-called railway supply industry which includes locomotive and car builders, manufacturers of couplers, draft gears, freight-car trucks, car wheels, brake shoes, locomotive superheater and feedwater heaters, locomotive boosters, and air brakes. It also includes firms that manufacture special power and control equipment for passenger-car lighting and heating, as well as track fastenings, ballast-cleaning equipment, power tools for track maintenance, and manufacturers of many other specialties for locomotives and cars, and even special shop tools for their repair. All these manufacturers employ industrial research in some form, many in their own laboratories, for the advancement and improvement of their products.

But this does not mean that the railways themselves have not been engaged in research. Indeed, some of the earliest industrial research conducted in the United States was initiated by the railroads. In cases where they did not conduct it directly, they nevertheless inspired and guided it. In fact, since shortly after the Civil War such projects in increasing number have been a continuous factor in the business.

**RAILROADS BEGAN EARLY**—One such investigation reported at the 1875 meeting of the American Railway Master Mechanics' Association was a series of drop-hammer tests of iron and steel axles conducted in a Philadelphia shipyard. The results showed that steel possessed superior stiffness and endurance. Indicative of a pattern which has been repeated many times since, the services of the physical testing laboratory at the Stevens Institute were utilized in determining the physical properties of specimens of the material in the axles tested.



**Drop-test set-up in the draft-gear laboratory of the Association of American Railroads at Purdue University**

In 1873 a committee of the Master Car Builders' Association arranged a competitive trial of the Westinghouse automatic air brake and the Smith vacuum brake. A year later the committee set forth a specification of what then seemed to be required of a perfect power brake. After further study and testing, the Master Car Builders' Association eliminated other brakes and, following the famous Burlington tests of 1887, the air brake became the standard for freight trains as well as for passenger trains.

The railways themselves were less directly responsible for the industrial research involved in the development and improvement of braking than in formulating requisites and stimulating progress by the manufacturers. Because the brake is an important factor in the safety of train operation, the government, through the Interstate Commerce Commission, has also influenced the direction which brake investigation has taken. After hearings on its own initiative, ordered on February 20, 1922, the Commission set forth a specification of functions which in its opinion were required by a freight brake to control safely the speed of long, heavy trains. Appliances created by the air-brake manufacturers to meet the Commission's specifications were investigated by the railways on the 150-car test rack of the American Railway Association at Purdue University. Those possessing sufficient merit were then given road tests on 150-car trains.

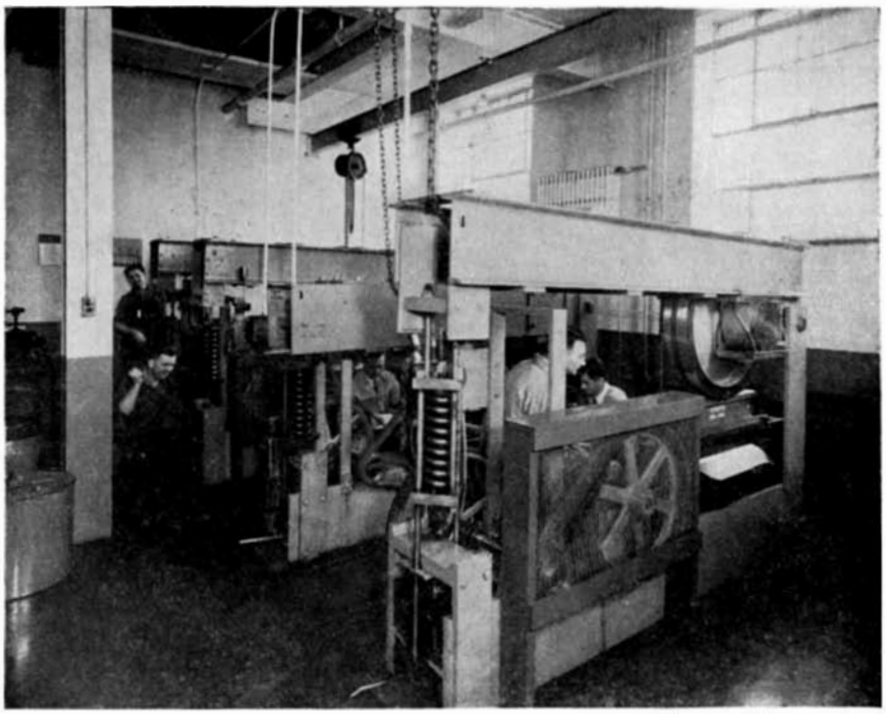
This project was placed in charge of a director of research appointed by the American Railway Association in 1924. The road tests were completed in March, 1931. The commercial brake developed by the manufacturers has now been installed on about half the freight cars of American railroads. Functioning interchangeably with the much simpler and less effective brakes which it supersedes, it has greatly improved the safety of long-train operation.

These examples are only suggestive of the pattern of research contributing to the advancement of railway transportation facilities. There is a long list of additional car and locomotive devices which industrial research has helped to establish, improve, and refine. Here are a few of the items. There is the friction draft-gear on which a large amount of work has been done by the Association of American Railroads in its draft-gear testing laboratory at Purdue University, in addition to the research by the manufacturers in their own laboratories. Chilled-iron car wheels are the product of many independent foundries having regional markets. The chilled wheel has been the subject of a continuing intensive research conducted by the Association

of Manufacturers of Chilled Car Wheels. Its studies cover metallurgy, design, and manufacturing processes, and have resulted in a uniform high-quality product.

The improvement of wrought-steel wheels has also involved extensive research, guided by the Technical Committee of the wheel manufacturers. The work has been done in the laboratories of the individual manufacturers. Car couplers have been the subject of almost constant study ever since the vertical-plane coupler was adopted in 1887. Cast-steel freight car trucks have been subjected to a large amount of research to improve the distribution of the metal to resist the stresses to which the castings are exposed and to improve their quality.

No account of the agencies which have been engaged in research for the benefit of the railways would be complete which did not cite the locomotive test plant of the Pennsylvania Railroad at Altoona, Pennsylvania. This plant, which was first installed at the St. Louis Exposition in 1904 and thereafter moved to its present location, has been utilized through the years for the conduct of a large number of complete locomotive operating tests in which accurate data on fuel consumption, steam production, cylinder horsepower, and drawbar pull were recorded, along with a large amount of data pertaining to the internal functioning of the locomotive. Additional studies were made of the effect of specific changes in locomotive proportions and design. The data from these tests are an important part of the working library of the steam-locomotive designer, and they have guided many an inventor of locomotive improvements.



**Rolling-load machines used in testing rails at the University of Michigan**

**ROADBED AND TRACK**—The track rail has been under constant development from the very beginning of its use as a path for wheels, even before steam power was adapted to railway use. The first organized attack on the problem of rail design and manufacture was undertaken in 1887 by the Roadmasters' Association of America. In 1897 the American Society of Civil Engineers brought to the research the scientific knowledge needed to carry it to a conclusion.

Since 1900, when the American Railway Engineering Association was organized, many phases of track and roadbed construction have been under investigation. When the amount of open-hearth steel rail in use was increased, rail failures began to occur with no previous warning. The cause was determined to be transverse fissures within the rail. While working with the rail manufacturers to control the cause, the committee in charge undertook to find some means by which these fissures could be detected before breakage occurred. A number of independent investigators also undertook the solution of this problem.

None of these efforts proved successful. The committee, backed by the American Railway Association, asked the late Elmer A. Sperry to undertake a program of research to perfect a dependable device for locating fissures.

The results were all that could have been desired, and now periodical checks of track rail by the use of rail detector cars are carried out on many railroads. The device finds and records fissures and other defects even in the incipient stage.

In the meantime, the railways and the manufacturers undertook to finance jointly an extended program of research to determine the cause of the fissures and what measures could be taken to avoid them. This project, started at the University of Illinois in 1933, discovered that transverse fissures were caused by the rapid cooling of rails on open racks at the rolling mill. Controlled cooling in enclosed boxes has substantially eliminated this hazard.

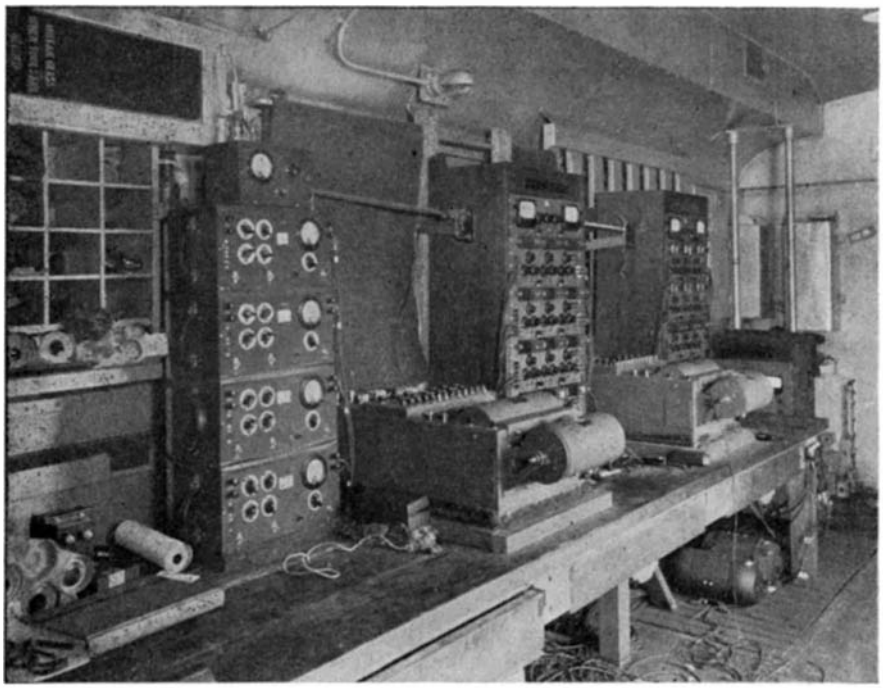
The railway tie, a simple stick of rough timber, has been the subject of research which began within a few years after the first railroads were built in America. Out of this continuous effort to increase the life of ties was born the wood-preserving industry. From the four or five years' use which could be obtained from ties of natural timber, the service life of treated ties has been increased to 25 or more years.

**SIGNALS**—The track circuit is the basis of automatic block signaling. Methods for its control, and its power supply, have been subjects of constant study for many years. Another important factor in extending the use of automatic block signals was the improvement in lighting; first to provide color indications at night and, later, light signals suitable for day as well as night.

One of the most outstanding steps in the signaling fields is automatic train control on which extensive research has been conducted since the Interstate Commerce Commission ordered installations on 49 railroads in 1922. The continuous inductive system, which does not depend upon impulses received at wayside signal locations for its functioning, also led to the development of cab signals which bring the signal indication into the cab where it is constantly in the sight of the engineman. Incidentally, the need of glass in colors other than red and green, so that it would be unnecessary to use white as a "clear" signal, led to research by glass manufacturers which produced a yellow glass that could be clearly distinguished from red.

An important facility which has been developed by the signal manufacturing companies is the car retarder, an electro-pneumatically operated device installed in the track by which the speed of cars in hump classification yards can be controlled at selected locations by one man in a tower. This dispenses with many car riders who would otherwise be needed.

**THE COLLEGES**—During the past 40 years two mid-western universities have made numerous contributions to railway development, some on their own initiative and others in co-operation with the railways or manufacturers or both. These are Purdue University and the University of Illinois. Beginning in the 1890's Purdue became immersed in a long series of tests relating to problems of locomotive drafting and use of superheated steam in comparison with saturated steam. These latter tests were run on the Purdue locomotive testing plant. From the front-end and smokestack tests was evolved the so-called Master Mechanics' front-end which is still in use as the drafting appliance on a large number of steam locomotives. More recently Purdue has become the seat of a considerable variety of test facilities owned by the Association of American Railroads, including air-brake-hose testing apparatus, drop-testing machines, a brake-shoe testing machine,



**Electrical apparatus for measuring stresses and riding conditions in the steam-locomotive counter-balance tests of the Association of American Railroads**

an air-brake test rack, and a draft-gear test laboratory.

The Engineering Experiment Station of the University of Illinois is also equipped with a locomotive test plant which has been used in a number of investigations. Illinois is better known, however, for its train-resistance and tonnage-rating tests which were run in 1906 with a dynamometer car on trains in actual service. In addition, this institution is also well known for its work on stresses in railway track.

**OTHER SOURCES**—Many other important changes and improvements in railway facilities have had their origin in the research of industries not exclusively devoted to the railway market. The list is a long one. It includes the steel, nonferrous metal, chemical, rubber, and wood industries; the manufacturers of electrical equipment and internal-combustion engines, of roller bearings and air-conditioning equipment.

Low-alloy high-strength steel and the strong alloys of aluminum have made possible marked reductions in the weight of railway cars, both freight and passenger. Rubber has been adapted to the insulation of passenger-car bodies against high-frequency vibrations reaching into the sound range. It is also being used as the cushioning medium in passenger-car draft gears. Roller bearings are now widely employed in passenger cars and locomotives. The internal-combustion engine has become a familiar feature of railway motive power. The gas engine in the rail car was followed by the Diesel engine in the articulated motor train. Today, the Diesel-electric locomotive is establishing itself in all classes of service.

**NOW AND IN THE FUTURE**—During recent years the range of research projects conducted by the railways themselves has increased materially. A long series of laboratory studies has been conducted on locomotive crank pins to find means of improving their fatigue resistance against failure in the wheel fit. These tests are being made for the Mechanical Division, Association of American Railroads, at the research laboratory of the Timken Roller Bearing Company, using fatigue testing machines that were developed for a similar study, completed six years ago, of fatigue properties of full-size passenger-car axles.

Considerations of safety have led to the development of strict limitations on the extent to which fractures in cast-steel freight-car truck side frames and bolsters may be welded. As a means of reducing the need for new castings a thorough study was undertaken of the feasibility of extending these limitations by dynamic fatigue testing of full-size welded castings. This work has led to the removal of restrictions imposed on the welding of these castings and specific regulations for the conduct of the work developed.

One of the problems presented by the steam locomotive of the reciprocating type is the counterbalancing of reciprocating parts. In March, 1944, a report was issued on an elaborate study of this problem which has been conducted on the Chicago and North Western jointly by the Mechanical and Engineering Divisions of the Association of American Railroads. It will undoubtedly influence the designing of future locomotives and the improvement of existing ones so as to provide smoother riding for the locomotive and reduction of track stresses caused by high-speed operation.

In the track field many studies of problems such as butt welding of rail and the design of rail fastenings to improve strength and durability are being conducted, either under the direction of the Engineering Division of the Association or by individual railroads on test installations in main-line track.

Consideration is being given to the redesign of rail sections based on present data relative to failures in the web sections of rail. Another proposal for the improvement of roadbed now being studied extensively is the pressure grouting of roadbed with cement to overcome the effect of water which, under certain conditions, accumulates in the sub-grade immediately under the track.

The current problem giving rise to the greatest popular interest is the application of wireless for head-end-to-rear-end communication on trains and for train-to-roadside communication. This is at present under development. While the proposals come from the electronics field, their adaptation to railway conditions without interfering with other fields of radio communication is in itself the subject of prolonged and intensive industrial research.

Intensified interest in the employment of research by the railroads is indicated by the appointment, last March, of Clyde Williams, director of the Battelle Memorial Institute, as technical consultant to advise the Association of American Railroads on research matters relating to technological methods and processes.

## TRACKSIDE SERVICING

### With Fuel and Water Increases Locomotive Runs

ONE of the war-time problems of the railroads is to get the maximum possible monthly mileage from each of the limited number of locomotives available. A measure which has helped to keep locomotives moving is the establishment of facilities for supplying them with fuel, water, and sand, and dumping ashpans for coal-burning engines, so that they can be serviced on main-line tracks at intermediate terminals without removing them from trains.

In a paper for the 1944 year book of the Railway Fuel and Traveling Engineers' Association, E. G. Sanders, fuel conservation engineer, Atchison, Topeka & Santa Fe Railway, cites installations which will deliver 42 tons of coal to the locomotive tender in 75 seconds. The coal is delivered through a spout which swings parallel with the track so that the entire coal bunker of the tender can be filled without moving the locomotive. To provide similar fast service to oil-burning locomotives requires oil cranes capable of delivering 1000 to 1200 gallons of oil per minute. Water cranes are now in service that can deliver 7000 gallons per minute.

Mr. Sanders cites the installation of high-speed servicing facilities at two intermediate terminals on a 637-mile run which made it unnecessary to relay locomotives on freight trains at these points. An assignment of 25 locomotives, making 8000 to 9000 miles per month, was thus capable of doing work which would have otherwise required 29 locomotives.

# Electronic Aids To Research

**Pure and Applied Research Alike Find a Multitude of Uses for the Electronic Tube. From the Laboratory to the Workbench, Electronics is Making Possible New Accuracy in Measurement and Control. A Survey of the Field Indicates Virtually Unlimited Possibilities for Applications of Electronic Tools**

By JOHN MARKUS
Associate Editor. *Electronics*

THE ELECTRON, fundamental building block of the universe, is today being put to work by countless scientists and engineers as a research tool to build a better world for the future.

Extensive studies regarding circuit interruption, electrical precipitation, arc welding, and many other fields have removed the limitations to growth of power and industrial activities. These studies have made it possible to meet the ever increasing requirements in the normal growth of the electrical industry and have been especially valuable in the enormous expansions necessary under the present war emergency.

It would take pages to list and describe even briefly every one of the multitudinous applications of electronics in research, development, and quality control laboratories. In almost any laboratory project are found electronic devices for instrumentation or for performing other functions which cannot be accomplished in any other way. Vacuum tubes and special circuits are the tools of the research scientist.

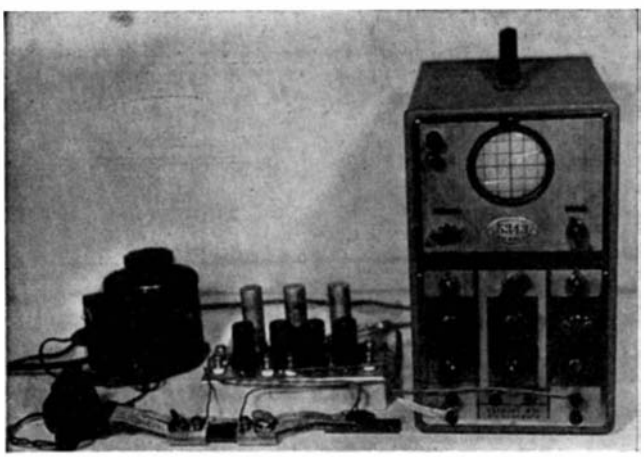
Electronics has brought to the everyday measurement of all kinds of physical, electrical, and chemical quantities a precision and facility that, 50 years ago, were thought possible only in the national physical laboratories or, with the expenditure of much money and labor, in some special project. Today a factory worker will measure the diameter of a piston or check the frequency of a quartz crystal oscillator with a precision of a few parts in a million as readily as the butcher weighs a pound of beef liver. Facility and accuracy are both provided by electronic tubes.

**DIMENSIONAL MEASUREMENTS**—Lengths and thicknesses are measured today with pointer-indicating gages whose scales can be read several feet away to fractions of a ten-thousandth of an inch. This precision may be achieved with an electromagnetic structure of which the inductance changes with the position of the measuring spindle, or the spindle may move condenser plates. In either case, electronic tubes amplify the resulting change and deliver the result to an indicating instrument. The electron microscope has made possible the measurements of lengths too short for perception by light waves. At the other extreme of length are the determination of longitudinal distances on the earth's surface (primarily a time determination), reaching new exactness by use of radio, and the estimation of stellar distances extended to new fields because of the electronic tube.

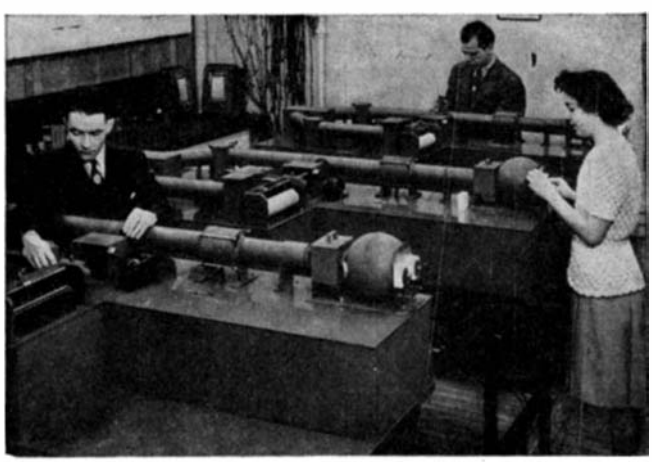
The measurement of mass has, perhaps, not drawn out the great variety of electronic devices that have been created for length and time measurements. The mass spectrometer, however, gives trajectories to electrons indicative of their masses and is a powerful tool for the separation of isotopes.

The electronic tube has probably made its greatest contribution in the field of time measurements. The variable-frequency tuned circuit, sustained by the electronic tube, is a powerful measuring tool. Controlled by the piezo-electric voltage of a quartz bar, such circuits have yielded time values accurate day after day to better than one part in a million, a precision that the finest astronomical clocks could maintain for only relatively short periods. The cathode-ray oscilloscope records phenomena which may occur in a few millionths of a second. Such an oscilloscope can hunt out the frequency of an unknown voltage and exhibit the contours of its wave shape.

**TEMPERATURE**—The measurement of temperature, and especially the control of temperature, finds new facility and precision because of the electronic tube. The familiar basic devices—expanding metals and liquids, thermocouples, resistance thermometers—now work through electronic amplifiers so that indicators and recorders can have larger or more sensitive scales, or so



**Electronic equipment that instantly produces on the face of the cathode-ray tube the curve that shows the important characteristics of a magnetic sample. This rapid method was developed by Zenith Radio Corporation**



**These General Electric recording spectrophotometers provide accurate identification or matching of colors for industrial uses or military camouflage. Such work prevents detection of camouflage by infra-red cameras**

that the temperature of a space, of a surface, or a kettle of liquid may be maintained with smaller drifting. The measurement of moisture and humidity in rooms, chambers, foods, lumber, soil, and so on, is a related field for which ingenious devices and arrangements utilizing electronic tubes are available.

**SPEED**—An oscillating tube circuit of which the frequency can be varied at will may excite a flashing light (stroboscope) which illuminates a rotating machine. The frequency of the light which "stops" rotation measures the machine's speed. And since the measuring device has no mechanical contact with the rotating object it can measure the speed of the lowest-powered machine without altering the speed under observation. Obviously this rapidly flashing light may be used for high-speed photography, which has become a powerful measuring aid in the study of high-speed operations. Likewise, when the frequency is held slightly off synchronism the motion of even a high-speed mechanism may be studied closely. Unbalanced vibrations in high-speed machines, down to hundred-thousandths of an inch, may be measured and corrected. The accelerometer, used to determine effective weight during the evolutions of an airplane trial flight, for example, is available solely because of the development of electronic tubes.

**Dr. John A. Hipple, Westinghouse physicist, examines the curved glass tube that is the heart of the mass spectrometer, important to research**

The sound level meter and associated analyzing equipment which utilize electronic tubes are used to evaluate the effectiveness of devices and materials placed to minimize noise penetrating to spaces which should be quiet.

**POWER**—The measurement of the power transmitted by a shaft has always been an alluring subject to the research physicist; when the shaft itself can be calibrated as a torque-meter, electronic devices can show readings on a scale. Electric resistance strain gages now take their place beside electromagnetic and mechanical strain gages for measuring shaft distortion as well as the more familiar function of measuring distortion under static stress, and for all of them the electronic-tube amplifier is important.

Electric voltages can be measured with electronic tubes with precision up to frequencies of the order of millions of cycles per second, by the use of negligible power from the circuit measured. The vacuum-tube voltmeter can measure the peak voltage of a fluorescent lamp or of the surge from the starting of an oil-burner mechanism.

Chemical reactions may generate voltages between certain electrodes and, although the accompanying energy is too minute to be detected by other means, the electronic-tube voltmeter or potentiometer serves the purpose. The hydrogen ion concentration (pH) method of determining acidity or alkalinity and the measurement of electrolytic conductivity are of this nature.

Electronic tubes amplify the feeble currents of phototubes measuring light and illumination. Here again there is a notable gain in precision as compared with optical methods. In some instruments, a variety of electronic tubes are combined to produce a measuring device. For example, the recording spectrophotometer is being used by the paint industry to match camouflage colors so that they cannot be detected by the enemy's infra-red cameras. By determining the amount of light or infra-red that is reflected by any paint or other material, it is possible to determine the effect which that material or color will have on the plate of the infra-red camera.

**DIFFRACTION**—X-ray diffraction methods have been widely adapted to the study of crystal structures since the wavelength of x-radiations is of the same order as the spacing of crystal planes.

The application of x-ray diffraction to problems of research in crystallography and to problems of applied science in chemical analysis and metallurgy, opens a broad field. The scope of the information obtained with this method includes the nature of the crystallographic system, uniqueness or aggregation of crystals, grain size, internal distortion or strain, and the state of atomic chemical combination in a substance.

In metallurgy, x-ray analysis is applied to the study of the constitution of alloys, their intermediate phases, solid phases, and crystalline structure. The effects of cold-working in producing grain distortion, fragmentation of crystal grains, and the introduction of preferred orientation by rolling and drawing are readily determinable.

The determination of a particle size has been extended into the range of submicroscopic grains, as in crystalline colloids. Substances like rubber, carbon-black, paint pigments, cellulose, glasses, and other substances usually considered amorphous have been found to give diffraction rings, and even some liquids produce diffraction halos which yield important information as to their nature and structure. Soils, minerals, dusts, and clays are being analyzed with the new techniques. The study of fibers found in drawn metal wires, silk, cotton, wood, rayon, starches, and stretched rubber is opening new approaches to industrial research. Another new phase of crystal analysis is the investigation of the crystalline and molecular structure of organic com-

**Drs. Zworykin (right) and Hillier, of RCA Laboratories, with an experimental model of the electron microanalyzer, latest of the electronic research tools for industrial scientists**

pounds, leading to new insight into the mechanism of lubricating films and the behavior of insulating oils and waxes. Research on synthetic resins and synthetic rubber is dependent on x-ray research.

Electron diffraction work on polished metals has given valuable information on the causes of piston and bearing wear. Research on the general problem of adhesion of electro-deposited metals can be expected to result in substantial improvements in plating techniques, while the knowledge gained of surface chemistry, of corrosion, and of the protective oxides on metals and alloys, is directly effective in solving many problems, theoretical as well as intensely practical.

**DIFFERING TECHNIQUES**—One of the important developments in the technique of electron diffraction was the discovery that electrons impinging at grazing angles on plane polycrystalline specimens would give diffraction rings characteristic of the material in question. Two main types of diffraction analysis are in use today, namely: (1) transmission patterns obtained by passing the electron beam through thin sections of the material, and (2) reflection patterns obtained by impinging the electron beam at grazing angles.

X-ray and electron diffraction techniques differ as a result of the charge characteristic of the electrons and as a result of the wavelengths of the radiation. Electrons are scattered a million times more effectively than x-rays, which fact limits the thickness of the films in the transmission technique. In the case of the reflection technique it is evident that at grazing angles, the first few atomic layers only are effec-

tive in the diffraction. This fact makes the electron diffraction camera extremely useful for the study of surface phenomena.

Electron diffraction analysis is not to be thought of as a substitute for the usual x-ray analysis because of the difficulty of preparation of the specimen for the general case. However, in its special field of surface phenomena, it shows utility.

Among the many problems which have been studied by the electronic diffraction technique are: thin films of inorganic and organic materials; oxide and other corrosion films; polished surfaces; crystal growth; electro-deposited materials; surface catalysis; colloidal state; wear and lubrication; impurities on surface; running in of bearings.

The electron diffraction camera consists of a source of homogeneous high-voltage electrons of 30 to 60 kilovolt energy, a magnetic focusing system, a sample holder and manipulator, and a camera section, all in a vacuum.

One of the interesting applications of the electron diffraction technique has been the study of oxidation and corrosion products of the various metals in different gas atmospheres. This is done by enclosing the specimen in a silver furnace whose temperature is carefully controlled. The samples can be cleaned by treating with hydrogen. The behavior of the metal in various gas atmospheres can then be studied by admitting the gases to the camera for specified time intervals at various pressures. At the conclusion of the experiment, the camera is evacuated and the diffraction picture taken at the temperature in question.

**MAGNETIC CHARACTERISTICS** — The characteristics of the magnetic material used in transformers and chokes are not easily measurable, and introduce a factor of uncertainty in the design and production of electrical equipment. A specified grade of lamination material may be essential for proper operation, but the various grades look very much alike, and electrical checks are often quite difficult.

Sometimes a deterioration in the characteristics of some complex circuit defies explanation until the change is traced to a change in characteristics of magnetic materials.

Apparatus for rapid and easy testing of magnetic materials is extremely useful in such cases. But to obtain such data as permeability, saturation, coercive force, and hysteresis loss of magnetic alloys, special equipment which is not easily available has been necessary.

The oscillographic equipment makes it possible to obtain these data with great rapidity. Comparison checks of a number of samples can be made within a few seconds. Initial and reversible permeability characteristics, or increase of loss with flux density, can be directly observed on the screen of a cathode-ray tube.

A little washer punched from a single lamination is all that is needed. Using a special four-tube amplifier and test jig with an ordinary cathode-ray oscilloscope, the electronic apparatus instantly provides a curve giving the desired information.

**RESISTANCE MEASUREMENTS** — Wire resistance strain gages are primary elements for measuring small linear changes of dimension of the surfaces to which they are attached. The surface strain causes a proportional percentage change of electrical resistance of the gage, which is measured with a suitable instrument. Most applications of these gages depend on the use of electronic instruments to get the necessary high sensitivity and measuring speed. The measurement of mechanical forces, weight, fluid pressures, and small motions are applications of strain gages and their associated electronic circuits to industrial problems.

Practically all commercial gages are rectangular grids of resistance wire about 0.001 inch in diameter, supported and held in place by a film of elastic cement. This may be strengthened by the further use of a paper backing. This structure of wire and cement is in turn cemented to the surface on which strain is to be measured.

When a conductor is placed either in tensile or compressive stress, its electrical resistance changes. With electronic circuits, this change in resistance is readily converted to an indication of the stress in the structural number being examined.

**MASS SPECTROMETER** — Production of high-octane gasoline, so important to war planes, involves precise critical processes requiring laboratory accuracy on a huge scale. Previously, chemical tests in an oil refinery have been laborious and have required hours to complete, but today the electronic mass spectrometer thoroughly checks operations in a matter of minutes—and requires only one or two technicians.

This instrument determines both qualitatively and quantitatively the constituents of a gas, using only a thimbleful of the gas at a time—and ionizes it by impact of electrons from a hot filament in an evacuated tube. The stream of charged molecules is drawn along the tube into a strong magnetic field, where it is bent into an arc-shaped path. The heavier the ion, the larger the radius of curvature of its path. As a result, different molecules emerge from the field at various locations—but all of the same kind leave at one particular spot. Differently charged molecules are collected successively at an exit slit into a current that can be amplified and measured. In this way, constituents of any gas can be determined as to kind and proportion.

The value of the spectrometer as an analytical tool in the analysis of gasoline, synthetic rubber, and plastics well justifies its development. Already in evidence are other promising fields of application. Among these are leakage testing, metallurgical analyses, and analysis of the purity of controlled furnace gases. It is also useful in automatic controls of processes where it may be important to measure the relative quantity of a desired constituent or to detect presence of an undesirable element.

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## CONTACT ASSEMBLIES

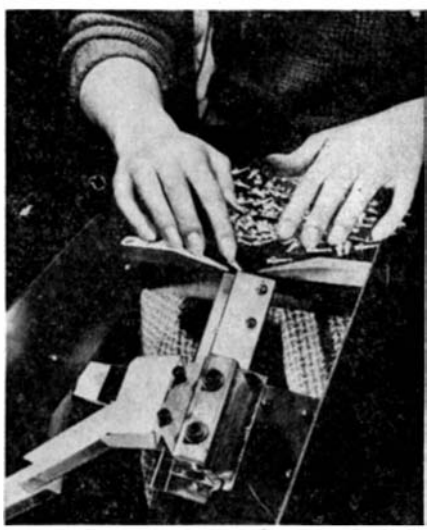
### Sorted Electronically into Three Groups

MUCH greater speed in the sorting and inspection of tiny contact assemblies produced at General Electric's Schenectady Works has been made possible through the development of an electronic sorting table which routes the assemblies into three different channels depending on whether they are too high, too low, or within the tolerances.

Each contact assembly was previously checked with a needle micrometer to determine whether it was oversize, undersize, or within the tolerances, and then sorted accordingly by hand. With the specially designed sorting table, each assembly is fed onto a 45-degree slide. About halfway down the slide, the assembly comes to a contact point located at a pre-set height.

If the assembly touches the point, it is oversize, and the contact made closes the grid circuit of a vacuum tube, which in turn energizes an electromagnetic relay. A solenoid is next energized, sending the assembly down a chute into a container for oversize parts.

A short distance beyond the first point, a second contact point is set at standard height less tolerance. Since oversize assemblies have already been eliminated at the first contact point, parts touching the second point are within acceptable limits and are "shot" down another chute. Undersize assemblies do not touch either point and slide undisturbed to a third tray, thus completing the automatic sorting operation at high speed.



**Electronic sorting table in use**

# Research Gave Mankind Wings

**From the Very Beginning, Research has been the Basic Element in Aviation Progress. The Wright Brothers Built a Wind Tunnel Long Before They Built A Flying Machine. From Then on, Research by Industry, Government, and The Universities Has Brought Flying to Its Present Astonishing Triumphs**

It is a remarkable fact that, the younger a branch of engineering, the more it owes to organized research and the more thorough is its grasp of underlying scientific principles. Thus naval architecture, which presumably dates back to Noah, has advanced through the ages mainly by experience, and with much of its knowledge based on tradition.

Aviation, on the other hand, dating back only a little more than 40 years, owes far more to scientific research. It has advanced more rapidly; it is more richly provided with laboratories, and it already has gained sounder and more comprehensive scientific knowledge. In fact, the tradition of research in aviation dates back to the Wright brothers themselves.

It is sometimes thought that the Wrights were inventors of genius who owed their success to inspiration and not to scientific training. On the contrary, the two brothers were scientists of the very highest type. While they owed much to inventive genius, they nevertheless undertook long and systematic researches in a home-made wind tunnel before they even attempted to build their first airplane.

For many years Orville Wright used to show personal friends a small red vest-pocket book which contained the sole record of early experiments. Only in 1939 were these records given to the world in the 27th Wilbur Wright Memorial Lecture delivered by Dr. G. W. Lewis before the Royal Aeronautical Society. In this lecture, Dr. Lewis gave ample evidence of the research skill and accuracy which the Wright Brothers had achieved. The tradition has remained, with scientific and industrial research in aeronautics undertaken by every civilized or merely technologically-trained country in the world.

The United States has a way of originating inventions, of neglecting them, and, later on, of surpassing the world in the same field. So, in aviation, the Government paid but little heed to the new science. Only in 1915 was the National Advisory Committee for Aeronautics established, and even then with a munificent grant of $5000 to pursue its researches. Of course, today America is in the lead both in research equipment and personnel, but it is doubtful whether we were leading in those crucial years when the dictators were arming for the conquest of the world.

**RESEARCH IN EUROPE**—In those dangerous years, Mussolini had built Guidonia, a whole city devoted to scientific research in aviation. In Germany, the Deutsche Versuchsanstalt für Luftfahrt, located at Adlershof near Berlin, had vast laboratories and workshops, as well as large numbers of well-trained men. The Russians had developed the huge Central Aero-and-Hydrodynamic Institute in Moscow. The British, while sound, had not kept their early leading position, and in France an early spirit of bold investigation had yielded to apathy and decay.

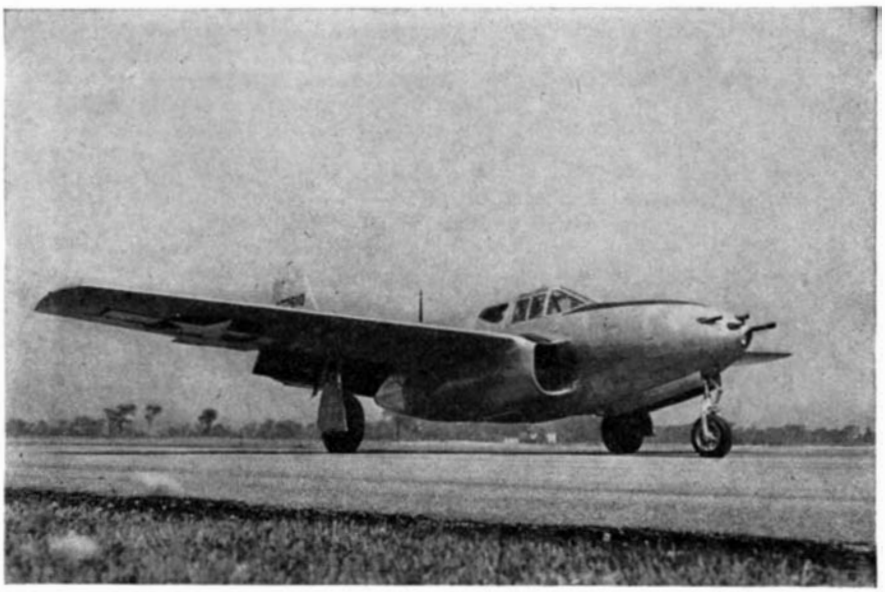
The Japanese, who excel as copyists, it is true, but can also do good research along conventional lines, had built up the quite respectable Tokyo Institute of Aeronautical Research. Particularly in Germany, the efforts of the government scientists were supported by industrial research and experiment on a wide scale by such companies as Junkers, Dornier, Heinkel, and others. Charles Lindbergh tried to do his country a service when he reported how powerful and advanced was German aviation.

The early days of the European war and even the early days of our own entry into the war certainly did not find us leaders either in aeronautical research or in excellency of airplane equipment, while quantitatively we were far behind.

It was our good fortune that Great Britain put up so courageous a fight and that two oceans separated the United States from its potential enemies. We were thus given time to bring our research facilities up to the highest level and to advance our military and naval aircraft to their present excellency.

Today, perhaps the most remarkable thing about aviation research in the United States is the co-operation which exists between governmental laboratories, the universities, and the experimental establishments (rather than laboratories) of the manufacturers of airplanes and airplane engines.

In the pure science of aerodynamics, the Germans led, up to a few years ago, but today they are rapidly going down hill. Now, thanks in part to the refugees which Germany has so benevo-



**A fine product of war-time research—the Bell Airacomet jet-propelled plane**

lently driven to our shores, we are fast overhauling them in the physical sciences and in applied mathematics. In the application of science and in industrial research we are already far ahead of the Germans.

In aviation we in the United States owe our superior position to the fact that we have known better than the Germans how to tie in our federal laboratories with the industrial research of our manufacturers and with the universities. It will not be out of place to give a brief picture of these diverse but co-operating elements.

To begin with, this country has the National Advisory Committee for Aeronautics. This, from its modest beginning in 1915, has now grown to a vast institution with its long-established Langley Field laboratory in Virginia, now almost matched by the Ames Laboratory in California, and supplemented by the splendid aircraft engine laboratory put into operation just a few years ago in Cleveland. The NACA, as it is generally known, is directed by a group of men who serve without compensation and who represent the Army, the Navy, the Civil Aeronautics Administration, and other governmental bodies, with perhaps one or two citizens of high distinction in aviation.

Under this governing committee functions the Director of Aeronautical Research, Dr. G. W. Lewis, who has established, perhaps, the Washington record for longevity in a prominent government position and perhaps an equal record for freedom from public criticism. Then there come a number of sub-committees which include members representing the industry and the universities. Research problems are frequently suggested by engineers from industry at the annual NACA Conferences held at Langley Field. Sometimes they are presented by the industry's representatives acting on the sub-committees. When research is initiated by the NACA itself or by members of its scientific staff, the subjects of investigation have to be approved by the sub-committees. There exists the most friendly relationship between NACA and the industry.

**DEMOCRATIC RESEARCH**—In a large measure, this is due to the fact that the NACA has known how to draw the line between the solution of fundamental problems and the *ad hoc* research which develops particular airplanes, engines, instruments, and accessories, and which is properly the realm of industry. The whole system of interaction between government laboratory and industry is a remarkable manifestation of the democratic process.

What results has this democratic scheme produced at Langley Field? It has yielded, first of all, the most systematic and correlated knowledge of airfoils available anywhere in the world. The NACA family of airfoils is quoted, studied, and used in every country and, in all probability, Hitler's proudest aircraft are equipped with NACA airfoils in their original or slightly modified form.

The NACA laminar wing maintains a laminar or smooth flow over the greater part of its surface, and, when operating at its best efficiency, cuts down the drag of the airfoil tremendously. Since, in the modern airplane, the profile drag of the wing constitutes a large proportion of the whole drag of the airplane, the laminar wing has meant much to the efficiency and performance of our fastest military aircraft. As the speed of the airplane increases, the local speed of air flow at certain points on the surface of the wing approaches the speed of sound, with the compressibility burble and shock waves as the result, and this compressibility burble at one time threatened to put an end to further advances in speed. Again, the NACA researches have gone far to bare the causes and remove the vexations of the shock waves.

**Preparing a 16-foot, 8-inch, diameter propeller for testing in a Curtiss-Wright propeller-research test cell**

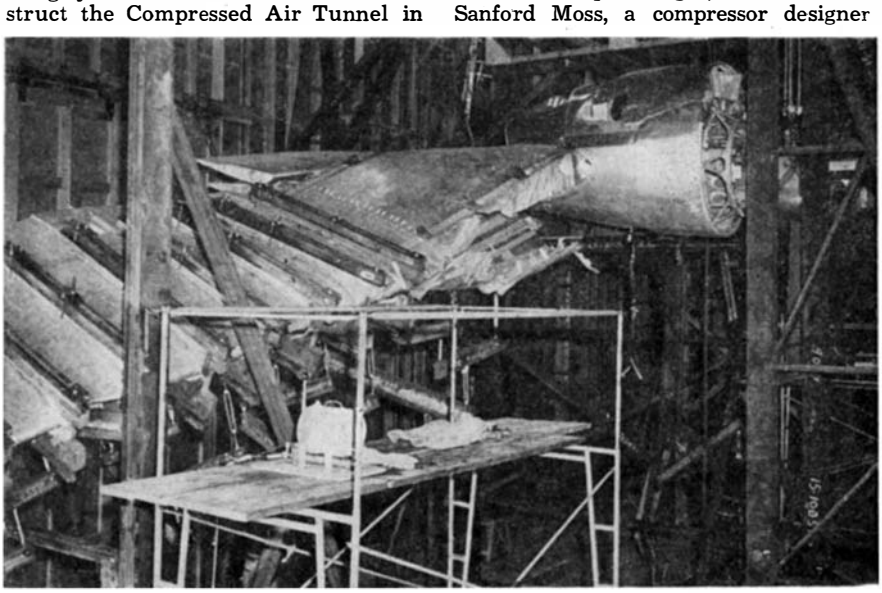
It is a well-known fact that America leads the world in the design of air-cooled engines. Such engines could never be used with the efficiency now available were it not for the NACA streamlined cowl which is seen in every picture of war-time aviation. To the NACA, America also owes a number of advances in experimental technique which have been copied or improved upon the world over. Thus, Langley Field was the first to construct the Compressed Air Tunnel in which the air, compressed to a pressure of 20 atmospheres, gives test conditions whereby small models can simulate the behavior of full-scale airplanes. To the NACA also, the United States owes the construction of the world's largest towing basin, and the knowledge derived in the towing basin has been an important factor in the development of our transatlantic Clippers. In addition, the NACA developed the high-speed tunnel in which the compressibility problems mentioned can be thoroughly investigated. America is also indebted to it for the first tunnels large enough to make possible the test of engine and propeller combinations, and the first tunnel (60 feet in span) in which it was possible to test a full-scale airplane.

Our universities, too, have fulfilled an important function in aviation. They have produced, in addition, such young leaders of the industry as Wellwood Beall, responsible for the Superfortress, who is only 37. It can be said that the American aviation industry, and American industry in general, as it has supported the aviation industry, has lived up fully to the lead of the NACA, and in fertility of ideas and in vigor of invention has surpassed the governmental institution.

**INDUSTRY'S CONTRIBUTIONS**—So much has been done by industrial research in aviation in the last 20 years and so much more under the recent pressure of the war effort, that it is difficult to select outstanding achievements.

The following is only a rough attempt at such selection. Long-distance flying and bombing in bad weather are possible only because the military pilot can pass on a large share of his task to the robot pilot. Elmer A. Sperry gave the world the Sperry automatic pilot based on a refined application of the gyroscope. It is a remarkable fact that the Sperry Company has persevered in this development for nearly 30 years.

Flying in the substratosphere would be impossible without the supercharging of the engine for the thin air of high altitudes. When America needed a supercharger, it found Dr. Sanford Moss, a compressor designer



**Testing a Boeing airplane wing to destruction**

who, with the full backing of the General Electric Company, gave it the turbo-supercharger which is making history every day.

Charles L. Lawrance and, subsequently, the Wright Aeronautical Corporation contributed the air-cooled engine, which was ultimately developed into a prime mover of over 2000 horsepower.

The principles of radar, first announced by two American naval scientists in 1922, were developed in England and saved her in the Battle of Britain because radio locators could find the Luftwaffe even at night. But radar received its finest development in the industrial laboratories of the United States. This branch of electronics, contributing vastly to the war, will also be of great help to peace-time aviation.

American industry has given us the materials and the "know-how" to enable the turbo-jet engine, coming from England, to surpass the fondest hopes of its original inventor, Captain Frank Whittle.

American ingenuity has produced the marvellous "thinking," automatically-computing gunsight which enables one of our pilots to shoot down his enemy when their relative speeds are nearly 1000 miles an hour.

From this brief survey of industrial aviation research, a few tentative conclusions may be drawn.

First of all, it is American industrial research which is one of the primary causes of American aerial supremacy. Since such research is the outcome of years of steady growth, and since laboratories and technicians cannot be improvised, it would be the worst kind of folly for the United States to discontinue aviation research after the end of the war. Let Congress cut, if it will, the mass production of aircraft. Not for one moment, however, can America afford to discontinue its efforts in aviation research.

Another statement which few will care to dispute is that the aviation research which for so long has been devoted to military ends, will indirectly cause peace-time aviation to flourish as a small compensation for the agonies of war. The automatic pilot will carry transports to the uttermost regions of the earth. Applications of radar will enable planes to land in the thickest fog. Supercharged engines and supercharged cabins will carry passengers at unbelievable heights in great comfort and at speeds which are impossible at lower altitudes.

**AVIATION'S DEBT PAID**—In the early day of aviation, the new-born science drew on the skill of men from other professions and built its equipment with the aid of other industries. Now it has more than repaid this debt.

Other industries have learned a great many things from industrial research in aviation for application in their own needs. For example, the turbo-jet engine will undoubtedly pave the way to advances in the gas turbine for general use. Because, in building the turbo-jet engine technicians learned how to design nozzles and select materials to withstand severe combinations of temperature and pressure, gas turbines can be expected in locomotives, in ships and, later, even in motor cars. Because radar has rendered so many services in aviation, the mariner will find it equally useful at sea.

Because supercharging has introduced the most difficult problems in heat exchange, the entire air-conditioning, heating, and ventilating industries will benefit. Because airplane builders had to face the highest decibel levels of powerful engines and fast-revolving propellers, sound-proofing will advance in many fields of industry and comfortization.

Because automatic pilots, airplane compasses, distance fuel gages have made use of electronics in its most refined form, and because remote indication and control have been indispensable in aviation, there will follow progress in many fields of industrial instrumentation and control.

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## BEATING COMPRESSIBILITY

### By Means of Two Simple Hinged Surfaces

WHEN an airplane approaches the speed of sound, as it may in a power dive, strange things happen to the airflow past the wing. The air, which flowed smoothly around the wing at lower speeds, now suffers "compressibility" effects. Shock waves are produced on either the lower or the upper surface of the wing, or on both. Pressure on the lower surface is likely to be converted into suction, while suction on the upper surface may become pressure. The efficiency of the wing is destroyed.

But that is not so serious as the fact that compressibility in the power dive produces violent buffeting effects on the tail, the pilot loses control, has tremendous difficulty in pulling out of the dive, and generally finds life unpleasant for the moment.

Now the engineers of Lockheed Aircraft Corporation, headed by their aerodynamicist, C. L. Johnson, appear to have found a remedy, which has worked splendidly on the Lockheed P-38 or Lightning and is being successfully tried out on other planes. Military secrecy still forbids detailed discussion of the device itself or of its theory, but the photograph shows how simple it is. Two simple hinged surfaces constitute the entire device. When they are outside the wing they break the shackles of compressibility; when retracted, they leave the airplane all its usual aerodynamic efficiency. After a power dive of 35,000 feet the Lockheed Lightning equipped with this device can pull out safely within 3000 to 5000 feet.

Compressibility shackle-breaker

## ATTITUDE INDICATOR

### Aids Pilot in Acrobatic Maneuvers

BY MEANS of a gyro equipped attitude indicator, the airplane pilot can now be provided with a visual indication of the position of his plane with reference to the earth, through all the possible attitudes into which an airplane can be maneuvered.


Airplane attitude indicator unit

In the past it has been impracticable to perform all aerobatic or acrobatic maneuvers without visual reference to the earth's surface. With the new Sperry Attitude Gyro it is possible to carry out such maneuvers even when the earth cannot be seen. The instruments thus constitutes an advance in training methods, and is also likely to be of help to combat pilots in a tight corner.

As in other gyro instruments, a gyroscope is the heart of the Attitude Indicator. It is electrically revolved around a vertical axis, and has the familiar gyroscopic properties of rigidity and precession, in order to provide an absolutely fixed vertical pattern around which the plane may be maneuvered.

The new feature is made possible by a novel method of suspension. The reference pattern is marked on the surface of the stabilized sphere with luminescent paint and is visible to the pilot through a marked opening in the front of the instrument case. The indicating sphere is divided into hemis-

pheres by painting the upper half white luminescent and the lower half black.

The only operating knob or adjustment required by the pilot is that for the "target"—a small circle which adjusts up and down to compensate for change in trim of the airplane in level flight.

### AIR TRAVEL

**Growth Predicted by**

**Result of Recent Study**

A REPORT by B. A. McDonald and J. L. Drew, which is a thorough and thoughtful study of what awaits aviation in the post-war years, has been issued by Curtiss-Wright. The report is based on assumptions of complete allied victory, a steadily growing income, growth of air transport based on economic rather than political considerations, regulation by Congress and The Civil Aeronautics Board following precedent, and on a continued, vigorous policy of air-traffic promotion.

Improvements in service may be expected, due in part to war-time developments applied to peace-time air transport. The number of accidents should become so low that fear of air travel will be entirely eliminated as a deterrent. Since fear has, in the past, kept more passengers away from air travel than any other cause, or causes combined, this advance in safety is of the utmost importance. Flight cancellations should be virtually negligible and almost 100 percent schedule performance may be expected.

Radar developments will help, as will also the blind landing systems which need only be installed at our great airports to be fully effective.

The comfort of air travel will increase greatly. Cabin pressurization; better lighting; excellent vision; complete soundproofing; stable flight, thanks to the automatic pilot; all are combining to make air travel more comfortable.

As a result of these favorable influences, the Curtiss-Wright report predicts an enormous increase in air travel, with number of passengers seven times that of 1940, five years after the war's end; with 700 million passenger miles a year as against 104 millions in the earlier period. A similarly rapid growth is expected in air express, with an estimate of 87 million ton-miles annually, compared with 10 million in 1940.

### JATO

**Rocket Units Being Tested**

**For Assisted Take-Offs**

IT IS not accidental that both the Navy and the AAF are experimenting with jet-assisted take-off—the readiest way of getting an over-loaded plane into the air.

The Navy has applied this principle to the Chance Vought F4U-I Corsair fighter. JATO, as these assisted jet take-offs are known in the Navy, reduce the normal take-off run from 33 to 60 percent of normal, or else they permit a greatly increased load to be carried. These devices are particularly useful in the restricted areas of carrier decks.

Rockets give added push

They resemble bombs, except that they are fixed to the under side of the fuselage rather than under the wing or enclosed in bays.

The jet units are really rockets (not jet engines) because they contain solid propellant which includes oxygen and do not take in air from the outside. They are ignited by electrically controlled spark plugs.

Air Technical Service Command experiments with such rockets have been going on at Wright Field for four years, with considerable technical success. It is not equally certain that they will be as helpful tactically. If runways are built so short that rockets are required for take-off, then the same runways will be short enough to cause many accidents on landing.

The rockets carry both fuel and oxygen, with the products of combustion escaping to the rear through a suitably shaped nozzle. There were two major problems to overcome—suitable fuels and oxidizers, and a nozzle which would stand the terrific heat of the ignited gas. Both problems have been solved, although better combinations of fuels and oxidizers are still being sought.

The Air Technical Service Command rightly warns us that rockets may be helpful in assisted take-off but have yet to show utility in long-range flight. The Germans are reported to have placed such take-off units in tactical use, possibly because their propellers, designed for high altitude, do not give sufficient thrust for good take-off at sea level.

### REVERSIBLE PROPELLERS

**Make New Navy Blimp**

**More Maneuverable**

BLIMPS have given a good account of themselves in the present war, and have proved invaluable in anti-submarine patrol. As compared with the airplane in such duty, the blimps have long endurance, can stay aloft for several days, and are able to hover over one spot; an airplane is obliged to fly relatively fast if it is to stay in the air, and has an endurance of only a few hours. Also, the blimps, when equipped with appropriate propellers, have a great deal of maneuverability. Such propellers are the Curtiss electric propellers with fully reversible pitch, which have been installed on the Goodyear M-I, the largest airship of this type owned by the Navy, shown in the photograph below.

The M-I is equipped with a mooring ring at the bow and a long lower structure with navigation and observation quarters at its front end. Nacelles on either side of the hull are braced by two powerful girders and contain 500-horsepower engines. With the use of the reversible propellers the blimp can be brought to a stop in the air and with the blades of one propeller pulling forward and the blades of the other pulling backwards, the M-I can turn in the air as if on a pivot.

It is also possible to make a running start into the air, with wheels on the ground. The blimp is then making use of the dynamic lift of the hull like the dynamic lift of an airplane wing. In general, ground handling qualities of blimps will be greatly improved by the reversible pitch mechanism, which has already proved very useful in maneuvering flying boats on the surface of the water.


Maneuverability of the M-1 is increased by reversible propellers

# Plastics—Products Of Research

**No Other Industry Has Profited So Greatly by Laboratory Research Than Has the One Built on the Original Work Done 75 Years Ago by Hyatt. A View of Accomplishments of Very Recent Years Serves as a Basis for Evaluation of Progress Yet to Come. Only the Surface has been Scratched**

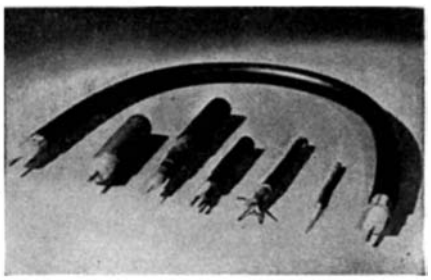
IN THE 75 years that have passed since John Wesley Hyatt founded the plastics industry by evolving the cellulose nitrate formulation known as Celluloid, new plastics materials have poured forth from research laboratories throughout the country.

In the past few years, the spur of war demands has abetted and perhaps forced the development of many new techniques and new plastics materials. And it has had a further effect. The exigencies of meeting rigid demands and specifications of the many Government offices and agencies, have brought about improvements in materials and methods of manufacture which will be of permanent benefit to the plastics industry long after peace is restored.

**SHATTER-RESISTANT GLAZING**—Characteristic of the activities that have engaged the attention and efforts of the plastics industry during the war years is the development of shatter-resistant plastic glazing. The history behind this Lucite-Butacite glazing, which is capable of resisting shock impacts such as the effects of penetration by machine-gun and cannon fire, or gunfire concussion, presents many interesting lights on the varied experience, the research, and the testing that must be called into play in the development of new plastics applications.

The strategy of modern aerial warfare involves the operation of aircraft at high altitudes, often in excess of 35,000 feet, where atmospheric pressure and temperatures are low. Hence pressurized airplane cabins were evolved whereby the atmospheric pressure inside the plane, at 40,000 feet for example, can be maintained at the equivalent of the atmospheric pressure existing at 12,000 feet, the highest altitude at which humans can live efficiently without accessory oxygen.

Pressurized cabins have another advantage. Heavy clothing, heated suits, and oxygen masks—burdensome when worn over long periods of time, as on bomber missions deep into enemy territory—can be discarded in planes equipped with pressurized cabins except, of course, during the period of actual bombing when an enemy shell might pierce the fuselage.

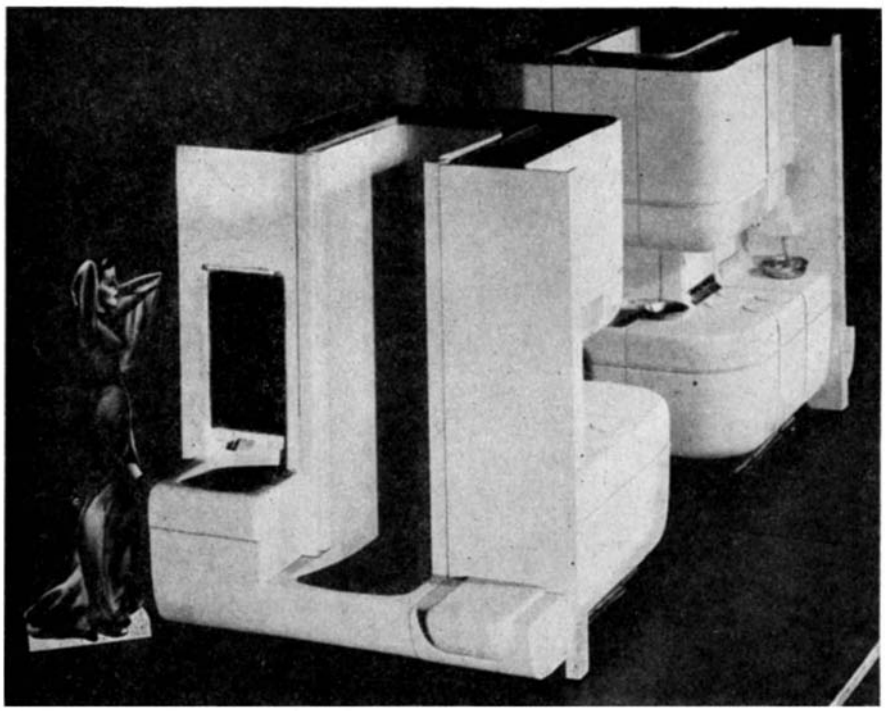


Courtesy Canadian Industries, Ltd.
**Polyethylene insulation is used in various high-frequency cable types**

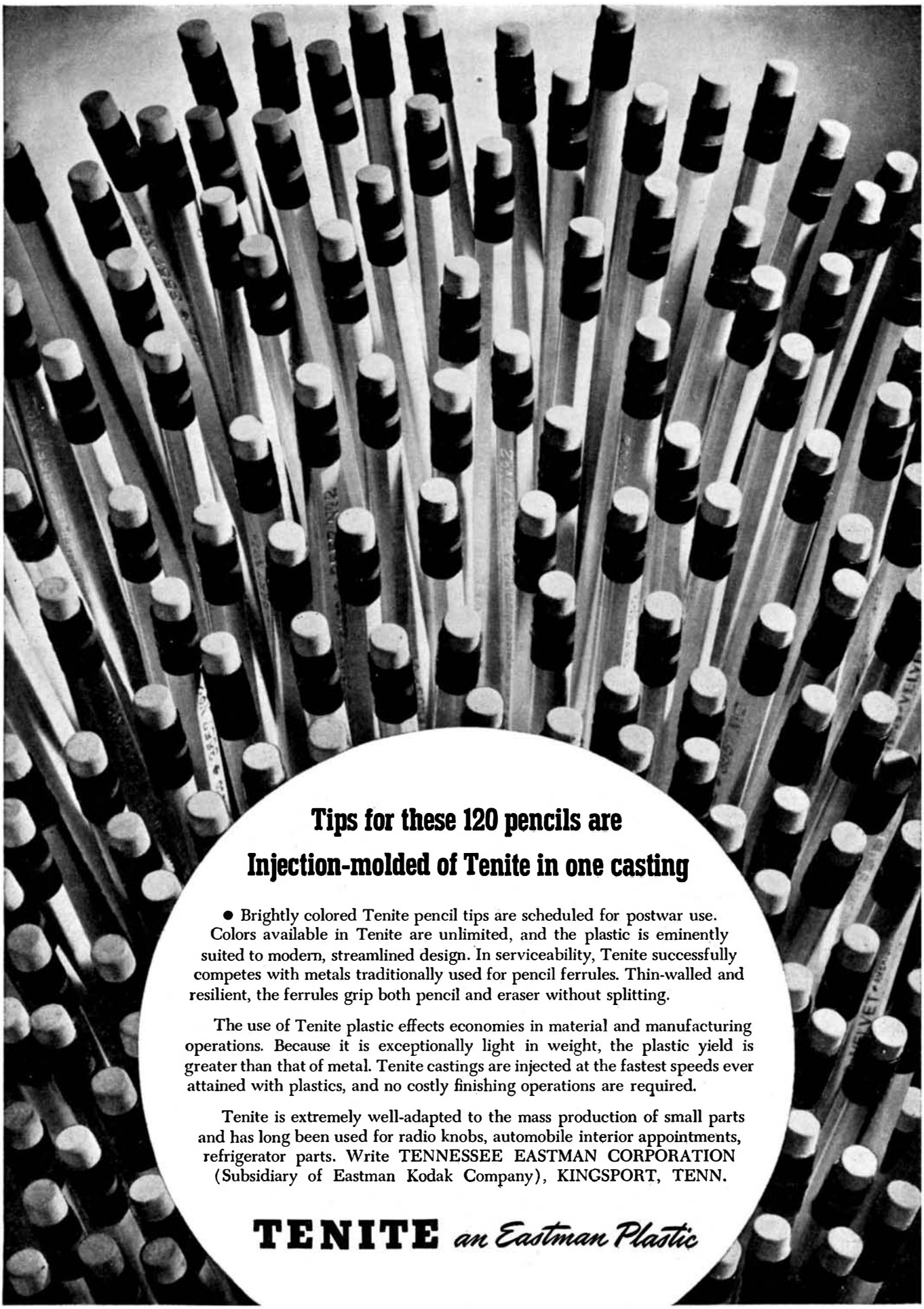
The problem then arose of preventing the escape of air from within the cabin when machine-gun fire pierced holes in the transparent plastic domes of pressurized cabins.

In the absence of a glazing that would resist enemy gunfire, a search was begun for a transparent plastic material which would, when penetrated by a bullet or shell, be self-sealing. Since no one plastic possesses transparency, the ability to be easily shaped, and the simultaneously contradictory property of rigidity with maximum flexibilty under shock impact to prevent shattering, the next step was to combine two materials which, when laminated together, might retain the desired qualities of each of its individual components.

Methyl-methacrylate was selected as one of the materials because of its rigidity, hardness, and weather resistance; and polyvinyl butyral resin was selected as the second component because of its tough, elastic, impact-resistant qualities. The experience and skill gained in the production of laminated safety glass was then applied to this new material, with sheets of methyl methacrylate placed on either side of a polyvinyl butyral sheet. Since polyvinyl butyral will not adhere to methyl-methacrylate, it was necessary to develop a special adhesive which would produce a strong bond between the two plastics, and several hundred



**For the home of the future, bathroom and kitchen sections may be assembled from plastics units. Many different arrangements of the parts will be possible**



## Tips for these 120 pencils are Injection-molded of Tenite in one casting

● Brightly colored Tenite pencil tips are scheduled for postwar use. Colors available in Tenite are unlimited, and the plastic is eminently suited to modern, streamlined design. In serviceability, Tenite successfully competes with metals traditionally used for pencil ferrules. Thin-walled and resilient, the ferrules grip both pencil and eraser without splitting.

The use of Tenite plastic effects economies in material and manufacturing operations. Because it is exceptionally light in weight, the plastic yield is greater than that of metal. Tenite castings are injected at the fastest speeds ever attained with plastics, and no costly finishing operations are required.

Tenite is extremely well-adapted to the mass production of small parts and has long been used for radio knobs, automobile interior appointments, refrigerator parts. Write TENNESSEE EASTMAN CORPORATION (Subsidiary of Eastman Kodak Company), KINGSPORT, TENN.

**TENITE** *an Eastman Plastic*

adhesives were tried before a satisfactory type was obtained.

Results fully justified the painstaking research involved in the successful development of this shatter-resistant plastic glazing. Tests on a ⅜-inch thick laminated semi-cylinder of this material showed no rupturing and only very small holes after being penetrated with a .50-caliber bullet under conditions where the pressure differential was 7.5 pounds per square inch and the temperature was —40 degrees, Fahrenheit. Further, these small holes can be patched by a crew member while the plane is in flight.

**The first BT-15 airplane to employ "sandwich" type of glass-plastics construction for such structural parts as the rear section of the fuselage, tail cone, and side panels**

**STRUCTURAL AIRCRAFT PARTS**—Probably the most noteworthy application of plastics to be made public during the year 1944 was the construction by the Army Air Forces Materiel Command at Wright Field of a Fiberglas laminated fuselage, tail cone, and side panels for a BT-15 airplane. This fuselage was the first primary structure in an airplane to be made successfully of laminated plastic. In the past, various plastic laminates had been used in the construction of non-structural airplane parts—fairings, fillets, doors, escape hatches—not subject to severe stresses, but none had exhibited the physical properties necessary for primary structures.

The success with which this experimental fuselage withstood the most stringent laboratory and field tests suggests a wide field of application in the future in the automotive, maritime, and building fields, as well as aeronautics.

Basically, the test fuselage for the BT-15 consists of glass cloth impregnated with resin to which a certain amount of glass fiber flock has been added to give increased strength. Sandwich-type construction is used, incorporating a balsa-wood core between an inner and outer skin of the laminate. No pressure is required for curing the newly developed resin used for this application. After laying up, the fuselage need only be subjected to a temperature of 220 degrees, Fahrenheit, for a period of three hours, after which it is ready for the trimming and finishing operations.

This laminated structural airplane part represents a synthesis of the results obtained from many years of research and test work in numerous fields —work that is still going on to perfect the material and the method of fabrication and make it practicable for large-scale factory production. On the one hand there is the long-range development conducted by Owens-Corning Fiberglas Corporation in the production of different types of glass cloth; on the other the research activities of seven resin manufacturers—Pittsburgh Plate Glass Company (Columbia Chemical Division), American Cyanamid Company, Libbey-Owens-Ford Glass Company (Plaskon Division), Dow Chemical Company, Monsanto Chemical Company, Bakelite Corporation, and Marco Chemicals, Inc.

Courtesy Westinghouse

**Use of silicone insulation accounts for the fact that the 10-horsepower motor in the foreground is half the size of the other, of the same rating, which has conventional insulation**

**PLASTICS IN THE HOME**—Just as the use of glass-reinforced low-pressure plastics for aircraft structural parts is well beyond the pure laboratory phase, so post-war applications of these same materials are now beyond the planning period. Perhaps the most interesting and promising of the proposed uses are to be found in models for space-saving, structure-supporting, prefabricated kitchen and bathroom units, which have been projected by Virginia-Lincoln Corporation.

These bathroom-kitchen designs take advantage of the ideal properties of glass laminates for individual units that are integral with standardized interchangeable wall sections. Many of the excellent features of these models would be impracticable to manufacture if the costly dies of high-pressure molded plastics were necessary, and on-the-spot assembly would be complicated if the units were made of light-weight metals.

The two-sided assemblies, which comprise a bathroom and kitchen, complete with full storage facilities, are intended in their most compact form to occupy a space only seven feet square yet are capable, because of airplane-type cantilever beams, of supporting the entire structure of the house. The strength of the main supports can be attributed to the use of straight-line, continuous glass fibers that are coated with a resin admixed with short lengths of finely divided glass-fiber flock.

The properties of this material make the glass fiber laminate ideally suited for the forming of refrigerators and plumbing units, and for strong, light, highly stain- and mar-resistant furniture for existing bathrooms and kitchens. Chairs and tables for terraces, even park benches, would possess improved weather resistance if formed from this material. Luggage is another market that offers interesting possibilities.

**ENTER SILICONES**—That returns already are being realized from the intensified war-time research is evidenced by the first commercial production of "silicones." Available as fluids, greases, resins, and lubricants, these materials, which are produced by Dow Corning Corporation and General Electric Company, bridge the gap between conventional organic insulating materials, which are limited with respect to heat stability, and ceramic-type materials, which have no such limitation.

While silicones may be said to derive ultimately from sand, brine, coal, and oil, their synthesis involves a number of steps and a considerable amount of industrial and chemical technology. They first reached commercial production in the form of water-white, odorless, inert liquid silicones. Two of these liquids have a low rate of change of viscosity with temperature and retention of fluidity at low temperatures, combined with inertness toward metals, coatings, and gasketing materials. These characteristics suggest that the fluids will have wide use as damping, gage, and ashpot liquids.

Excellent resistance to chemicals makes them useful as impregnants for asbestos packing and gaskets in chemical pumps; and their extremely low power loss, low water absorption, and stability to heat suggests their use as liquid dielectrics. These silicone liquids, when in solution with chlorinated solvents, can be employed in the treatment of glass surfaces or ceramic insulating forms to render them water repellent.

In resin form, silicones have a wide field of application in electrical equipment where the working life depends to a great extent upon the insulating and spacing material that is used. Because of their inherent instability to heat, conventional organic insulation materials tend to crack or carbonize, and to admit water and conducting materials when subjected to excessive

thermal conditions. While inorganic spacing materials can be used in electrical equipment, there must be temperature-stable resinous dielectrics to fill in voids, hold the conductors in place, keep out moisture, and insure good heat conductivity. This role the present silicone resins will undoubtedly fill in a great many insulation constructions.

It has been found possible, when design limitations are based on insulating temperatures, to reduce the weight of electrical equipment by as much as 50 percent through the use of silicone insulation. A comparison of two 10-horsepower motors, one insulated with the high-temperature silicone resin and the other with conventional insulating material, shows the unit employing silicones to be half the size of its mate.

**AND POLYETHYLENE**—Another plastics material having excellent electrical properties which was introduced to the public in 1944, is polyethylene, a hydrocarbon resin made by the polymerization of ethylene. Produced in this country by E. I. du Pont de Nemours and Company, Inc. and Bakelite Corporation, it has in its uncompounded state a waxy white, translucent appearance but may be made transparent in thin sections by quenching. Being a thermoplastic, polyethylene can be readily molded by injection or compression, or extruded to form sheets, films, fibers, tubes, and the like. In a sense, it is somewhat of a paradox. In thin sections it may be classified as non-rigid, yet it lacks the limp, rubbe y quality that characterizes most non-rigid plastics. In thick specimens it is often stiff enough to be classed among the more rigid materials.

The outstanding properties of polyethylene — flexibility and toughness over a wide range of temperatures, good resistance to water and to penetration by moisture, chemical inertness, and excellent electrical properties — should find it a place in many important applications.

Regardless of the method used in producing a finished article from polyethylene, standard equipment seems to work satisfactorily. Thus, conventional plastics and rubber equipment is used for the extrusion of the resins, while conditions normally applicable to the calendering of vinyl chloride-acetate resin compounds are suitable for polyethylene after modification.

When available for other than war needs, polyethylene will undoubtedly be used for collapsible tubes for foods and cosmetics, for flexible tubing or more rigid piping, and for gaskets and battery parts. Performance under service conditions already has shown promise for use in electrical applications, applications involving chemical resistance, medical applications, molded and extruded products (industrial and civilian), packaging, applications involving fibers or monofilaments, impregnated cloth, lighting applications, and numerous unclassified applications from furniture casters to printing plates.

Research laboratories can point to an impressive record of achievement during these years of war. But not content, they already are making and carrying out plans that may have a profound effect on our way of life in years to come. It is upon the results of their activity that we in America will depend for the material items that comprise our standard of living and for many of the jobs that make our purchases possible.

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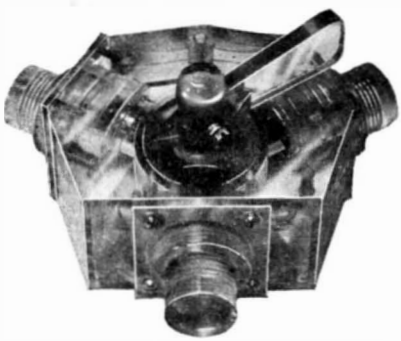
## PLASTICS MODELS

### Show Exact Functioning of Intricate Mechanisms

ONE of the most serious problems facing industrial plants has been the rapid training of new workers, many of whom are without knowledge or experience in engineering or manufacturing practice. The Ford Motor Company has solved this difficulty with a system of teaching which makes use of Plexiglas models.

The Ford method is based on the assumption that if a transparent plastic bubble in the nose of a bomber assists a navigator in plotting his course, a



Plastics reveal inner workings

block of the same substance surrounding a metal part should enable a student to see the inner workings of a bomber's more intricate mechanisms. Experiments were started in the construction of fuel selector valves, engine-driven hydraulic pumps, and hand pumps. It was found possible to machine blocks of transparent acrylic plastics to exact specifications for assembly with other plastic parts or with functional metal parts. The transparency of the acrylic allows the interior workings of the bomber mechanism to be seen in their true perspective without recourse to prismatic projection by engineers. Instructors are thus able to explain in step-by-step detail the separate functioning of each unit and to demonstrate its relation to the whole mechanism.

## PENCIL FERRULES

### Made of Plastics Stand Up Under Test

THE PENCIL chewer will have to acquire a taste for plastics. The American Lead Pencil Company has been testing plastic ferrules successfully for several years and plans to recommend them to its post-war customers.

The company's reason for this is based on the performance record of the Tenite II ferrules under test as well as the economies in material and manufacturing operations they effect. Compared to traditional copper alloy ferrules and tips made of other metals, the plastic pieces are superior in lightness, flexibility, and color appeal.

Two types of these cellulose acetate butyrate ferrules are manufactured by this company. The simpler type, used in cheaper grade pencils, is a reproduction in plastics of the old metal part. It is a simple injection molded tube anchored to the pencil and to the eraser plug by the traditional prick-punching method.

The second type, with glue-anchored ferrule, is used on the company's quality products—its Venus and Velvet pencils. The two ribs of this model, separated by a 3/32-inch depressed band, serve as borders for a brand-identifying colored stripe which is lacquered on the ferrule after molding. No prick punching mars the glossy surface and except for the lacquering of the stripe the ferrule emerges from the mold ready for assembling.

## BETTER FURS

### Produced By Using Chemicals Present in Natural Fibers

SHEEP in mink's clothing is the best description of a new fur-treating process developed by Dr. Jose B. Calva, a Mexican-born scientist. Using his method of chemically reacting groups already present in the fibers of sheepskin and lambs wool with a reagent to form a thermosetting resin, luxurious furs can be simulated.

Such added effects as luster, curl, water repellence, wear resistance, moth-proofing, and an increase in the diameter of the filaments, can be produced by variations in the reagents.

The process can also be of benefit to the luxury furs, adding permanent luster, crease resistance, and wear resistance to rare and fragile skins. Other applications include the treatment of jute, cloth, felt, pile, carpeting, and bristles.

The treating solution used in the Calva method can be applied so that it encases the fibers to add certain properties without changing the nature of the material. On the other hand, it can be used to alter radically the nature of the fiber as in the case of sheep pelts. In this process, tanned shearlings, selected for uniform quality, are first degreased and dried. They are then soaked in water and redried.

Next, the skins are subjected to two dipping operations—first in a solution composed of 60 parts by weight of commercial cresol and 40 parts of a mixture of benzol, alcohol, and water, and then in another solution of commercial formaldehyde. After removal from the final bath the skins are put through a series of washings. Finally they are dried, and given a heat treatment which completes the formation of the condensation products.

# Everything Under Control

**Chains of Control, Developed Through Constant Research, Result in Better Products, Made Faster and at Lower Cost. All Industrial Production Men Have a Stake in this Important Phase of Mechanical Engineering, to Which Teamwork Holds the Key. How Plant Safety is Increased**

MODERN factories make better products than ever before, make them faster and sell them for less money, all because research has been married to control. The future of all industry lies in that couple: research to find out what to do, control to make sure it is done. And of the two, control is probably the more important.

Almost any industrial product of today is produced under more controls, exercised by more people, than the production executives of 20 years ago would have believed possible. Nowadays a finished product is likely to be the result of chains of controls, exercised by groups of engineers who fully trust each other although they may never meet.

The fabrication of stainless-steel products is a case in point. Stainless steel, a tough, hard metal which for 20 years was a headache to any production man who put it through his machines, now goes down the production line with no trouble at all. And the reason is that the cutting of stainless really starts in the junk yard from which the scrap for the steel mill is purchased.

The junk yard has a laboratory. Here the scrap is tested, retested, and segregated as carefully as if it were an ingredient for a medical product. Often the yard management knows the complete history of the scrap, including the name of the steel mill which produced the original metal and the exact analysis which the metal was guaranteed to have. Fact is added to fact until the character of each bin full of chips and each bale of stamping trim becomes known.

The scrap goes to the mill of a maker of stainless steel, such as, for example, Rustless Iron and Steel Corporation. Here scrap of many different analyses will be mixed with virgin metals.

It would be easy for the steel-mill metallurgist to take so much of this scrap analysis and so much of that, and estimate that he would come out with the mixture he wants. But metals have ways of producing unexpected results when mixed. So the metallurgist must make sure. He takes fair samples of all the lots of scrap he intends to use, and melts them into an experimental ingot. Separate analyses can tell a great deal, but an analysis of an ingot tells the whole story.

Now, for a minute, let's shift the scene to the product development department of the company which is to fabricate this steel.

**AIMING AT THE END**—Stainless steels can be of many different analyses. Some are difficult to fabricate, others very much easier. The product development staff, aided by the sales research group, has worked out the exact qualities which the steel must have in order to result in a satisfactory end product. They have transmitted this list of qualities via their purchasing department to the steel mill. The steel-mill metallurgist therefore knows exactly what he must produce.

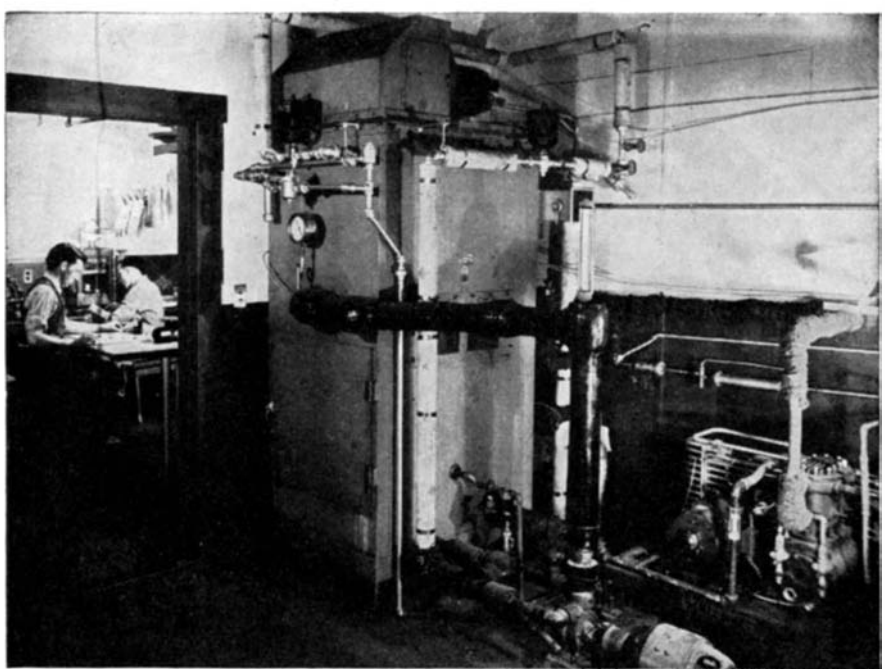
The production men are in the picture, too. Modern machine tools are capable of more exact control than any previously known to industry; they function as they are intended to function. So the production men tell the steel mill exactly how they will fabricate the metal. If necessary, a steel-mill sales engineer calls at the plant and sees the whole procedure.

This information means a great deal to the steel-mill metallurgist. Machineability (ease of machining) can be compounded into the steel.

But there are certain factors which must be observed. One of them is the matter of whether the cuts are to be deep or are to be fine. Sulfur, as an ingredient of steel, helps machineability on deep cuts and heavy feeds; it causes the chips to shear away easily and break up readily. But if feeds are going to be fine and cuts light, selenium in the steel may be more helpful than sulfur. And it is possible to vary many of the ingredients in accordance with the work to be done.

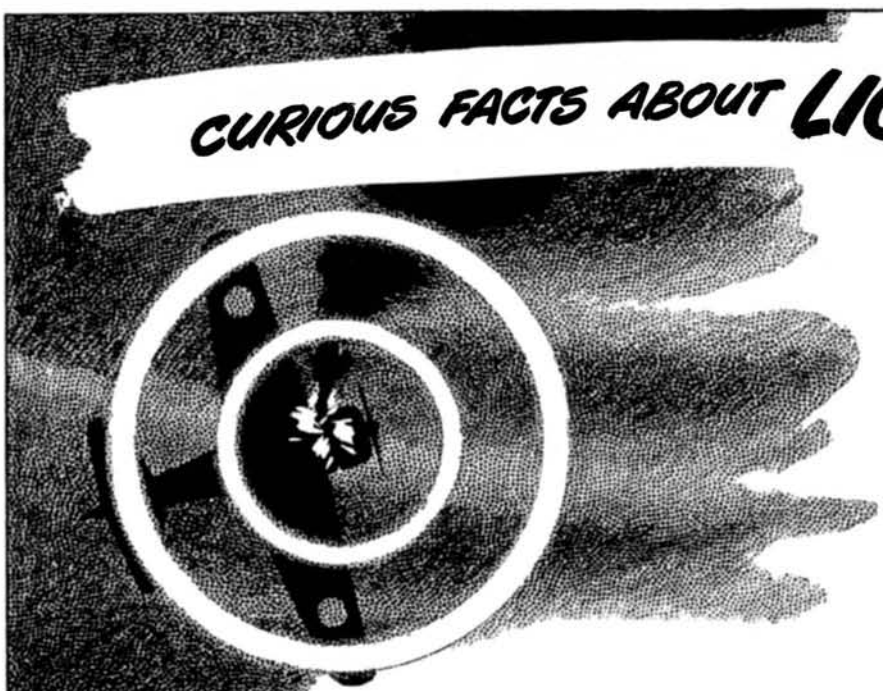
With all this information—and plenty more—in his hands, the metallurgist has his sample ingot put through the laboratory. Spectrographic analysis uses the flash from a carbon arc to excite the atoms of a tiny bit of metal. In 10 minutes a spectrum photograph sorts out the elements by their wavelengths and gives a quick but accurate picture of what the sample contains. And the laboratory with its furnaces, bunsen burners, hardness testers, and complicated glassware follows through.

The mixture finally decided upon is weighed out and put into the electric



Courtesy Robert Gair Company
Air-conditioning equipment (foreground) is often a laboratory "must"

# CURIOUS FACTS ABOUT LIGHTING



**LIKE SHOOTING FISH IN A BARREL . . .** There was a time when Jap Zeros could "sit in the sun" and come in with guns blazing — protected from our gunners by blinding sunlight. Not long ago, they had an unpleasant surprise. U. S. Army and Navy gunners now have a *new Westinghouse gunsight lamp* that lets them fire with deadly accuracy — directly into the sun. Formerly, our gunners could aim within only 15 degrees of the sun, leaving a dreaded "blind spot". This has now been removed — and, with it, a lot of Japs.

Lamps of 10,000 different types, using from 1/10th to 10,000 watts — incandescent, fluorescent, infrared, ultraviolet lamps, produced at the rate of about 1,000,000 units daily — lamps for seeing, for heating, for fighting disease — *wherever you see the Westinghouse Mazda Trade Mark, you'll find top quality!*

**CEILING, 2000 . . .** Vital "ceiling" information is provided for American fliers by *alidade* sighting device, which "draws a bead" on a cloud — illuminated by giant Westinghouse searchlight. Height is read directly in hundreds of feet.

**HAM AN' . . .** New sealed-beam landing lights for army bombers are so powerful that a Westinghouse engineer actually cooked a meal on the surface of an upturned lens. Infrared rays did the trick.

**DAVY JONES** could find good use for this 1000-watt sea salvage lamp. Inside are loose grains of tungsten which the diver can whirl against the glass — to scour off clouding particles emitted by the filament.

**SELF-CONTAINED SUN LAMP,** developed by Westinghouse, produces comfortable warmth with infrared, as well as beneficial ultraviolet rays. Mercury vapor, electrodes, reflector, and incandescent filament are sealed in a reflector bulb of special glass, which screws into any lamp socket.

**MAXIMUM "SEE-ABILITY"** is provided by Westinghouse 3-kilowatt mercury lamps — in blimp hangars, airplane factories, steel mills, etc. These lamps produce 120,000 lumens of light.

*Tune in:*
*JOHN CHARLES THOMAS*
*Sunday, 2:30 pm, EWT, NBC*

**Westinghouse**
PLANTS IN 25 CITIES OFFICES EVERYWHERE

*Tune in: TED MALONE*
*Mon. Wed. Fri. 10:15 pm, EWT,*
*Blue Network*

furnace. And here the control is as exact as it can be made. No longer does the steel man judge the temperature with his eye and the time for pouring by the behavior of the gases. A pyrometer with its thermocouple in the furnace measures the temperature, and the timing of the pouring is as carefully controlled as science can make it. A small sample ingot is poured so that its temperature can be taken separately and the metallurgist can have a complete record. Upon bits of evidence

Courtesy Robart Gair Company

**Modern packaging design requires application of structural engineering**

taken from such samples will be built tomorrow's improvements in metallurgy.

When the bars have been rolled and checks made to be sure they are of the intended analysis, another matter important to machining is taken care of—the surfaces of the bars are prepared.

**CONTROLLED PICKLING**—In recently bygone days, steel was pickled just enough to take off the scale, and that was that. Or it might be cold drawn or cold rolled for accuracy and to improve its surface quality. But every modern machinist knows that the skin of that steel, and what the tool has to do to get through the skin and start its cut, can make big differences to machining costs.

For one machining operation the stainless may be pickled lightly; the tools will not enter too easily and accuracy will be preserved on light cuts. For another the pickle must be deep; some kinds of tools simply will not take hold on a lightly pickled skin. Centerless grinding produces highly accurate bars, easy to turn into accurate parts, and with skins which invite top-speed machining. Cold drawing and other finishes have their places too. The point is, the steel fabricator gets the exact kind of surface which will best suit his machines, tools, and methods.

In his lathe, then, the machinist finds a bar which has been made exactly right for his task by control based upon research. But control is not yet finished.

Quite independent of the steel makers, the manufacturers of cutting oils and of tool steels have been carrying on their own exquisitely careful controls. The machine is equipped with oils and with tools exactly worked out for machining stainless steels. The oils usually are sulfur-bearing, the tools the hardest obtainable while avoiding any brittleness. The stainless will impose heavy tool loads; if it was not hard and tough enough to do this it would not be durable enough to serve in many of the products made of it.

Around him the machinist sees an array of instruments which would have bewildered an old-timer. His cutting oil is kept at an exact temperature, sometimes as high as 150 degrees, Fahrenheit, and there is a thermometer to show him what that temperature is. An electric meter shows him the amount of power his machine is using; if its needle does not point to the correct figure for each cut then he knows that something is seriously wrong. Dial gages follow every cutting tool; the machinist knows instantly if his work is becoming inaccurate. And at his elbow may be an array of inspection

Courtesy Rustless Iron and Steel Corporation

**Pouring a test ingot**

instruments ranging from micrometers and magnifying glasses to special templates and fixtures; no matter how many other men may be exercising controls, the individual responsibility of the machinist never diminishes.

Unlike his old-time predecessor, the machinist does not lubricate his own machine, test his own cutting oil, nor adjust his own lighting. These matters are too important to overall control to be entrusted to any one man. A special maintenance gang does the lubricating, and does it with special equipment which applies the correct lubricants and keeps them perfectly clean. Laboratory men check the cutting oil; chemical and physical tests are made with instruments. Lighting is a job for experts; the exact number of foot candles at every work plane, coupled with methods of preventing optical illusions and glare, all have been worked out by research. Cleaning the chips from the machine is a task by itself; those chips must be segregated, metal by metal and alloy by alloy, so that the cycle which started with the junk yard may be kept under control. The very cleaning of the floor about the machine is done with vacuum scrubbers which operate with machine tool precision.

And so stainless steel has hundreds of uses where it formerly had dozens, all because the close control of all factors has made its fabrication easy.

**CONTINUOUS CHECK-UP**—Control by continuous laboratory check-up is another method which makes modern industry more effective. A fiber carton maker, such as the Robert Gair Company, is an example.

A fiber carton really starts its life with a study in structural engineering. Every part of the item to be packed must be protected and supported, the item must be made to contribute as much strength as possible to the finished package, no weak part of the item may bear any heavy load, and the stresses must be distributed throughout the package so they do not concentrate at any point. In fact, a highway bridge can be built with less schematic engineering than goes into many a package. But when that structural engineering is finished, the product packaged will arrive safely at its destination.

The materials of which the package is made must be exactly as specified or the structural engineering will be useless. Therefore laboratory control of those materials starts with the pulp wood, waste paper, and other raw materials and never stops until the finished fiber board is being fabricated into packages.

There is a small laboratory, or at least a laboratory man with the necessary equipment, at every important machine and process. The laboratory

Courtesy Rustless Iron and Steel Corporation

**Checking tensile strength of steel**

man makes continual checks. He does not tell the production man what to do nor how to adjust his machines, but merely informs him of the immediate condition of the work in process.

The production man has at his finger tips a series of highly sensitive controls. He can change the amount of power being supplied to the machines and thus vary the amounts of work

Courtesy Rustless Iron and Steel Corporation
**Carbon determinations by the laboratory control the quality of steel**

being done on the stock. He can change temperatures, speeds, timings, the amounts of water being fed, or the ingredients in use. Standing at the push-button control station for a sequence of machines hundreds of feet long, he can change the coördination of that sequence to get more speed here, less heat there, higher pressures elsewhere.

A master laboratory does the final testing and lays down the original specifications by which the production men work. This laboratory continually tests the finished board, and may change its working specifications for any step in the production sequence.

Without this hand-in-hand working of laboratory and production men, thousands of tons of stock might be spoiled, or packages might have to be made bulkier, heavier, and far more costly in order to compensate for the weaknesses of faulty fiber board. But control is having its usual results. Packages are far better than ever before, and far less costly.

**INSTRUMENTS TAKE OVER**—Instruments are being used more widely than ever before to inform production men of how processes are working, and even to control the work directly. In fact, the 1930s are becoming known as the "instruments decade" during which mechanical and electrical controls displaced the five human senses as means for control. And the pace at which instruments are taking over is now much faster than in the '30s.

In everything from bakeries to brass mills the weather can affect the performance of processes; therefore instruments continually interpret the changes in weather and change the adjustments of process controls. Many plants making chemicals, paints, and like products are subject to wide fluctuations in the amounts of heat and power needed; instruments mounted at important machines interpret the conditions of the materials in process, translate their interpretations into predictions, and relay their readings to the power plants so that changes in the amounts of power and heat supplied may be made in advance of needs.

Instruments stand guard over hundreds of different kinds of explosion hazards, poisonous fumes hazards, and other dangerous processes; they are largely responsible for the fact that, in spite of its vastly multiplied potential dangers, industry is safer than ever before.

More than one highly complex sequence of machines is completely walled in so that its operators cannot touch it. Instruments do all of the controlling. Pushing a control switch button results in changing the settings of instruments, and the instruments in turn actuate the mechanisms which change the process controls.

And this is the future of manufacturing. Industry will grow by research, because research will be made useful by continuing development of control.

## FUEL ECONOMIES

### Reflected by Reduced Haulage of Coal

In 1918 the United States railroads hauled five tons of coal per capita per year. In 1943 (both years were war years) it was only 3.6 tons. Neither figure includes the coal hauled for burning in the railroads' own locomotives.

Very little of this decrease is represented by the substitution of fuel oil, gas, or other fuels. Any inroads these substitutes may have made into coal use are enormously overbalanced by the increased burning of fuel for power generation by public utilities and by factories alike.

These figures are direct indicators of how far mechanical engineering has progressed in getting more heat out of the same amount of fuel and making more efficient use of the heat after it is obtained.

## UPSETTING UPSETS

### Show Definite Gains in Forming Metal Parts

In the many-sided "battle of the processes" for forming metal parts, upsetting is obtaining a large share of the field. While not used as often as casting, cutting, extruding, or drawing, it nevertheless is making rapid strides.

One contribution to upsetting progress is harder and better metals for dies. This means that more heads or other shapes can be upset on soft stock before tools must be replaced, and that harder metals can be upset economically.

The use of controlled atmosphere furnaces for heating parts which are to be upset has greatly promoted the art. Formerly, scale from exposure to oxygen in the air was a serious problem to parts which were to be hot-upset. Now such scale can be prevented.

Resistance heating of parts, so that the upsetting takes place at the very instant the parts were ready for it, is a development originating a few years ago. The heating is done with the parts actually in the dies and the whole production cycle can be finished and the parts in the quenching bath before scale gets much chance to form.

Induction heating is making upsetting practical for large masses of metal. In the Chevrolet Saginaw forge plant, for example, the hub ends of aluminum propeller blades are induction heated in three minutes for upsetting, compared to two and one half hours needed to heat them by gas. Such gains in speed will lead to the use of upsetting processes on many more large parts.

## INDUSTRIAL PROTECTION

### Being Adapted by a Number of Organizations

Devices for the protection of workmen promise to become a major industry by themselves. Many of the most forward-looking companies are well in advance of the state and national laws in their use of them.

Westinghouse Electric and Manufacturing Company, for example, uses an ultra-violet lamp to kill any fungus growths which may have been left in safety shoes during fitting trials.

Another Westinghouse ultra-advanced method is the wearing of a piece of photographic film in the pocket of a

**Vest-pocket film protects worker**

man who works with x-ray tubes. Once a week this film is inspected. If the worker has been exposed to the dangerous x-rays, the film will be clouded. Search is then made for the source of the danger, and correction is completed before the man resumes work.

## WELDED CONSTRUCTION

### Applicable to a Number of Different Types of Projects

A diversified application of electric arc-welding to practically any type of steel construction for projects adaptable to peace-time purposes is forecast in a recent issue of *Construction Methods*.

An all-welded steel swimming pool is durable and usable with little care. An all-welded storage sphere for liquefied natural gas kept at a temperature of —258 degrees, Fahrenheit, has been constructed with an inner sphere welded of a special alloy steel, using a

shielded-arc electrode specially designed for welding various stainless steels. This procedure guarantees that the containers can be kept at extremely low temperatures without fear of fracture. After the war, liquid natural gas may be shipped in tank cars, barges, and ships, making this important fuel available in many additional areas.

An all-welded bus garage of extremely light construction is provided with long-span trusses, permitting a large, unobstructed repair area underneath without vertical support. A special tank, or "vertical bullet," used for the storage of highly volatile gases in the petroleum industry has been built by arc-welding. Increased use of high octane gasolines after the war may cause a growth in this type of fabrication.

Welded fabrication has been found to reduce maintenance materially and give a factor of safety in a rigid-frame all-welded steel building. The completed structures cost substantially less than was indicated by bids for other conventional types.

### CORNERSTONES

#### Aid in Improving Industrial Construction

New industrial materials come along so fast nowadays that many a plant management has trouble in keeping track of what materials were used for various purposes so it can know what values each material proved itself to possess.

One user of high-temperature processes has to tear down its furnaces when they are badly worn. It has trouble, however, in remembering what materials were used in them, since the life of a furnace between teardowns may be more than two years. The problem has been solved by putting, in a corner of the furnace remote from the heat, a hollow block in which is placed a list of materials used, the building method, and blueprints. Comparisons of these data with the repair and maintenance records, and with the condition of parts of the furnace when torn down, give the data needed for more durable rebuilding.

### LANDING STRIPS

#### Will Land New Jobs in Many Industries

The steel landing strips which are laid on the runways of new military airports, on invasion beaches, and the like, may have an important peace-time future.

One expected use is for secondary roads. The steel strips are laid, then filled in with mixtures of sand and oil, rubble and tar, and the like.

Roads of this type may be laid for temporary as well as permanent use. When a main arterial highway is being rebuilt, for example, the "one way only" and "pass at your own risk" strips which contractors must keep open, are as expensive to contractors as they are bothersome to motorists. Much of this trouble may be saved by laying temporary landing strip roads, and the method may pay for itself out of savings in the costs and time needed for rebuilding the main roads.

Some types of factory floors offer other uses. Where there are heavy castings which must stand and cool, for example, a readily replaceable mat of heat-dissipating steel beneath a shielding layer of sand may offer great advantages.

Chemicals and other plants which make use of process muck to fill in swamp or waste land, are eyeing these landing strips with favor. The strips will permit temporary roads to be laid for dump trucks, make the handling and piling of the muck for the smoothing bulldozers easier and less costly.

### SALVAGED BTUs

#### Show Profits to Far-Sighted Industries

Industry is coming out of this war with greatly advanced techniques for salvaging and using heat units.

More heat than ever before is being generated in melting, grinding, welding, and other processes. Less of it is being wasted by exhausting heated air to the atmosphere or running heated liquids to the sewer.

One long-time technique is to run dust laden air from grinding machines through filters, remove the silicosis-dangerous dusts, then return the cleaned air to the work zone. Since the air has been heated largely by the friction of the grinding operation, the BTUs contained in it are salvaged materials. The savings in plant heating bills often pay for the cleaning of the air and then show a profit. One electrical products plant estimates that it saves 800 tons of coal a year in this way.

Another method is to run water, heated while cooling rolling mills, direct to metals washing tanks which must have their water supplies kept at above 150 degrees, Fahrenheit.

Offices, and even the nearby homes of workers, are heated by steam or hot water piped from heat-producing processes. The water is recirculated to the process tanks.

Waste heat is used to preheat metals before flame cutting, to heat thermoplastic materials before molding, to preheat metals before abrasive blasting, to heat baths used in plating, to heat water used in the processing of textiles, and for dozens of other purposes.

Often the salvaging of heat units adds tiny weights and secures delicate balances in the economies of the production line—economies which pay off in their total effects upon profits.

### REMOTE CONTROL ON THE HOOF

#### Enables Operator to Select Advantageous Observation Post

As more and more machines are connected together into continuous processes and as mile-long continuous conveyor systems become commonplaces, the problems of remote control and of mid-point temporary adjustments of speeds, and so on, are on the rise.

The most common control method is to have variable-speed motors, variable-speed power transmission drives, and the like, spotted along the chain of integrated machines. Skilled operators then can change operating speeds as needed to keep the continuous process functioning.

One trouble with this has been the tendency for unskilled men to monkey with the controls. Often the adjustments in operating speeds, although made with the utmost of good intentions, have very bad effects.

Another trouble is that it may be impossible to locate a push-button station at the best post of observation for the operator, since that post is wherever the trouble—the conveyed material pile-up or whatever—occurs, and this is largely a matter of chance.

One way of handling both troubles is to hang a push button electrical switch box on the belt of the operator. Leads from this plug-in at the control stations, and since no other buttons are located at these stations, unauthorized personnel cannot operate the controls.

The operator carries spare lead wires which are long enough so he can plug-in at the regular control station and then stand several feet from the station while manipulating his switches. He thus can do his controlling from a place which gives him the best view of the trouble he is correcting.

### WOODEN DIE BLOCKS

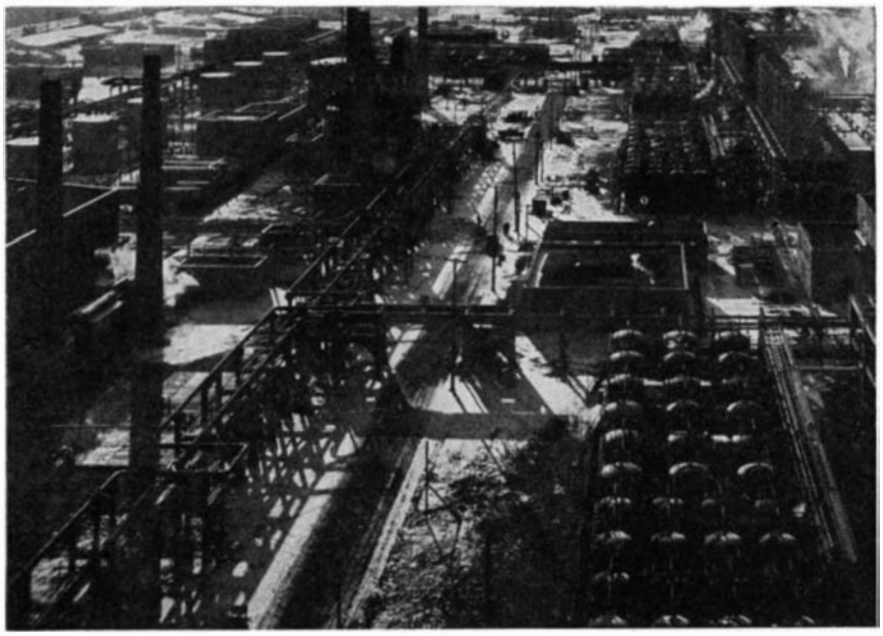
#### Are Inexpensive and Increase Speed

Wood fiber processed by the Masonite method is capable of being given wide varieties of hardness, weight, water absorption, and other characteristics. Many of the resulting products are military secrets, but one which has come to light is the wooden die block.

This block is compressed to such hardness and weight that it will not float in water. But it can be cut and shaped to a smooth finish and it will hold its shape under changing temperatures.

One principal use is for dies on metal spinning machines. The wooden block costs only a few dollars to finish into a die, whereas metal blocks may cost hundreds of dollars. Once shaped, the wooden block provides a surface over which the metal flows very easily, in some cases materially decreasing the labor and increasing work speed.

Large pieces, such as sections of airplane wings, also are shaped over these blocks. The use of wood in large sized bending brakes is old in the sheet metal art; many mechanics preferred the friction characteristics of metal over wood to metal bent over metal. One of the old troubles was the non uniformity of the wood. With this new product—and perhaps other wood dies to be made of lumber prepared by the new Du Pont and other processes—wood may be an important factor in the tools of the intricate shaping sheet metal industry of post-war days.



**The synthetic rubber industry is a product of chemical research. This partial view of Koppers United Company's Kobuta plant gives an idea of its immensity**

**CHEMISTRY IN INDUSTRY**

Conducted by D. H. KILLEFFER

# Where Research is King

**In the Chemical Industries More than Any Other Field, Research is the Basis of All Progress and Profit. Outstanding Among its Achievements Has Been the Drastic Lowering of Prices on a Long List of Materials Used Widely in Production, with Consequent Benefit for All Humanity**

By F. J. VAN ANTWERPEN
Associate Editor, *Industrial and Engineering Chemistry*

THERE IS nothing in chemistry today that research has not affected. This is another way of saying that there is nothing in your life which has not been influenced by this same force. Research has been defined as "a state of mind." The field of chemistry, with its many offshoots—industrial as well as theoretical—well represents this state of mind. Fortunately, this state of mind has paid immense dividends both in dollars declared to stockholders and in discoveries basic to progress.

Although research is continually concerned with the development of new and better things for mankind, not the least benefit to come from the application of the research method is the reduction of prices to the consumer. The chemical industry is a long-time champion in this respect.

It was said recently that the cost of triptane—marvelous new fuel—was $1000 a gallon when it was first produced on a laboratory scale. Pilot-plant trials brought the cost down to $35 a gallon and recent experiments have perfected a process that is going to make this tremendously powerful gasoline for less than a dollar a gallon.

**COST REDUCTIONS**—Research has also lowered the prices of certain chemicals as follows:

Acetanalide cost 66 cents a pound in 1918; now it costs less than 23 cents.

Acetone cost nine cents in 1934; it is priced at four cents now.

Ammonia has been halved in price in 30 years.

Aspirin fell from $3.26 in the last war to less than 47 cents in this.

Cellophane cost $2.65 in 1924 and research has reduced this to about 30 cents today.

Coal-tar dyes, short in 1918 at $1.07 a pound, are plentiful today at about 61 cents a pound.

Benzyl alcohol reached the stratosphere during the World War I shortage at $6.25 a pound. With the proper priorities you may buy it now at 51 cents.

Chile, at one time, with a corner on iodine in the world marts, forced the price to well over $4.00 a pound. Several chemists out west, noticing that oil-well brines had a high iodine content, devised a process to recover this halide and Chile's monopoly was crushed for all time, as was the exorbitant price.

When dry ice first appeared the price was close to 4 cents a pound; by 1939 it had come down to 1.5 cents.

In six years cellulose acetate prices fell 20 cents a pound.

Hydrogen gas has dropped from $6.85 to $1.38 a thousand cubic feet in 10 years.

Obviously, only the application of intensive and deliberate research could produce results such as those described above. It is a long cry from the attitude of early industry when manufacturing was an art, techniques were handed down from father to son, and not a jot or tittle could be changed. Today, research deliberately attempts to find improved manufacturing methods and cheaper and more available raw materials—all dedicated to making a finished product that will be accepted more readily by the public. Research is a powerful tool that is busy at all times creating new industries and new comforts for mankind.

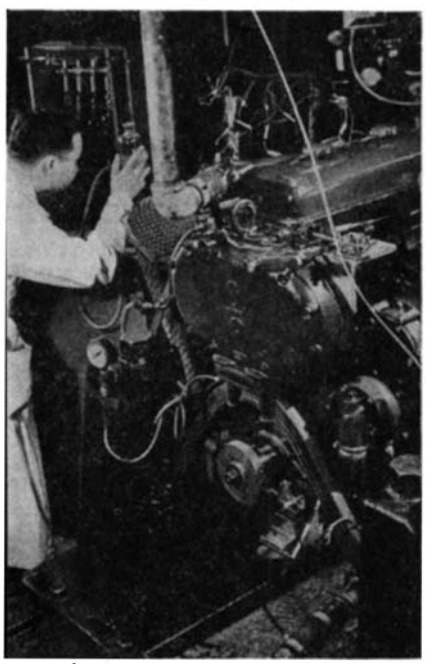
**UNPREDICTABLE RESEARCH**—Arthur D. Little, one of the men in America who sold the necessity of research to industry, once said that research had one characteristic in common with lightning — one never knew where it would strike. In analyzing that statement

another aspect of research is seen—that, even though research is generally planned along certain lines, the results are never certain and a successful research organization must be able to capitalize on whatever new facts are turned up.

Chemical research has always been able to do this, from the day when the boy who was later to become Sir William Perkin, trying to synthesize quinine, found the coal-tar dye industry in his test tube, down to the present, when a food concern improves mechanical greases or discovers a material that will purify water.

In early 1939 several German scientists toured the country inspecting the industrial plant of the United States and at the end of the tour they were asked what had impressed them most in all they had seen. Their answer is a tribute to the greatest institute that has ever been developed for research; the thing that filled them with envy was the Mellon Institute and the close co-operation which it fostered between research and industry. To them that was the crowning achievement — only to be found in a country where industrial progress is a continuing thing — upon which general prosperity is dependent.

There is nothing new in organizations dedicated to research. The Germans had them. The uniqueness was to be found in the co-operation between industry and the scientist—proof that the intangible basis of research *is* a state of mind. The donors of the money that founded the Mellon Institute had recognized that research was a necessary condition to the general welfare of the country. Andrew Mellon said: "It is science, not governments nor wars of conquest, that opens up to us new horizons." Mellon recognized other truths concerning business and science when he stated that "improvement in the standard of living of the human race can come about in the future only by reason of new discoveries and inventions, just as in the past the steam engine and other inventions have been responsible for many improvements in the standard of living enjoyed by the average man today. It is these things and not governmental or political action that have increased production, lowered costs, raised wages, elevated the standard of living, and so have brought about a greater participation of the human race in these benefits."



**A General Motors' Diesel on a test stand where many thousands of hours were spent on lubrication research**

**FINDING THE UNSOUGHT** — Chemical research as practiced at the Mellon Institute has fully met the expectations of the founders. One example will be given—the most famous, perhaps, of any example that could be chosen to illustrate research and the queer twists that may be expected from it. As in many research problems, the chemist was looking for one thing and found another.

Dr. George O. Curme, working for the Prest-O-Lite Company on an industrial fellowship, was seeking better ways to produce acetylene, the gas used in oxy-acetylene welding and cutting torches. The method then in vogue for generating the gas depended upon the reaction of water on calcium carbide.

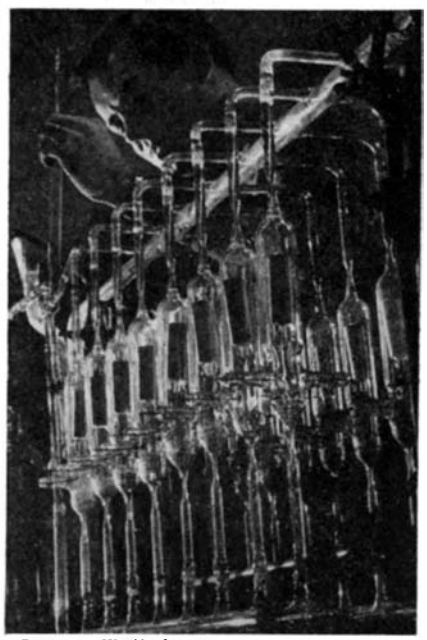
Curme soon found that acetylene could be produced by cracking gas oil. The one drawback was that ethylene —an unwanted by-product—was formed also. If the process was to be economical, it was necessary that an industrial use be found for ethylene, and research was started to find some outlet for that by-product. The outcome was the anti-freeze that you probably use in your car — ethylene glycol. This same material is also used in the explosives industry and is serving purposes entirely new to the arts. Its ethers are ideal solvents and are finding irreplaceable (until further research topples them) applications in the lacquer field. And from the researches on acetylene has today grown the mighty Carbide and Carbon Chemicals Corporation.

The list of chemicals developed by this corporation from the application of intensive research methods is longer than your arm. The young man who made the original discovery is a vice president of the organization and still its sparkplug in research. Upon these basic researches is founded an industry producing organic chemicals from petroleum gases. The same Carbide and Carbon Chemicals Corporation has been making ethyl alcohol from the ethylene of natural gas for many years. This was another triumph of research, for it had been predicted freely that such a process would never be economical in the face of alcohol from fermenting blackstrap molasses. Research paved and proved the way.

**PROFITABLE BY-PATHS**—The paths along which the state of mind just exemplified may lead a company are strange indeed. The Eastman Kodak Company, conducting research on problems basic to the photographic business, found itself with a highly successful means of producing vitamins. A technique that was investigated by the Eastman laboratories was that of high vacuum distillation. The investigators soon found that the methods, developed for the study of a problem dealing with ways to improve the taking of a picture, were also conducive to making vitamin A by the distillation of natural oils.

The same company is a large producer of cellulose acetate yarn—a business that stemmed from production of safety film. And that compound pays dividends from its use as a thin, transparent wrapping material.

The photographic business leads inevitably to plastics, for the inventor of the phenol-formaldehyde type plastics,



Courtesy Westinghouse

**Research is seldom wasted. This elaborate set-up was made for the purpose of testing the insulating qualities of paper used in radio condensers under extreme heat and cold**

Baekeland, was also the inventor of Velox photographic printing paper. If any industry can be considered a product of research, certainly the plastics industry can be. It began when a young man experimented until he found a substitue for ivory, and received its great impetus when Baekeland invented, through research, his famous plastics. The industry is continuing on the same basis—research—and is making the older plastics stronger and cheaper; the same state of mind is bringing out more and more new plastics for newer applications.

The ancient and honorable field of textiles also yields to the organized search for knowledge and improvement. An example from this field serves again to illustrate the tenet that everything is grist for the research mills. A textile chemist has no real business worrying about the tarnishing of silverware, but the intellectual curiosity of such men will always provide progress. Silver tarnishes because the sulfur gases in the air combine with the silver to form silver sulfate, the black film that sends good house-

wives into dithers. One solution hit upon was that of impregnating a flannel bag with metal salts, but research soon proved that the sulfur that formed as a sulfate on the metal salt moved, in time, to the interior of the bag and caused an even greater formation of film. The final answer to the dilemma was to saturate the flannel with silver itself, and millions of the tiny pieces of metal are incorporated into each bag. The sulfur in the atmosphere combines with the metal in the bag and the result is to protect the eating implements. Lightning strikes in strange places and a state of mind can lead along unorthodox paths.

**BASIC RESEARCH**—There is an untold debt that civilization must acknowledge to so-called basic research. The development of nylon owes its success to the pure research done by Carothers in the field of polymerization. The synthetic nitrogen industry traces itself back to the experiments made by Dewar on the liquefaction of air, and the glowing neon signs that light up the city are direct descendents of Sir William Ramsay's experiments on the densities of nitrogen.

Can anyone adequately sing a paean of praise to a force that has to its credit the many chemical wonders that are seen on every side? In two wars research in the chemical field has fought to a standstill the shortages threatened by blockade. In World War I there were shortages of dyestuffs, potash, drugs, anesthetics, and many other materials. In this war the shortages were rubber, tin, antimalarials, and high-octane gasoline, and additional manufacturing capacities for aluminum and magnesium had to be provided. In each case the victory was won. Research proved it could be done and industry proceeded to fill the empty warehouses.

The story of research is always dramatic. In the last war there was an acute shortage of aniline. According to the Germans, we could not hope to make this material because benzene from American coal wasn't the right kind. This palpable nonsense impressed our chemists not one bit, and by 1917 we were producing 37 million pounds of aniline per year. Research is, after all, only observation and deduction, and these qualities brought a happy solution to a serious problem.

Research may be a key to the unknown, but it is a key that requires a great deal of turning. Results in research are not usually obtained by waving a wand or appointing a crew of chemists as research workers. Results are usually obtained by the investment of patient money over a long period of time.

No story on research illustrates this better than the discovery of tetraethyl lead by Thomas Midgley, Jr., who was one of America's most capable chemists and who recently died a tragic death. The discovery of tetraethyl lead, according to Midgley, is only one part of another major research problem still continuing—the improvement of the automobile. Even after tetraethyl lead was discovered, there still remained the problems of reducing production costs and proving beyond question that there was no health hazard in its use.

In the words of Midgley, tetraethyl lead was a "tough uncompromising problem . . . possible only because courageous corporate executives had the foresight to invest large sums of money and continue backing an idea . . . when less astute minds might have dropped it . . . With only slightly different circumstances the whole project of ethyl might have been written off at one time as a $3,000,000 flop."

Such is research. Truly, it is a state of mind found only in men who will back to the hilt an investigation into the unknown, looking for an intangible something that will solve a problem not yet defined, to give to mankind benefits they do not expect.

**RESEARCH IN WONDERLAND**—There is a delightful bit of nonsense in Lewis Carroll's "Through the Looking Glass" which may well represent all industrial research. Alice was in the garden of live flowers talking to the Red Queen. Suddenly they both were running hand in hand. (From here on the Red Queen is Research and Alice is the Public or Industry or what have you). The Queen went so fast that Alice could just about keep up. Still the Queen kept crying, "Faster! Faster!" The most curious part was that the trees and other things around them never changed places at all. However fast they went, they never seemed to pass anything. "I wonder if all the things move along with us?" thought poor puzzled Alice. And the Queen seemed to guess her thoughts, for she cried, "Faster! Don't try to talk!"

Finally Alice managed to pant. "Are we nearly there?" "Nearly there!" the Queen repeated. "Why we passed it ten minutes ago! Faster!" On they went, the Queen urging "Faster Faster" —and at last when they did stop Alice discovered that they hadn't covered any territory at all—they were yet in the same place. Upon commenting upon this phenomena, Alice was surprised to hear the Queen say that it was what one could expect.

"Well," said Alice, "in our country you'd generally get to somewhere else —if you ran very fast for a long time, as we've been doing."

"A slow sort of country," said the Queen. "Now here, you see, it takes all the running you can do to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"

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## SUBSTITUTE PLASMA

### Realized Through Use Of Ion Exchangers

ION-EXCHANGE resins have a possible new war-time use, it may now be revealed. Newest application of these chemical materials promises to be the purification of pectin and gelatin for use in the preparation of substitute blood plasma. Substitutes for blood plasma are being developed because of shortages, and present indications are that pectin and gelatin will serve as temporary and partial replacements.

The ion-exchange materials eliminate unwanted salts from supplies of the substitute blood. Salts which can be eliminated are calcium, sodium, arsenic, and lead. It is possible, through the use of the ion exchangers, to eliminate completely the salts normally present in water, the finished product being similar to distilled water. The present application is a continuation of that technique.

## FAT SALVAGE

### Has Averted a Soap Shortage

FATS and grease saved by the housewife come back to her in the form of soap. The successful campaign to collect these materials from the homes of America has paid a handsome dividend to the citizens by preventing a soap shortage.

The war, which cut off the normal supply of coconut oil, presaged a difficult time for the soap maker. He has been forced to use substitute oils and fats, and the changes have in many cases forced a revision of formula. Lard, a fat seldom used in the soap field, was one of the materials that offered itself, and 74 million pounds were used in 1943. Resin entered into all soaps for a time, but shortages have cut into its use.

The housewives, above all, helped considerably and the amounts of kitchen grease normally consumed by the soap industry have been increased 54 percent. At the same time, materials obtained from the waste fats have done their job in munitions and medicinals production.

## GLASS TOMORROW

### Will Perform Many New And Strange Duties

A POST-WAR age of glass, in which new and strange duties will be performed by that material, is predicted by Professor Alexander Silverman, head of the Department of Chemistry of the University of Pittsburg and one of the nation's leading authorities in glass technology.

Glass will be used to reduce heating costs, to bring clearer movies, to help in the cooking of dinners by lamp radiation, and possibly to harness the sun's rays for heat and power, according to Professor Silverman.

The glass industry, he said, now valued at $500,000,000 in the United States alone, has made more progress in manufacture and technology in the last 50 years than in the thousands of years before. The war, Professor Silverman adds, has hastened many developments, most of them yet secret, that will bring transformations in the everyday mode of living.

# Research In Metal Heating

**Cheaper and Tougher Metal Parts for Many Uses are Expected to Follow as a Result of Research at a New Laboratory for the Development of Wider Applications of High-Frequency Induction Heating to the Tasks of Metal Hardening, Brazing, and Annealing**

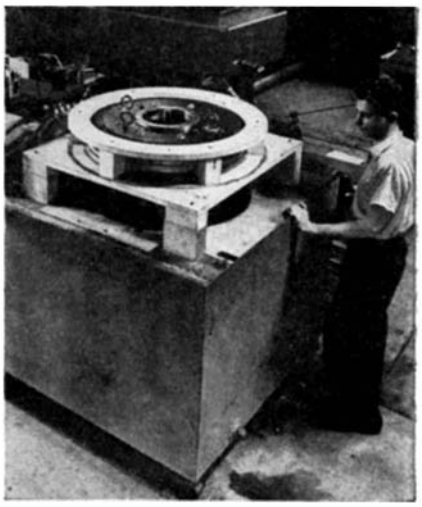
WIDER fields for induction heat-treatment of metals are expected to be opened as the result of the recent completion of a new high-frequency experimental laboratory by the Tocco Division of The Ohio Crankshaft Company. Its facilities enable full-scale experimental work on applications for the hardening, brazing, annealing, or heating for forming of both ferrous and nonferrous parts of varied size.

Power supplies available in the laboratory include 333 kilowatts of 1000 cycle current, 1000 kilowatts of 2000 cycle current, 300 kilowatts of 3000 cycle current, and 335 kilowatts of 9600 cycle current. Power is controlled by a four-way standard-type panel board governing each of four generators that produce the high-frequency current.

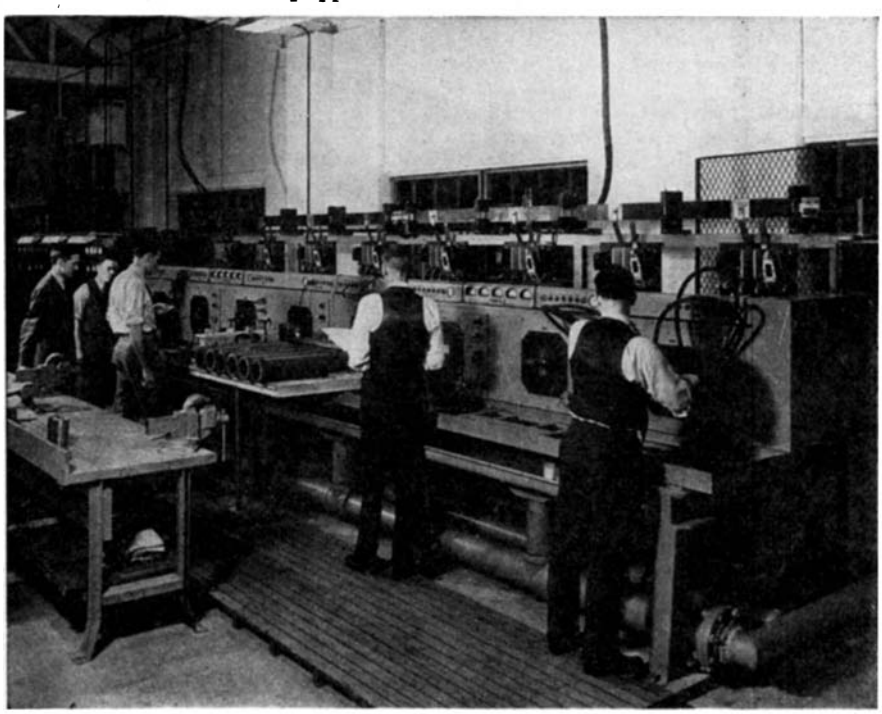
Experimental induction machines are of varied styles and capacities, the most distinctive being an eight-station, panel-type unit of 9600 cycles, 25 feet long and six feet high, having automatic controls. Each station is equipped with a different turn-ratio transformer for maximum experimental usefulness. Here various tests can be run simultaneously without interference or delay. Physical dimensions of the work area of this large unit coincide with standard Tocco machines, facilitating development and testing of new fixtures and inductors.

The progressive hardening of bars and tubing is carried out on two machines, one hydraulic and the other mechanically controlled. In the mechanical style the piece remains stationary while the inductor moves up along the bar to be treated. These two units, which really are fixtures operating on 9600 cycles received direct from the generator, have facilities for obtaining maximum range of speed and power depending upon requirements of parts under test.

Experiments on big parts, crankshafts, steam-hammer rods, generator shafts, and the like, are made on what is termed a "tunnel line" because of its long sheet-metal hood. This is a four-station unit, 20 feet in length, ruggedly constructed, and equipped with a moving cradle set on a track to hold test parts positioned in the water-cooled inductors. Each station is equipped with automatic and manual control devices. Power frequencies of one, two, three, and 10,000 cycles give the tunnel line the ultimate in induction flexibility.



**Hardening a 26-inch gear in the special experimental unit. The induction heaters can be changed to accommodate different sizes of gears**



**Eight-station test panel used for experimental inductors and special heat-treatment applications. A variety of tests can be run without interference between them**

Another special test unit is that for gear hardening. It is a five-foot-square box-like fixture, five feet high, with full automatic control devices, and with a circular inductor which can be changed to accommodate a new size. A quenching mechanism is set in the center, providing water or oil quenching.

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**POST-WAR DINING CARS**
**Will Feature Diagonal**
**Arrangement of Tables**

PLANS for a post-war railway dining car embodying diagonal seating and possessing the "atmosphere and appointments of a fashionable club" have been prepared by the Pullman-Standard Car Manufacturing Company.

The outstanding feature of the car is its floor plan which is arranged to accelerate service, to eliminate inter-

ruptions caused by arrivals and departures at the tables, and to enable waiters to step to the side when serving so that aisles are free at all times. Other innovations include vibrationless tables, spot-ray illumination, linen storage at each table, and intercar telephone communication.

Tables, which have a total capacity for 42 persons, are placed diagonally and seats are set at a 45-degree angle to the side of the car instead of at right angles as in ordinary diners.

"One of the greatest benefits accruing to the traveler from the angular seating arrangement," according to Ellis W. Test, Assistant to the President in charge of Engineering and Research, "will be unobstructed movement. Each person will slip into his seat or leave the table without disturbing his neighbor. Everyone will have a side of the table to himself and enjoy a normal conversational position instead of knocking elbows as at ordinary diner tables.

"At the same time, each one will view the passing scene without even turning his head. The diagonal arrangement will permit waiters to step between the tables when serving, and they will serve from the side instead of reaching over the person occupying the aisle seat as is necessary in the old diners."

## CRYSTALIZED LIGHT

### Brings Closer an Understanding of Electricity

BY TRANSFORMING electricity directly to light, a phenomenon common to fluorescent tubes and vapor lamps, "we have freed electricity in an uncrystalized form," a Westinghouse lighting authority recently told The Franklin Institute.

"Fluorescent tubes, mercury vapor lamps, and the various other new electric lamps which produce light without the intermediate step of heat, as represented by a hot incandescent wire, simply develop uncrystalized electricity so that it goes out as radiant energy," said Samuel G. Hibben, director of applied lighting for the Westinghouse Lamp Division.

The lighting specialist expressed the belief that these new "quasi-electronic methods of illumination, which produce light by sending an electrical discharge through vapors, should bring us closer to understanding what electricity is." Light is uncrystalized electricity or, stated another way, electricity is crystalized light, Mr. Hibben said.

## SALT BATH FURNACES

### Anneal Brass on Production-Line Basis

A FULL anneal of brass cartridge cases on a continuous production heat treating basis is being accomplished with what are said to be the longest continuous conveyor-type salt-bath furnaces in operation in America, and with an unequalled absence of oxidation.

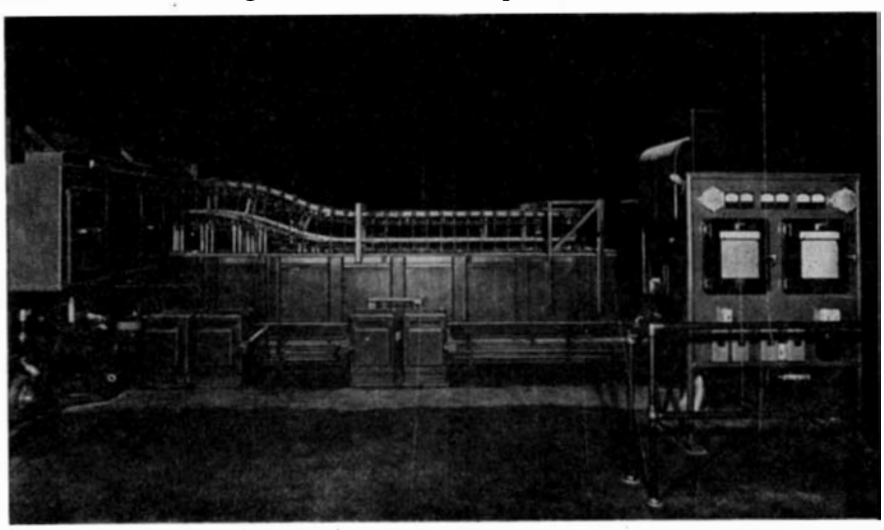
In addition to the expected reduction in costs of operation, plus the increase in speed, the feature of the operation which employs Upton Electric Salt-Bath Furnaces is that the anneal on the brass is not only a full one but it is absolutely bright as well.

While this has been attempted on other occasions, it has never before been accomplished to the extent that the cases come out of the heat treatment clean and bright and without the slightest trace of oxidation, so that pickling or other cleaning is not required following the anneal.

Two furnaces are employed, each capable of annealing 6000 pounds of brass every hour. One gives the cases a full anneal at 980 degrees, Fahrenheit, before the nosing operation. The second furnace full anneals the cases at the same temperature after the nosing operation.

Each of the two furnaces replaces ten individual non-continuous-duty furnaces previously used and with such savings that the management of the Detroit concern where they were installed is reported to have stated that "the furnaces paid for themselves in the first three weeks of operation."

The annealing operation is not only continuous but entirely automatic, with the exception of the occasional shovel full of salt required to replenish the salt lost through normal operation and from the nominal drag-out. The temperature of the bath is held within ±5 degrees, Fahrenheit, by automatic electric temperature control.



Electrodes in this salt bath furnace enter the sides instead of the top

The first furnace to be installed was equipped with removable covers with the idea that sufficient heat would be radiated from the salt to make them advisable. Salt is added through a small door in the covers at the turn-around end of the furnace.

The second furnace installed is not equipped with covers since, through experience, it has been found that the amount of heat lost is so small as to be not worth even the small additional expense.

Uniform temperature throughout the entire bath is made possible largely through the placement of electrodes which enter the sides of the furnace instead of being thrust in from above the surface of the salt. These electrodes, which conduct the current into the bath from the transformers located outside the furnace, are so positioned that the transfer of current through the salt generates the heat at the bottom of the pot rather than anywhere above that point. The result is that a normal flow of heated salt circulates upward, thereby heating the entire content of the bath evenly and uniformly.

## HOME WORKSHOPS

### Will Probably Increase in Number After the War

HOME workshops, either for hobby or business, will have a place in more than 60 percent of all homes after the war, reports the Delta Manufacturing Company, designers of power tools, as a result of a survey just completed.

An interesting fact brought out by the survey is that the majority of men and women in the armed services are planning now the homes they intend building after the war. They are reading any and all literature dealing with home building and are intensely interested in new developments calculated to make homes more liveable and easier to maintain.

The excellent mechanical training the Army and Navy has given to its personnel reflects itself in a desire on the part of these men and women to continue using their newly acquired skills when they return to civilian life, both to create objects of beauty for the home and to keep down the cost of home maintenance.

Civilians are equally anxious for information to aid them in future home building. It was noted that men, and especially women working in war plants, have been agreeably surprised to find that they have first class mechanical ability as shown by the many diversified products they have created. These persons indicate a wish to apply this aptitude for their personal use at home in the fabrication of many articles of wood, plastics, and metal.

It has been the experience of home owners that, for a fraction of normal market cost, they have been able to build excellent storm windows, bookcases, kitchen cabinets, and even complete sets of furniture for the entire

house. With the high cost of labor and the acute shortage that is expected to exist for some time after the war in many of these products, home owners state that they intend to construct many of these articles themselves. They have found that, with a small number of inexpensive power tools such as a table saw, drill press, lathe, and sander, repairs and additions to the house can be completed economically in a professional manner in a fraction of the time it would take to do the job with hand tools.

### COMPREHENSIVE EDUCATION

#### Needed by Embryo Industrial Scientists

In addition to the scientific course which they are given, it is important that students preparing for a career in science should be taught to express themselves, says Dr. Saul Dushman, assistant director of the General Electric Research Laboratory in the *American Journal of Physics.*

Writing on the subject of "Post-War Training of Physicists for Industry," Dr. Dushman says it is often forgotten in connection with the training of physicists, and of scientists in general, that "progress in science as well as other branches of human endeavor depends ultimately upon the ability to communicate ideas to others by means of language. Whether it be the exposition of an idea by word of mouth, or the description of experimental observations in a paper for publication, clarity of expression and logical presentation of data and conclusions are prime requisites. It is not required of the scientist that he be either an orator or a clever wielder of $64 words, only that he express himself clearly in everyday language and use this language correctly."

The role of the physicist in war-time developments has shown that he can be very practical, Dr. Dushman declares.

"Industry has learned through the experience of the past few years," he writes, "the fact that physicists are capable of contributing to, and initiating, fairly complex engineering developments. The design and operation of a cyclotron requires a technical skill such as compares very well with that required to design and operate high-voltage generating equipment. The physicist has indeed demonstrated by his activities in the war effort that he is not the theoretical recluse intent only upon some abstract objective; that, in fact, he can become under proper conditions just as practical and just as hardboiled as any industrial engineer. In view of these considerations, it would seem reasonable to suppose that in the post-war world there will be a much greater demand for physicists in industry than in the past."

Such industrial physicists must know other subjects besides their basic physics and mathematics. "The physicist in industry," Dr. Dushman continues, "must be versatile and adaptable. In view of the increasing complexity of materials and operations used in industry the physicist should also know considerably more chemistry than has been the case in the past. Indeed, I would like to suggest that the proper course of training for an industrial physicist should be one that would comprise almost as much chemistry as physics."

### CONTINUOUS MOLDING

#### Achieved in Machine that Handles Plastics or Rubbers

A continuous injection molding and extruding machine, the only known device of its kind in the world capable of producing an unbroken seamless tube of any kind of plastics or rubber and of any length, has been developed by engineers and technicians of Chrysler Corporation. One of the machines —in use by a licensee in another state —is producing seamless plastics tubes to launch rockets, and another one is ready to mass-produce rubber insulators. An experimental machine in the corporation's Engineering Division has produced hundreds of plastics and rubber parts and articles.

The new machine, which employs a worm screw similar to those found in coal furnace stokers, has undergone extensive tests and has shown that it can step up the manufacture of many thermo-plastics and thermo-setting plastics, and real and synthetic rubber articles, at least ten fold. Because of the quadruple field the single machine is capable of covering, the range of plastics and rubber parts and articles, in much larger sizes than realized under previous manufacturing methods, is apparently very great.

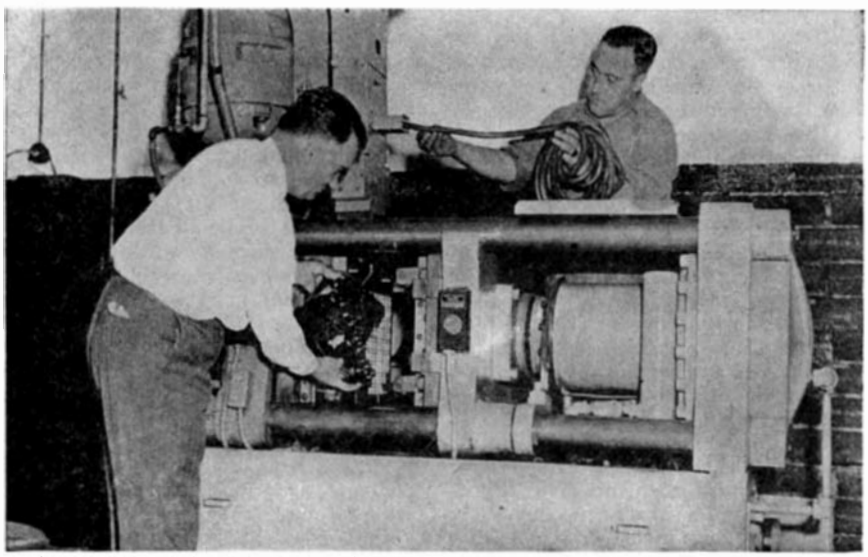
The machine has produced as large an item as a plastics battery case in less than five minutes, using 128 ounces (eight pounds) of thermo-setting plastics. No other machine is known to be capable of injection molding an article of this material weighing more than 36 ounces. It has produced at one molding in less than three minutes as many as 144 rubber insulators. It is also capable of producing precision rubber parts for many war products.

In the tubing field the machine has enormous possibilities. Thermo-setting plastics tubes, made in any lengths desired, can be used for overhead and underground pipelines. The thermo-setting plastics is highly resistant to corrosion, and in some cases can replace steel and iron pipes with lesser resistant qualities. Where long lengths of iron, steel, or concrete are necessary for rigidity, thermo-setting liners produced by the machine would provide resistance to corrosion.

Under the conventional compression molding method, plastics or rubbers are placed in a die by hand, and pressed into shape by clamping another die to it. To insure adequate material in the finished product, more than enough is inserted in the die cavities. Under pressure the excess material forces itself out through cracks where the die faces join, causing flash, or waste material.

**Some of the many articles that can be produced by continuous molding**

With the continuous injection machine only the quantities of plastics or rubbers needed are injected into dies already clamped together, eliminating flash and saving time and materials and cutting costs of production. The ordinary "one shot" injection machine, which was an advancement over the compression type, eliminates flash waste, but is limited in the size of parts it can produce. With the new Chrysler-



**One of the new continuous molding machines producing link bushings for shock absorbers. The inventor, Walter P. Cousino, left, is removing links from the die**

developed machine, producers are able to inject plastics or rubbers in a continuous stream as long as there is mold area to be filled. Different dies for different sizes of products can be used with the same continuous injection head.

The continuous injector consists of a simple hopper holding plastics or rubber. The material is fed to a heating cylinder where a special churning apparatus keeps it evenly mixed. The putty-like substance is then shot under screw pressures up to 22,000 pounds per square inch through a nozzle clamped to an opening where the die plates join. When the material has filled every tiny crevice in the mold, or series of molds, the back-pressure automatically shuts off the feeder.

When the machine automatically shuts off the flow of plastics or rubbers the worm screw reverses itself, keeping the material remaining in the heating and feeding chambers pliable and ready for the next injection.

Because of the uniform feed, and even mixture of materials, the curing time required by the new machine, compared to similar materials and other types of machines, has been cut by approximately 93 percent, besides the complete elimination of waste. Where multiple molds are used the tiny canals through which the putty-like materials pass from one cavity to another produce excess webbing which is easily trimmed away without impairing the finished products.

## HEAT EXCHANGERS

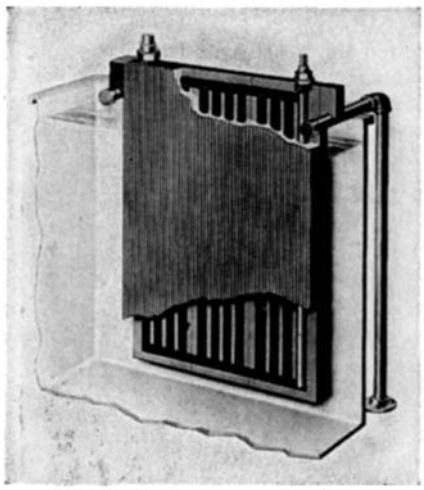
### Resist Chemical Action and Temperature Changes

MADE of "Karbate" chemically inert graphite materials, a new type of heat exchanger has been perfected for use in chemical and process industries by National Carbon Company, Inc. Designed specifically for chemical applications, the corrosion resistant "Karbate" heat exchangers possess high heat transfer values and are resistant to practically all acids, alkalis, and solvents. They are unaffected by acute thermal shock and may be used freely in intermittent operations, or in alternately hot and cold chemical baths.

Of plate type, the heat exchangers employ the principle of extended, or corrugated, surface to attain maximum heat transfer area within small overall size. The compactness of the exchangers increases their inherent mechanical strength. At the same time, it reduces the tank space required for the heaters, further minimizing the hazard of mechanical shock during process operations. The exchanger is a four-inch thick plate with a number of internal 1½-inch diameter communicating channels for steam or cooling medium.

Production of the heat exchanger units is standardized in four design groups, incorporating both parallel and series flow channels, thus making possible different combinations to meet the widest range of heating and cooling requirements. The heaters may be installed in sections, depending upon tank capacity or solution temperatures required, and are suitable for nearly all tank sizes or shapes.

A number of the heat exchangers have been in use in various processes for a year or more and afford sufficient service data for comparative purposes. Such heaters, 4 by 10 by 48 inches in size, operating on 25 pounds of steam and maintaining tank temperatures of



**Sectioned view of new heat exchanger**

180 to 190 degrees, Fahrenheit, have been in service in tanks containing approximately 10 percent nitric acid and 3 percent hydrofluoric acid. There has been no visible sign of deterioration in these units in the year or more of their operation. In the same application, no metal heat exchanger has been found that would stand up for more than a few days.

In other types of corrosive chemical operations, the "Karbate" corrugated plate heaters have greatly increased heating efficiency and reduced process costs through longer service and through eliminating maintenance costs.

## TELEVISION PROJECTION

### Uses Special Lens And Mirror System

REFLECTIVE optical systems for television receivers employing special types of mirrors and lenses, according to a paper by Ioury G. Maloff and David W. Epstein of the Radio Corporation of America, are now being used to pick up images from the face of the cathode-ray receiving tube and project them on a screen suited in size to the requirements of the room or auditorium in which the images are to be viewed.

RCA systems for projection of television images, the authors of the paper stated, consist of a spherical front surface mirror and an aspherical lens. The non-technical reader may visualize the mirror as a shallow bowl, while the aspherical lens is flat on one side, with the opposite surface rising slightly at the center and at the edges, but depressed in the intermediate area. The surface contour of the lens renders it optically positive in the center with a gradual change to negative in the outer portions.

The gain in illumination on the viewing screen obtained with these new systems is about six or seven to one when compared with a conventional *f*/2 lens, it was revealed, and the quality of the images obtained is comparable with images produced by conventional projection lenses.

Because of more nearly perfect diffusion of the light emitted by the fluorescent face of a cathode-ray tube, as compared to light from an intense source such as is used in motion-picture projection, the paper pointed out, the efficiency of the conventional motion-picture projection lens is extremely low when such a lens is used to project a cathode-ray tube image on a viewing screen. Any increase in the brightness of the image on the face of the tube could be obtained only at great cost. Attention was centered, therefore, on the problem of providing a manifold increase in the percentage of light that could be delivered to the screen.

"It has been known for a long time," the paper continued, "that aspherical surfaces in combination with spherical or aspherical mirrors may be arranged into optical systems of high aperture and high definition. Astronomers have made use of this principle, but high costs and difficulties in constructing such systems have prevented their general use.

"Since the principle had been developed only for the infinite throw used in astronomy, much painstaking study and work was required to adapt it to short-throw projection.

"Aside from this necessary adaptation of the principle, a major problem was the high cost of the aspherical correcting lens. Astronomers produced them only by tedious, step-by-step methods. The apparent solution was that of molding the lenses from a suitable transparent material.

"After such a material was found, there remained the problem of making molding surfaces of metal in shapes of the negative replicas of aspherical lenses and obtaining optical finishes on

**Removing from its mold one of the plastic lenses used for projecting brighter, larger television images**

he metal surfaces, but this was accomplished."

In one type of receiving unit described in the paper, the projection ystem is mounted near the floor of the abinet, with its axis vertical, projecting he image straight up and on a flat irror inclined at 45 degrees to the inoming beam of light. The mirror hrows the image on a translucent creen which is built into the cabinet. uch an arrangement presents the adantages of compactness and a cabinet f relatively small depth which can be tyled along the familiar lines of a adio console.

Because of their great light-gathering ower, the paper stated, other types of effective optical systems, built for innite rather than finite throw, find very seful application in television pick-up ameras under conditions of low illumination, such as during the last mintes of a football game or in direct ick-up from a theater stage.

## UBBER TANKS

### eveloped for Fuel

### ransportation

PORTABLE synthetic rubber tanks are ow being extensively used in combat reas for both transportation and storge of gasoline, oil, and aromatic fuels, o insure an adequate supply of these ital materials at all times.

Developed by United States Rubber ompany, these huge collapsible tanks an be set up or taken down very uickly. Advantages of the synthetic ubber fuel tanks for overseas use are hat they are collapsible and can be hipped in small space. They are light n weight, easily camouflaged in the eld, and can be quickly set up or nocked down for transportation to a ew location by a very small crew. Before their use, steel tanks were needed or storing or transporting gasoline.

Tanks for transporting fuel are made ith 750 gallon capacity, carried on a tandard 2½-ton truck, and with 2700 allon capacity, three of which are arried on one railroad flat car.

Storage tanks, used for advance comat or reserve supply back of the lines, ill hold either 1000 gallons or 3000 allons of gasoline.

The collapsible fuel tanks are made of ildew-proofed fabric coated with synetic rubber. Tanks can be repaired n the field as easily and speedily as can tire's inner tube.

## NFRA-RED LAMPS

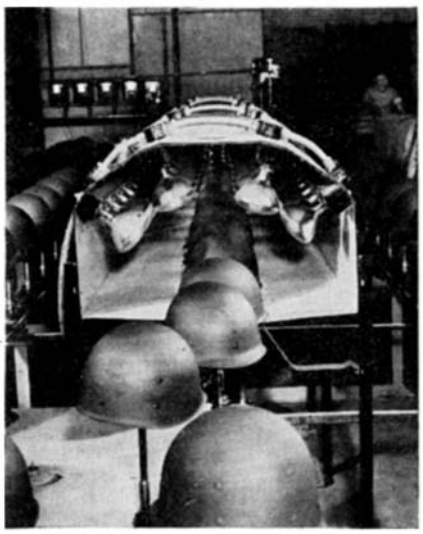
### an be Applied to

### lany and Varied Uses

NEW post-war heat sources, speeding eace-time drying jobs in the home and ndustry and providing a flexible supplement to regular space heating equipent, will be developed from infra-red mps, according to James D. Hall, Vestinghouse Lamp Division engineer.

"Lamps operating on the same prinple as those which now are swiftly ooking' paint on tanks, jeeps, helmet ners, and other war material," Mr. Hall ays "can be used to dry everything in the home from fingernail polish to freshly bathed Fido. Heat lamps also will be popular for chasing the chill out of the house during late spring and early autumn."

As comfort heaters, Mr. Hall forecasts, radiant heat lamps screwed into regular lighting circuits and clamped on the reading-lamp fixture will be beamed to keep the reader's neck and shoulders comfortable. Similar lamps, spotted around the house, could protect tender plants from the cold, speed up the drying of hair and laundry indoors, and



**Drying time for Micarta helmet liners is radically reduced by passing them under a bank of infra-red lamps**

perform other household drying and spot-warming chores.

Up to now, heat lamps have been applied mostly to industry for war-time drying jobs. A vast indicated expansion in industrial uses, particularly in automobile plants, textile mills, and food dehydration plants, offers what the specialist described as the "brightest prospects" immediately after the war.

Banks of infra-red lamps will be on every post-war automobile assembly line, the engineer forecasts. From five to six minutes will be required to whisk a thoroughly dried automobile off the paint rack, instead of the 50 minutes required by the customary drying process in pre-war days. In woolen mills, lamps heat the cloth to high temperatures so that unwanted particles of wood, burrs, and other foreign material in the finished product are reduced to carbon which can be easily shaken free. In food dehydration, infra-red reflector lamps can dry food in five to 30 minutes, as compared with 15 to 30 hours previously required.

Listing some peace-time industrial infra-red applications which already are in operation, Mr. Hall says the man-made radiant heat is quickly and efficiently drying foundry molds in place of drying by kerosene torch; fusing label paint onto glass bottles; baking insulating varnish on electrical equipment and paint on electrical transformer tank covers; drying glue on paper envelopes; processing burlap used for sandbags, and drying sample swatches of cloth pasted on cardboard.

Typical of the war production contri-

**Infra-red lamps, placed under desk, keep the office worker comfortable**

bution of radiant heat lamps is their record in drying the paint on tanks, Mr. Hall says. Radiant heat lamp rays, beamed from the sides of a drying tunnel in one of the nation's giant tank arsenals, complete the drying of paint on tanks in four minutes instead of the 24 hours required previously. In the manufacture of plastic helmet liners for the Army, infra-red lamps have speeded the drying process from an estimated 15 minutes by the oven-drying method to a new low of 95 seconds. The oven process required a tunnel-shaped unit 225 feet long; the infra-red dryer is 19 feet long.

Still another peace-time possibility for the lamp is the assistance they will give the motorist in winter. One bus company, the lamp specialist relates, "no longer has trouble starting its vehicles on cold mornings. Infra-red lamps turned on under the hood of a bus an hour or so before the driver reports for work, bring the engine to spring-like temperatures."

## TREE OF LIFE

### Yields Industrial

### Materials in Brazil

BRAZIL has a tree which produces the most important vegetable wax in the world, flourishes in drought when other vegetation withers, yields food, fruit, medicine, and materials for building paper manufacture and other useful arts, according to *Chemical and Engineering News*.

The tree is the carnauba wax palm, known as the "Tree of Life." It has defied not only the greatest scientists to produce it synthetically, but also other nations to grow it successfully.

"When everything else shrivels and seems to die, the carnauba palm reaches its greatest productivity in wax," reports Dr. Nelson S. Knaggs of the Hilton-Davis Chemical Company of Cincinnati.

"Cattle can live on the shoots of the young carnauba palms which emerge from the baked earth. The tender hearts of the palm become a green vegetable or salad. The tree bears long clusters of edible fruit not unlike a

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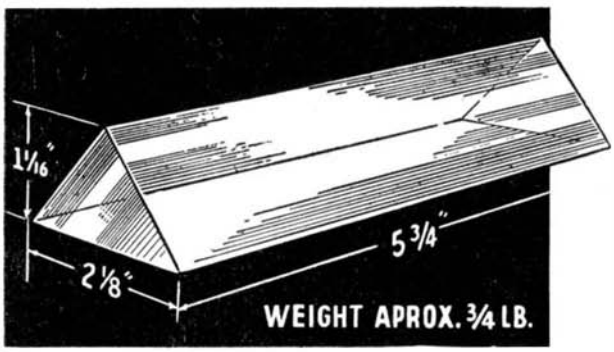


## TANK PRISMS

In order that the tank driver shall not get shot in the face, two of these Silvered Prisms are used to make a periscope (without magnification). We have secured a number of these that are very slightly chipped, making possible their sale at a very low price. They are 90-45-45 degree prisms of huge size — 5¾" long, 2⅛" wide, finely ground and polished.

You can use these Prisms to make Periscopes to see over the heads of crowds, fish under water, high or low gauges, inspection of machinery without climbing, for examination of hot metals without danger to eye or camera, etc. Also excellent for experiments, class-room demonstrations at high schools, colleges, camera clubs, astronomy clubs. Some of our ingenious customers have used these Prisms to make camera stereo attachment, photometer cube, range finder, etc. And here's an excellent, unique gift idea. For 5¢ we supply 100 gold letters with which you can turn one of these Silvered Prisms into a desk name plate in 5 minutes of easy work.

Normally, these Prisms would retail from about $24 to $30 each.

Stock #3004-S . . . SILVERED TANK PRISM — Price $2.00 each Postpaid. Free Booklet on Prisms incl.

Stock #3005-S . . . PLAIN TANK PRISM — Price $2.00 each Postpaid. This one is excellent for projecting all the colors of the spectrum — a beautiful sight. Free Booklet on Prisms incl. FOUR TANK PRISMS — Special $7.00 Postpaid . . . This is the most sensational bargain we have ever been able to offer.

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date. The seed is crushed and a cooking oil is extracted. The shell around the nut is roasted and a coffee-like beverage is brewed.

"The pith of the tree contains a high starch content, and a food similar to farina is made. The roots yield an extract and medicine for illness. The wood is burned and the ashes yield an alkali for home soap making. The wood of the tree is extremely hard and is impervious to insects and sea water. It is used in building the frames of native homes. The fronds of the palm are used to thatch their houses.

"Most of the natives in the carnauba sections sleep in hammocks, and it is said that 80 percent of the people sleep in hammocks woven from carnauba frond fibers. Their homes are swept with brooms made from the fanlike fronds and candles made from the wax furnish light at night. Tons of fronds which have been discarded after the wax has been removed may play an important part in the new Brazil, for a high-grade paper has been made from it."

### ASSEMBLY-LINE FREEZER

#### Rapidly Shrinks Parts and Dispenses Them as Needed

A COMBINATION refrigerating machine and dispenser used in the aircraft building at the Ford Motor Company has cut in half the time necessary for a single assembly operation which depends on shrinking of parts by the liquid oxygen method.

Tappet guide inserts, 36 of which are used on each of the 2000-horsepower Pratt and Whitney engines manufactured, are shrunk by reducing their temperatures to 300 degrees below zero. The new type freezer and dispenser makes this possible on an assembly-line basis.

Outwardly the dispenser resembles a soft drink vending machine. There are eight openings to accommodate various size guides. To obtain a shrunk part, the operator inserts one from stock and presses a button. A chilled part drops into a rubber receptacle at hand level. If desired, a shrunken part may be obtained without inserting a warm one.

**A tappet guide insert at room temperature is pushed into the freezing dispenser. Cold-shrunk inserts are delivered, as needed, at the bottom**

The parts never come in direct contact with the liquid oxygen. They are chilled by their slow passage through tubes suspended in a tank of liquid oxygen.

At normal temperatures the valve tappet guides are from two to three thousandths of an inch over-size. After emerging from the refrigerator they drop into prepared holes with ample clearance and expand as they warm. The resultant fit is nearly as firm as a weld.

The advantage of shrinking a part to size lies in the fact that no metal is removed or burnished by forcing it into position. Normal machining leaves tool marks around a part in a position radial to the center. When these microscopic grooves expand, from the center out, they fill in the high spots and valleys of a prepared hole and create a much better seal.

Before the dispenser was developed, tappet guides were placed in a container which was immersed in liquid oxygen. The machine was built to Ford specifications by the Linde Air Products Company.

### SEALING ZIPPER

#### Makes Water- and Air-Proof Closure

DEVELOPMENT of a unique rubber construction applied to metal slide fasteners which makes them completely water-proof and prevents escape of air or gasses was recently announced by The B. F. Goodrich Company.

The Pressure Sealing Zipper is constructed with over-lapping rubber lips which have such initial pressures built into them that they assure a perfect seal against any pressure which the structural strength of the slide fastener will withstand.

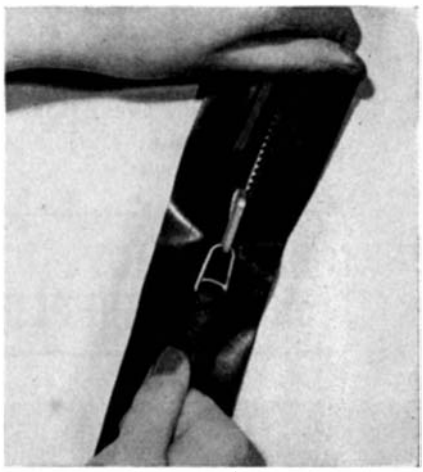
The lips are placed on either side of the article to be sealed, depending on where the pressure is exerted. Used on the outside they make the article water-proof and prevent the entrance of air or gasses. Used on the inside they prevent the escape of air, gasses, or liquids held in the vessel.

Three such Zipper styles are being manufactured, two being of the non-separating type, the first sealing along its entire length but open at the top, the second sealing along its entire length and at both ends. In the first, which is used in such applications as exposure suits, the slider is operated from either side; in the second, originally developed as a closure for pressure vessels, it is operated from the side opposite the sealing lips.

The third construction is of the separating type, which seals along the entire length but not at the ends, with the slider operating from either side.

The new rubber Pressure Sealing Zipper can be applied to metal, fabric, or sheet rubber, provided that sufficient clearance is allowed for operation of the fastener. Installation can be accomplished either by stitching or cementing, depending on the use.

The pressure seals are effective in a wide temperature range, not cracking when bent at — 70 degrees, Fahrenheit, nor becoming soft at 150 degrees, Fahrenheit. Weathering and aging characteristics are reported to be excellent.



**Unzipping one of the self-sealing water- and air-tight slide fasteners**

One of the great advantages of the sealing lip construction is that it conforms to changes in position of the sealing wall, withstanding stresses caused by these movements.

Among the war-time uses for the Pressure Sealing Zipper, according to the company, are as closures for life saving suits or divers suits, which need to be perfectly water-proof. Use of the Pressure Sealing Zipper makes these much easier to put on or take off.

Many uses of the new development are present in the airplane industry, the company says, including application on both high and low pressure ducts, where sections may be effectively joined with a Pressure Sealing Zipper, on doorways and handholes, where there are pressure differentials, and on bail-out kits and instrument cases.

Other potential uses which the company sees are as openings for tent flaps, where the arrangement makes the flap water-proof, as covers for hatches and other places on shipboard, and as seals for all types of emergency equipment.

### SWEET-POTATO ALCOHOL

#### Seen As a Possible Solution to a Problem

THE FOOD program, molasses transportation difficulties, and tremendous alcohol requirements have focused attention on new raw materials for alcohol production. The subject promises to be of continuing interest in the post-war period if the industrial alcohol requirements remain above 300,000,000 gallons. There will be insufficient molasses to provide for fermentation alcohol, and corn or wheat prices may be prohibitive for industrial alcohol production.

Drs. Jump, Stark, and Zarow of the Seagram Research Department, reported at a recent American Chemical

Society meeting on the use of dehydrated sweet potatoes as a raw material. Their laboratory and plant studies indicate that the L-4-5 variety of "non-edible" sweet potatoes are superior to the Puerto Rico variety. The laboratory yields compared with corn were respectively 3.2, 3.0, and 2.7 wine gallons at 190° proof per 56 pound bushel.

A commercial trial at one of the Seagram plants resulted in a yield of 2.8 wine gallons per bushel of L-4-5 potatoes; the yield from the Puerto Rican variety was lower. This plant fermentation yield problem is under current laboratory investigation, and appears to be susceptible of solution.

Dehydrated sweet potatoes offer the advantages of storage to provide a year-'round supply, and processing with equipment similar in design to conventional grain alcohol plant equipment.

The authors concluded their paper with the observation that the yield of alcohol from sweet potatoes in terms of acres of land is much higher than can be obtained from grain and closely comparable to sugar cane. The difficulties standing in the way of immediate use of this raw material are the small acreage now in cultivation, the necessity for simplified planting procedures, and mechanization of the harvesting operations. A Seagram Fellowship has been established at Louisiana State University, where the L-4-5 sweet potato was developed, to improve planting and harvesting procedures.

On the other hand, sweet potatoes may be grown throughout most of the South and under efficient farm management high yields per acre may be expected to bring the raw material cost in line with molasses. Thus sweet potatoes offer another possibility for agricultural and industrial expansion of the South by virtue of their value as a raw material for alcohol.

### INDUSTRIAL DEVELOPMENT

### Held to be Curbed by Present Tax System

EVEN after the pent-up demands for merchandise growing out of war shortages have been met, prosperity can be maintained in post-war America on the basis of new products and a higher standard of living than ever before, according to Larry E. Gubb, chairman of the board of directors of Philco Corporation.

"Actually years of research and development have been crowded into the past 32 months since the war began," Mr. Gubb said. "The stern necessities of war have been a great stimulus to research and technical progress on the part of our scientists. This war, which is being fought on both sides with the very newest technical weapons, has carried us along the road to new scientific developments at breakneck speed. The world of 1940 has already become obsolete.

"Our nation will emerge from this war with a capacity for producing raw materials and manufactured goods of unprecedented quality and workmanship on a scale never dreamed of four years ago. Great new industries, such as television, frozen foods, private and commercial aviation, and many others, are on the horizon awaiting development and offering tremendous employment opportunities.

"But before we Americans are going to participate in the advance of our scientists, there must be created the desire to get in and build this economy. We must recreate the incentive system that encourages enterprise and stimulates new undertakings. That is the way jobs are made.

"The figures show that in our country it takes about $5000 of invested capital to create a new job. Nothing could do more to make for a high level of employment and great prosperity after the war than the encouragement of 'risk capital.' If all capital is going to seek 100 percent safety, there can never be any progress. All you get is stagnation.

"But if capital is to be expected to embark in new ventures, there has to be some incentive held out to it; there has to be a reward for risk-taking, or people with capital cannot afford to do otherwise than hold it idle.

"These incentives are entirely lacking under our present tax system. Under today's conditions, there could be no such things as the building of our great railroad systems; the automobile industry could never get started and grow to maturity, for the simple reason that if a failure ensued, the burden would have to be borne in

large part by those who furnished the capital, while if they were successful, an extremely high percentage of the profits would be drawn off in corporate income and excess profits taxes and, insofar as earnings were paid out, in personal income taxes. In other words, as things stand today, the tax collector says, 'Heads I win; tails you lose.'"

## NYLON APPLICATIONS

### Will Spread into Many Post-War Fields

MILITARY applications of nylon developed during the war suggest possible uses for this versatile synthetic yarn in civilian fabrics, according to George J. Groh of the Nylon Division of E. I. du Pont de Nemours and Company. Mr. Groh, in charge of nylon fabric development, says that, for example, the weaving of nylon insect netting has given the textile industry experience in handling the yarn, which might be utilized later on in the weaving of similar fabrics for many uses.

"A 30-denier nylon flare (parachute) fabric is not far in construction from a nylon sheer," he points out, adding that "with some minor changes in weaving and a few more turns in the yarn, a fabric might be developed which should have a large number of practical uses."

The nylon fabric which is now going into the human escape parachute might, by being built up slightly in construction, suggest a sleeve lining, Mr. Groh adds.

Development of woven nylon fabrics was undertaken before the war in a limited way and all work of this kind was stopped as soon as nylon was needed for military purposes. The early studies were carried far enough in the development of fabrics for underwear, slips, panties, gowns, and foundation garments to indicate that nylon contributed a great deal toward lessening the weight of garments, he says, and its advantages in easy washing and quick drying were found particularly valuable.

Experimental work before the war also indicated that properly constructed fabrics of nylon could be permanently "set" to minimize wrinkling and that they might possess advantages in washability. This work gave definite indications that good nylon neckwear could be manufactured, that nylon in velvets and other pile fabrics could be made crush-proof, that the curtain stretcher as a result might "become a thing of the past," and that permanent ruffles and pleats might be "set" so as to be unaffected by cleaning and even washing.

## POWER CONCENTRATIONS

### Are Crux of Electronic Heating Processes

IMPROVEMENTS in the heat treating of metal products made possible by the use of electronic power concentrations up to 20,000 kilowatts per cubic inch are described by Dr. Wesley M. Roberds, development engineer of the RCA Victor Division, Radio Corporation of America. Power concentrations of this order, Dr. Roberds explains, have advantages of product quality improvements growing out of closer control and more uniform effects. Additional advantages include increased production resulting from savings in process time, greater heating efficiency, and greater convenience.

"When intense heat concentrations are mentioned," he says, "one immediately thinks of the oxy-acetylene flame or the electric arc. In the case of the torch, the transfer efficiency from source to work is extremely low, so that heating equivalent to that produced by an electrical power concentration in the work of five kilowatts per square inch is about the maximum attainable at present. In electronic induction heating it is not difficult to put 100 kilowatts into a square inch of surface area with an overall efficiency of 50 percent.

"With the electric arc, the power concentrations may be comparable to those obtained in electronic induction heating, but the intensity of the arc has a much lower range of control. With a 100-kilowatt electronic power generator, the surface of a two-inch steel bar can be brought to the melting point in half a second, or the power can be reduced until it will require five seconds to solder a small can.

"The ability to create very high power concentrations is especially advantageous in processes where it is desirable to confine the heating to a small, sharply defined volume. For example, in such operations as case-hardening, welding, brazing, or soldering, it is desired to heat only a thin shell or a narrow strip on the work, while the other parts are to remain relatively cool. This effect may be achieved by applying the necessary energy at high power levels for very short times, thus minimizing the conduction of heat and creating high temperatures only in those regions were heating is desired.

"Because the current penetration into the work is small, the application of 100 kilowatts per square inch may result in a power concentration in volume of 20,000 kilowatts per cubic inch. This concentration of energy beneath an inductor makes it possible to heat a highly localized area on a piece of work."

Although power concentrations attainable in dielectric heating of electric insulators such as wood and plastics are much lower than those used for induction heating of metals, Dr. Roberds says, they are nevertheless up to 1000 times as great as can be obtained by heat conduction into the work. Practical power concentrations in electronic dielectric heating range from 10 watts per cubic inch at a frequency of 10 megacycles, used for gluing thick wood sections, to 20,000 watts per cubic inch at 200 megacycles, used to seal thin plastics films.

## CAM CUTTER

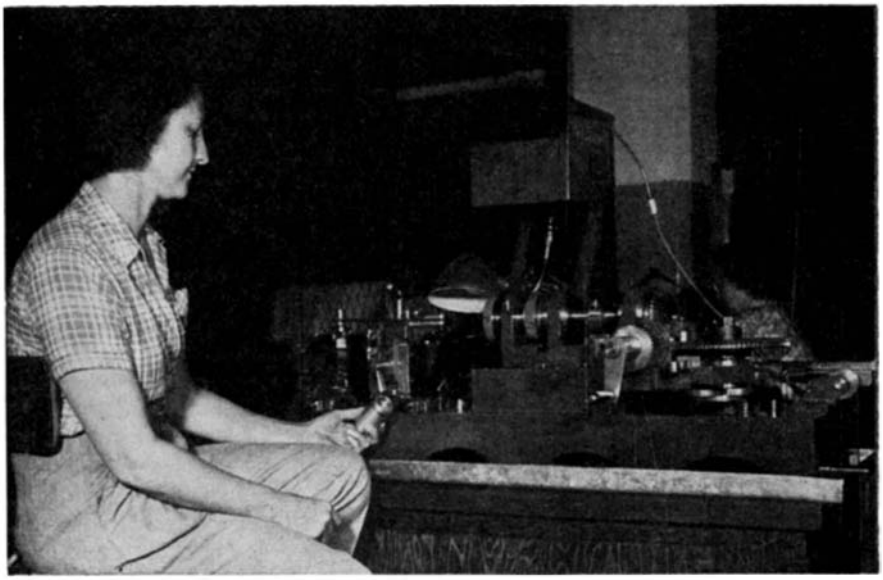
### Performs Special Operation In Routine Manner

DESIGNED to cut two irregular curved tracks of minute dimensions on the inside of a thumb-sized metal barrel, a special cam-cutting machine has proved highly successful in operation in a plant of Fairchild Camera and Instrument Corporation.

Believed by its designer, Edward Lay, of the Fairchild company, to be the only machine which cuts inside tracks on a barrel cam, it grew from urgent military needs. Assisted by Theodore Fraser, a Fairchild tool designer, Lay planned an assembly including a carriage, chuck, and two master cams in one unit; stationary followers in the second; and a third cutter head unit.

The two master cams govern the track cutting, giving it a forward motion. In one revolution of the master cam the barrel turns three times, and a track is milled on its smooth surface. This revolving action is attained by one worm and two worm gears. The result is like a bullet in flight, which spins as it shoots forward. Weights keep the master cams in constant contact with stationary followers.

An operator can master the fundamentals of the special cam-cutting



The operator is holding one of the barrels to be milled in the cam cutter

machine in two days. Placing a metal sleeve on the carriage, he pushes the cutter into place, then turns on the power unit, and with it a flow of kerosene to lubricate the action and clean stray chips from the cutter. As the cutter spins through the solid metal, the operator steadily turns the carriage's handle, moving the cam slowly along while the cutter bites its first track. Repeating the operation, a second track is cut. Though the carriage handle was formerly turned by power, it was found easier to detect manually any "bugs" in the operation.

Though the machine was originally designed to fulfill the need for a particular type of barrel cam, it is equally adaptable to the manufacture of other types. Lay believes it will aid many designers who have omitted vital parts of their machines simply because they lacked a practical way to cut barrel cams.

### SOUND-CONDITIONING

#### Involves Control of Waves to Reduce Undesirable Noises

ADD to the possibilities of post-war living one more—"sound-conditioning." New types of plaster have been developed, according to the Gypsum Association, which make it possible to have every room "conditioned" to sounds as they can now be conditioned to temperatures.

The industry expects this new development to make rapid strides, and soon to be incorporated in the plans for many institutions, office buildings, apartment buildings, and individual homes. Reported to be less expensive than other materials for the same purpose, it will have an appeal for the great mass of new home builders, the Association says.

Sound-conditioning and sound-proofing are distinctly different, the Gypsum Association points out.

"A room is sound-proof if sounds originating in it cannot be heard outside the room, and vice versa. Sound-conditioning has to do with the control of sound reverberations and the curtailment of echoes—the absorption of sound waves after the action that created them has ceased. Sound-conditioning is the control of sound waves to reduce undesirable noises."

Greatly advanced over previous materials of its type, the new gypsum acoustical plaster is inexpensive. It is very porous, the air passages "blotting up" the sound. In most cases its use on ceilings alone is sufficient.

### THE WAY TO WEIGH

#### There's More to It Than Meets the Eye

IF YOU had several objects to be weighed on a refined balance, how would you go about weighing them? "Well," remarks your hard-headed friend who is suspicious of too much theory, "I'd just plain go ahead and weigh them, that's all. What else could I do?"

That could be done and wouldn't be wrong but there are even better ways. When you begin looking into the subject, you find, perhaps, some things you hadn't thought of before. At a recent meeting of the Institute of Mathematical Statistics, Professor Harold Hotelling of Columbia University explained what applied mathematics has to say about some of these practical considerations of which relatively few readers are aware.

"For example," Professor Hotelling pointed out, "if two objects are to be weighed on a balance which is known to be correct, they should be weighed together in one pan, and also weighed with one of the objects in each pan. From the sum and difference thus obtained, the separate weights can be determined with greater accuracy than as if the objects were weighed separately

"If the weighing is to be repeated several times so as to get greater accuracy in the averages, only half as many weighings are required in the combined operation as for separate weighings giving the same final accuracy," he said.

Greater economies of effort are possible with larger numbers of objects to be weighed, Dr. Hotelling reported. If seven objects are to be weighed on a scale which must itself be corrected for bias, eight weighings are necessary in all.

For various other numbers of objects, Dr. Hotelling described efficient weighing plans, for various other situations and numbers of objects to be weighed, deriving them from the statistical theory of the design of experiments by means of the mathematical principle of ortho-

gonality. He pointed out that this statistical theory has been used widely by agricultural and other biological experimenters to improve the efficiency of their work, and has also entered into census operations and other economic and social investigations involving stratified sampling in this country, in England, and in India.

However, physicists and chemists have on the whole been ignorant of the new statistical developments and consequently have been put to unnecessary work, or else loss of accuracy, in many of their experiments, he declared.

John Mandel, a chemist of New York City, discussed Dr. Hotelling's paper from the standpoint of practical laboratory work, and suggested that an analytical laboratory should have some simple equipment, including standard cups of predetermined weight, to facilitate the application of the new methods. It was stated that, following Dr. Hotelling's suggestion, some of the new methods are already in use at the United States Customs Laboratory in Boston.

## OIL TESTING

### Eliminates Necessity Of Using Engine

PERFECTION of a new method of testing lubricating oils will help to open the way for the lubrication of the high-speed, high-compression motors which post-war developments will put on the market.

The new testing method was described by Dr. E. C. Hughes, director, Chemical Research Department, The Standard Oil Company (Ohio), at a recent meeting of the American Chemical Society.

Under ordinary procedure, lubricating oils must be given at least a 36-hour test in an ordinary automobile motor. This limits drastically the testing which can be done.

The causes of the deterioration of oil in an engine were disclosed to be a combination of heat, air, and certain catalysts found in engines.

Under the new method the oil is examined in a specially designed test tube. The tube is held in an aluminum block in which the temperature is controlled to correspond to the temperatures in the motor. Within the test tube are the metals and other catalytic materials found in a motor in the same proportion as they are in motor construction. The oil is placed in the tube and a certain rate of air is passed through the oil. A unique arrangement enables the air to agitate the oil and keep solids in suspension.

Though the test takes 36 hours, many of them can be made at the same time. The results parallel those revealed by the use of an engine.

Modern lubricating oil is a laboratory product. The natural oil is used as a base and other chemical materials are added to prevent corrosion, sludge, thickening, the formation of "varnish," and the formation of carbon.

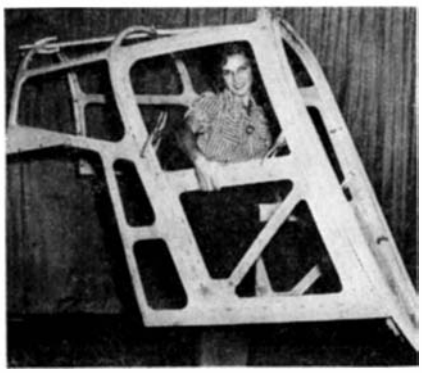
"With this in mind," said Dr. Hughes, "the more tests we can conduct, the more rapidly we can discard unsatisfactory products and perfect those of superior quality. Within the past two years we have tested well over 600 combinations in the laboratory—many more than we could have done had we used the regular automobile motor."

## HELICOPTER CABINS

### Will Incorporate New Plastics Structural Material

PLASTICS are being used for the cabin structures of the new helicopter, R-6, which may help speed war wounded from inaccessible combat areas and may soon be servicing military outposts with needed supplies.

The plastics material, developed and produced by the United States Rubber



Light-weight helicopter cabin frame

Company, was chosen for the cabin structures because of its light weight—only half that of aluminum of similar thickness—together with its great tensile strength, rigidity, and ability to withstand strains and excessive vibration. It met specifications of the A.A.F. Materiel Command at Wright Field for this new structural use after it was put to many rigid tests.

Made of Fiberglas, laminated and reinforced with thermo-setting resin, the composite material is a non-conductor of electricity and is not affected by gasoline, oils, acids, most alkalis, alcohol, or fungus growth. After a blow, it returns to its normal position with no permanent distortion or denting. Another feature is that it retains all of its properties in the sub-zero temperatures of the Arctic as well as in the excessive heat of the tropics.

As far as is known, this is the first use of laminated plastics on a production basis in this type of construction. Its success probably will open the way for many post-war applications of this plastics material. It is now extensively used to support bullet-sealing fuel cells in all types of combat planes.

## PAINT

### An Important Part of The Housing Problem

IT IS of the utmost importance to get the word around that America cannot be rebuilt over night, believes the Post-War Planning Committee of the National Paint, Varnish, and Lacquer Association.

"We couldn't all have new homes at once—even if we had the money to pay for them and new construction started up at full speed immediately post-war," points out the latest edition of the committee's post-war planning publication, *Looking Toward Tomorrow.*

"Our present homes will be needed for a long time to come," it continues. "Therefore, for those who live in the 38 million dwelling units of the nation already in existence—which now average 25 years of age—and for the half million new families formed each year, we must make our present structures last."

Furthermore, the bulletin points out, the paint industry can help the owners of down-at-the-heel properties who wish to buy new homes. Much higher prices for their present properties can be realized if they are put in the pink of paint condition, both inside and out, before offering them for sale, it states. In this way property owners can realize a larger sum for investment in a new home when it is possible to obtain one.

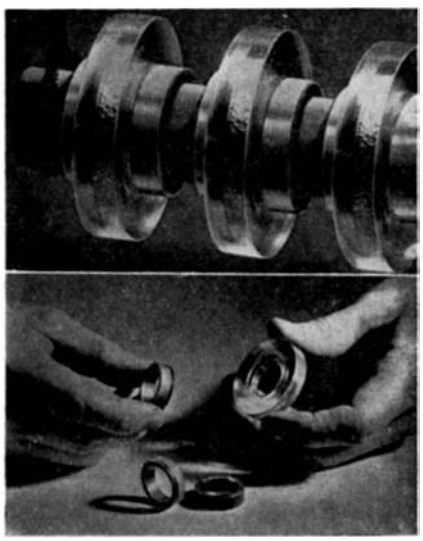
Still another reason for the maintenance of existing dwellings is reflected in the need for housing lower income groups. As new homes are built and occupied, the older, moved-out-of homes—if adequately maintained—can be used to house comfortably those with lower incomes who formerly lived in much worse surroundings. In time, the elimination of obsolete and unfit housing can thus be facilitated.

"It's tremendously important to give our nation's homes a good, rugged transfusion of paint plasma as soon as possible," the bulletin stresses, "so they will hold their own."

## CARBON PLATING

### Speeded by Use of Plastics Jigs

IN A FIELD where previously-used materials were severely limited, Plexiglas masking jigs are now used exclusively in the copper plating of carbon rings by the Morganite Company, manufacturers of carbon specialties. Because of its machinability, dimensional sta-



Top: Plexiglas masking jigs. Bottom: Carbon rings, plated except for the narrow edges protected by the masks

bility, and light weight, Plexiglas has been found most successful, not only reducing rejects but also stepping up production rates. Carbon rings to be plated are inserted in grooves on either side of the Plexiglas jig rings. They are then mounted in gang fashion on a carbon rod; electrodes are attached and the entire assembly is suspended in a plating solution. The durability of these Plexiglas jigs and their resistance to the plating solution makes them highly practical.

### SPECIAL PRODUCTION TOOLS

#### Have Limited Application to Peace-Time Manufacture

THE DEFEATS suffered by American arms in 1941 at Pearl Harbor, Guam, and the Philippines spawned a phrase that no adult American is likely to forget during his lifetime—"too little and too late." It was freely and widely interpreted to mean that our fighting men simply had too few weapons and the wrong kind of weapons to meet the enemy on even terms.

Not nearly as well appreciated was the truth that these weapons didn't exist because the precision machinery required to make them didn't exist either. Even after a long uninterrupted string of victories in Africa, Europe, and the Pacific it is difficult to grasp the direct connection between a high-speed automatic screw machine in a mid-western arms plant and a machine gun platoon entrenched in a palmetto clump on the island of Saipan.

Mass production in volume means proper tooling. But even though about 75 percent of the automotive industry's tools were converted to war production, the war products were so radically different from cars and trucks, and the need for these weapons was so great that thousands of additional tools were required—special tools, designed specifically to machine tank parts, to extrude aluminum for airplanes, to draw out slabs of metal into long cartridge cases.

These specialized tools, so vital to victory, take on a different aspect when viewed against the post-war era. About 10 percent of the special war production tools made for the automotive industry have no foreseeable peace-time use. Converting them would be prohibitively expensive, and their cost of operation would be disproportionately large after they were converted, because they were made to handle heavier metals in larger quantities than peace-time goods would call for.

Consider, for example, a 3300-ton rod extrusion press, made to handle aluminum for aircraft production. The complete installation of such a press costs $250,000 and, because of its size, six freight cars would be required to transport it from one location to another. Throughout the war, it labored faithfully on millions of pounds of aircraft aluminum, but after the war there may be no demand for its capacity.

Or, what of the huge vertical boring mills especially designed to speed tank manufacture? Weighing 112,000 pounds, and costing $49,500 each, these mills can handle an armored tank turret with ease, but in peace-time there will be no immediate need for their sinews.

Again, what of the complicated machine which drills, reams, countersinks, and mills the trigger housing of the Garand rifle? Its cutters work simultaneously from six different directions, and this one machine alone does in 58 seconds the work which it formerly required four general-purpose machines each 11 minutes to perform—an increase in productivity of 4400 percent.

Many hundreds of machine tools like these are in automotive war production, and their daily output of war goods makes up a large part of the mass of material which is giving the Allied armies ascendancy on every front. Their cost of construction and operation is part of the price of victory in war, and their proper disposal bids well to be of major importance in the over-all problem of reconversion.

To avoid having them interfere with reconversion, however, a true and realistic appraisal of their worth to the nation's economy must be made, not in terms of their cost, because that cost is part of the price of victory, but rather in terms of what they can contribute efficiently to the post-war production volume of the industry.—*Automotive War Production.*

### FOOD PACKAGING

#### Requirements Studied for Frozen and Dehydrated Foods

TEMPERATURE is not an important factor in maintaining stored dehydrated foods at a low moisture content, but it plays an important part in maintaining moisture levels in stored frozen foods, says Dr. G. J. Hucker, food bacteriologist at the State Experiment Station at Geneva, New York. Doctor Hucker and his associates are studying the packaging and storage of processed foods under a range of temperature and humidity.

Dehydrated beets with a moisture content of 5 percent were stored unprotected under various conditions ranging from 20 to 29 percent relative humidity. They reached equilibrium

with the surrounding atmosphere in about six days in an atmosphere of 90 percent relative humidity, while it required 40 days for them to reach equilibrium in 20 percent relative humidity. With this information as a basis, the Station workers made a series of tests of protective wrappings and packages which varied in moisture transmission rates.

"Thirty-two trials of this type have been completed," says Doctor Hucker, "and results indicate that, in order to maintain a moisture level sufficiently low in dehydrated vegetables to retard spoilage by microörganisms, the protective wrap should have a moisture vapor transmission rate of less than 0.3 gram of moisture vapor per square meter if the stored foods come in contact with an atmosphere of 70 percent relative humidity or over. The results also indicate that temperature is not an important factor in the protection of stored dehydrated goods against moisture absorption."

In a similar series of experiments with wrapping materials for frozen foods where the relative humidity in cold storage lockers is relatively low, it was found that temperature is an important factor in maintaining moisture levels in stored frozen foods. Selected frozen foods were held at 10 degrees, Fahrenheit, and at minus 2, minus 5, and minus 20 degrees. Preliminary results indicate that wrappers with higher moisture vapor transmission rates may be used for frozen foods to prevent "freezer burn" than can be used in protecting dehydrated foods against moisture absorption.

## TRANSPARENT LAYOUTS

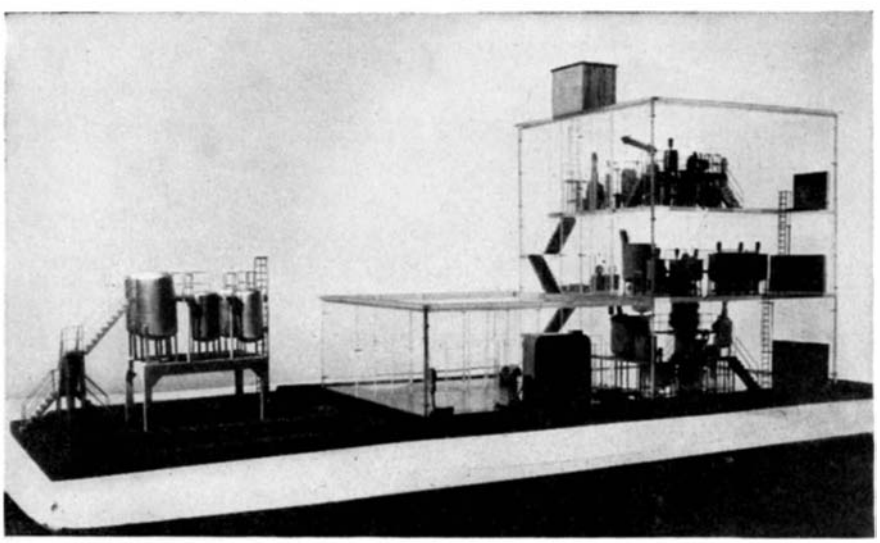
### Assist in Visualizing

### Industrial Plant Construction

THE PROBLEM of visualizing plant layout and location has been effectively surmounted by Display Studios of Pittsburgh with the use of transparent plastics models. The synthetic rubber factory illustrated, constructed to scale for the Blaw-Knox Company, is an example of many such plants this firm has designed and built.

The walls, floors, and partitions of this model are made of Plexiglas, aviation's standard transparent plastics used for the familiar bomber nose and other aircraft enclosures.

Construction of even the most intricate mechanical models for study or demonstration is simplified with the use of Plexiglas; not only can it be cut to size with ordinary saws but it can be drilled and machined like soft metals.



Scale model of a factory, constructed of clear plastics

## YOUTH AND AGE

### Both Have their Places

### In the Advance of Science

Too many old men are at the helm in science, which needs the originality of youth to keep pace with its opportunities for service to mankind, according to the late Dr. Thomas Midgley, Jr.

"The extension of life, resulting from the applications of those principles regarding disease, developed nearly a century ago, has produced a condition in society whereby too many men are being kept in service beyond the years when previously they would have been eliminated," Dr. Midgley said. "This is particularly true in those activities requiring originality for scientific progress.

"Their retention is denying advancement to younger men at the very age when these younger men may be expected to be entering those years when their maximum efficiency will be attained. Earlier retirement ages or transfer for men engaged in work requiring originality is indicated."

Dr. Midgley explained that he does not mean that men over 40 are of no use to society, for "it is too evident that they are. But their usefulness is distinctly of a different nature from the usefulness of youth.

"Youth is original and creative, while age is simply experience. Both are essential elements on any team that is to make for lasting progress. I am not complaining that we have old men in active service; but I do complain about having old men in young men's places."

As evidence of youth's greater creativeness, Dr. Midgley cited an unpublished Patent Office "Table of Important Inventions," ranging from the steam engine by Watt to the airplane by the Wright brothers.

Of these inventions, 85 in number, 46 were by men 35 years or less. Fifty-eight were by men under 40. Thomas Edison made the list five times, with inventions patented at the ages of 24, 27, 30, 32, and 46.

Dr. Midgley, who was vice president of Ethyl Corporation, was 33 when he attained fame by his discovery of tetraethyl lead, which has made possible spectacular advances in automotive and aircraft engines, and which has contributed vitally to the success of Allied air power on the world's battlefronts.

The Patent Office list, prepared some years ago, begins with Sir William Perkin, inventing aniline dyes at 18. Then come William Siemens at 20 with the steam engine governor, Bessemer at 21 with electroplating, Marconi at 21 with his first patent on radio, Edison, who at 24 patented the stock ticker, Howe at 26 the sewing machine, Whitney at 27 the cotton gin, Watt at 29 the steam engine, Bell at 29 the telephone, Mergenthaler at 30 the first linotype, Nobel at 34 dynamite, Eastman at 34 the Kodak camera, the Wrights the airplane at 34 and 38, Fulton at 36 the submarine, Goodyear at 39 with vulcanization of rubber.

Fulton at 42 patented his steamboat, Siemens at 44 the dynamo and open hearth process, Stephenson at 45 the first successful locomotive, Morse at 46 brought out the telegraph, Roentgen made his x-ray apparatus at 50, Daimler patented his gasoline vehicle at 52, and Harvey patented Harveyized steel at 67, the end of the list.

The original work leading to a patentable invention often is done some time before the actual invention itself results, and this must be considered in trying to reach a true measure of the originality factor for various age levels.

Dr. Midgley concluded: "For genius and display, take youth; for cold calculation and planned execution, take age."

## WELDING MACHINES

### No Longer Cause

### Power-Line Troubles

IMPROVEMENTS in the design of resistance welding machines, together with excellent co-operation between manufacturers of resistance welding machines, power company officials, and resistance welding machine users, have solved the power load problem and eliminated the difficulties encountered 10 to 15 years ago when resistance welding equipment was connected to power lines.

This opinion was voiced by Mr. A. D. McLay, vice president of The Detroit Edison Company in charge of sales, during a talk before a recent meeting of the Resistance Welder Manufacturers Association.

Years ago, the installation of resistance welding machines caused power companies considerable trouble because the electric lamps of other consumers would flicker, grow dim, or almost go

out when the equipment was used. In addition, it caused interference with the power supply of nearby factories and was responsible for numerous complaints from other customers.

Design improvement, plus better co-operation between resistance welder manufacturers, the power companies, and users, have enabled them to determine the power load required and take steps to anticipate difficulties before they actually occur. This may be done through the installation of a motor generator set, running in lines to take care of the extra load, and at times isolating sections of sub-stations to meet load requirements.

### RUBBER-TO-METAL
### Adhesive Shows
### Great Versatility

DEVELOPMENT of an adhesive that is increasing the service of thousands of American combat vehicles and aircraft, and that is conserving tens of thousands of hours of manpower for war production, was reported recently by L. R. Jackson, executive vice president of The Firestone Tire and Rubber Company.

The adhesive was described by Mr. Jackson as the only one that will bond any synthetic rubber to metal. This means that it eliminates involved, time-wasting, and costly steps in many manufacturing processes where rubber must be bonded to metal.

"In addition, the new adhesive has the greatest bonding strength of any now known," he said, "and consequently permits longer and more efficient service by the dozens of rubber-to-metal bondings in aircraft and combat vehicles."

Many metals, he explained, formerly had to be brass-plated before they could be bonded to synthetic rubber. The new cement not only eliminates this step but provides a more uniform adhesion than is possible through the brass-plating method.

The presence of spots of water or rust film, both of which destroy the effectiveness of other cements, does not affect the adhesive.

This cement is particularly valuable, Mr. Jackson pointed out, in bonding rubber to aluminum, which can not be successfully brass-plated. Since aluminum and magnesium are the key metals in the aircraft industry, the new adhesive has a very important role in that field, and will be equally valuable for use with the light metals scheduled for post-war automobiles.

### VITAMIN-A SOURCE
### Seen in Leaf Wastes
### From Vegetables

WASTED leaves from carrots, beets, and spinach are rich sources of carotene and vitamin A, according to studies reported to the American Chemical Society.

One possible use of this vitamin A is in feed supplements for animals, thus turning back to the farm food value salvaged from material formerly wasted.

The new experiments, testing several different methods of extraction, obtained from leaf wastes deep red carotene concentrates equivalent to 20,000 to 200,000 International Units of vitamin A per gram, say Monroe E. Wall, Edward G. Kelley, and J. J. Willaman of the United States Department of Agriculture's Eastern Regional Research Laboratory, Philadelphia.

"Although they may vary within wide limits, spinach, beet, carrot, turnip, kale, and brocoli leaf wastes, when properly collected and dried, have an average of 300 to 700 micrograms of carotene per gram," they add. "Hence it is conceivable that carotene concentrates may be economically prepared from these materials."

The three researchers described a number of methods for preparing carotene concentrates from vegetable-leaf meals, most of them based on the rapid saponification of chlorophyll in petroleum ether solution, followed by adsorption treatment with dehydrated lime.

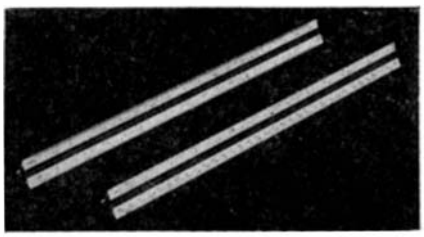
The methods developed will be tested in a pilot plant to determine their suitability for commercial production of vitamin A as a food or feed supplement.

### DRAFTING INSTRUMENTS
### Now Made Precisely from
### Plastics Materials

PRODUCTION of vitally needed drafting instruments has been materially increased through developments by

Pereles Brothers, Inc., which makes possible greater accuracies in thermo-plastic molding than ever before.

In some cases, instruments such as triangular relief facet scales are being produced complete and ready for use in 24 hours by thermo-plastic molding, compared to the two to three years formerly required for boxwood alone or celluloid-faced boxwood scales. Seasoning of the boxwood took 24 months, and if celluloid was applied, another 12 months was required for it to set and cure properly.



**Injection-molded plastics make high-precision scales and drafting tools**

All the instruments are being produced by the injection molding process, and several different types of plastics materials are used. However, it is the accuracy and precision achieved by Pereles in the dies for the various instruments that has made their production possible. Using special equipment and special methods in its own engraving, tool, and die departments, the company has been able to maintain a dimensional tolerance of one half of one thousandth of an inch per inch between lines as delicate as three to three and one half thousandths of an inch in width.

Another step forward in the engraving of the fine dividing lines in the Pereles plant is that the lines are deeper than they are wide, which increases the life of the instruments and also make it far easier to wipe in the color.

Plastics used in slide rules are Lucite, made by Du Pont; Plexiglas, made by Rohm and Haas; and polystyrene, made by Bakelite, Dow, and Monsanto. The five-inch types are made of Lucite or Plexiglas and polystyrene. The ten-inch slide rules are made entirely of Lucite or Plexiglas.

High precision likewise is attained in the other instruments now being molded by Pereles. Calibrations on the triangular relief facet scale for engineers are in tenths, twentieths, thirtieths, fortieths, fiftieths, and sixtieths of an inch. The triangular scales, as well as flat four-bevel scales for architects and engineers in 6-inch pocket size and 12-inch standard size, are molded either of Lucite or Plexiglas.

## GOLD-PLATED MOLDS

### Increase Production of Plastics Fixture

FIFTY thousand man-hours represents a lot of time and a lot of valuable manpower, especially if that manpower is made up of highly skilled tool makers.

That was the time, nevertheless, which, with the ordinary procedure, would have been necessary to complete an order for a vitally essential fixture (it's still a military secret) for a branch of one of the Armed Services. The need for this part was urgent.

The use of conventional methods was out of the question. That would not only have taken 50,000 man-hours but, to complete the order, thousands of pounds of precious tool steel. The contract had been given to the Eastman Kodak Company so it was up to Kodak to produce.

Kodak chemists proved first that the fixture could be molded of a casting resin instead of steel and thus made the first cut in cost and time. But then too much time was consumed in painting the original mold after each casting to permit the release of the molded plastics. There was another huddle of chemists and they came up with the answer. By gold plating the original mold—a method never before used—the increase in production was almost unbelievable. They could produce the fixture with this method at the rate of four an hour or about 60 times faster than would have been possible with the old accepted method. This method also resulted in much closer tolerances and a smoother over-all finish.

## LIGHTNING

### Not a Power Source, but Beneficial in Other Ways

MAN'S dream of harnessing lightning flashes for electrical power has been kicked into the realm of scientific nonsense, according to studies made by Dr. Gilbert D. McCann of the Westinghouse Electric and Manufacturing Company, who recently stated that investigation has shown that the maximum electrical energy that could be obtained from the two billion lightning strokes that annually bombard the total earth's surface is approximately 175 billion kilowatt-hours per year.

"In contrast," the scientist, whose reports on lightning are internationally known, added, "the American power station industry alone last year generated 221 billion kilowatt-hours—about one third of the total electric energy generated in the world. These men have outdone nature on a major scale and have, through engineering skills, set aside the wild dreams of men who would harness lightning."

Dr. McCann explained that while lightning carries a terrific wallop, its usable energy is only of momentary duration.

The powerful strokes that rip into buildings, split trees, and sometimes kill human beings release energy at a very great rate. For example, a stroke can momentarily produce upwards of 200,000 amperes—enough current to light two hundred thousand 100-watt light bulbs or a city of about 30,000 population. However, it could do this only for a fraction of a second.

At the same time, Dr. McCann said, lightning serves two very useful purposes—releasing nitrogen from the air and charging the earth's crust with electricity.

"Lightning is much like rain," he continued, in that it is "a sudden tangible precipitation that has been accumulating slowly and invisibly. In the spectacular show that lightning stages, the stroke itself, the thunder it creates, and the damage it causes are visible actors. But they are only three fourths of the cast. The unobserved principal is the constant flow of electricity from the earth to the clouds.

"To offset this loss of electricity, the earth's surface must be struck by lightning at the average rate of 50 times a second, or about two billion times a year."

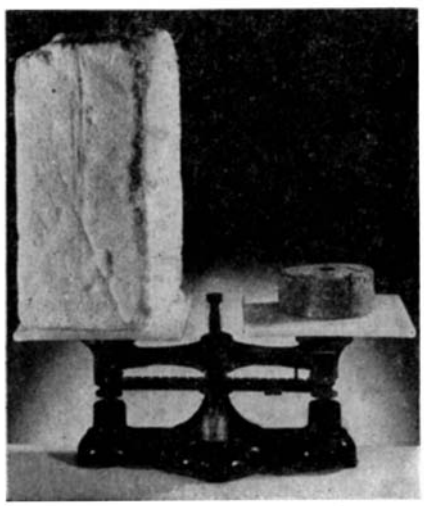
Nitrogen is produced for the earth's surface in this way: The action of the thunderbolts in streaking through the atmosphere releases nitrogen from the air. In the form of nitric acid, the nitrogen falls in rain drops and enriches the soil. "In this way," Dr. McCann pointed out, "lightning annually produces nearly 100 million tons of nitric acid—more of this soil builder than is manufactured by all the world's fertilizer plants."

## LIGHT PLASTICS

### Has Many Insulation, Flotation Possibilities

PLASTICS foam weighing only one seventh as much as cork has been developed and is being manufactured by United States Rubber Company. Important peace-time uses foreseen include insulation for trains, airplanes, automobiles, and homes and in life-saving equipment such as life preservers and floats.

Although it has great buoyancy, it is semi-rigid. Because it contains so much air space, it has good insulation and sound-deadening properties in comparison to its weight. It weighs less than a pound and a half a cubic foot and can be made to weigh as little as three quarters of a pound per cubic foot.



**New plastics foam has insulating qualities, is extremely light weight**

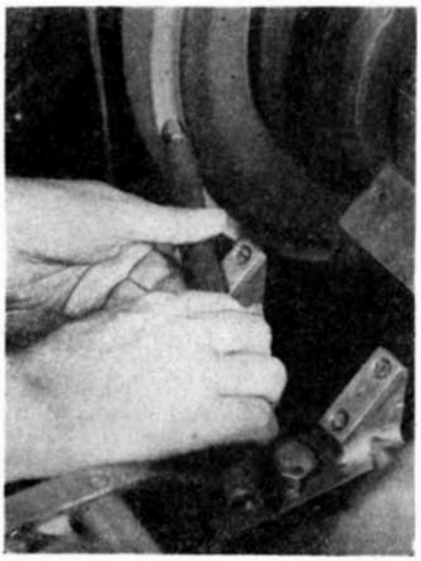
To produce the new and different war material, a combination of synthetic plastics materials are foamed and then solidified. The new product is called "flotofoam" because of its buoyancy.

# New Products

### DIAMOND DRESSER

WHEEL dressers made with small commercial diamonds set into a matrix of Carboloy cemented carbide are being used to true-up recesses in finish grinding wheels employed to grind aircraft cylinder sleeves.

When a conventional single diamond dresser was used for the recessing operation—which is necessary in order that the grinding wheel may produce a sharp corner at the bottom of the cylinder sleeve's flange—the holder had to be ground flat and the diamond lapped so that the stone would perform the dishing-out operation correctly without the holder touching the edges of the recess.



Dressing a recessed grinding wheel

The Carboloy diamond-impregnated dresser, on the other hand, contains diamond particles distributed throughout the matrix, thereby insuring that at least one or more of the stones will be in contact with the grinding wheel at all times as the holder is swung through a small arc. Moreover, new cutting faces are presented to the abrasive wheel as layer after layer of diamonds are reached and exposed, due to the gradual wearing-away of the carbide matrix. Hence no lapping and no re-mounting are needed as in single diamond dressers.

### HANDSAW RETOOTHER

THE NEW Burro automatic handsaw retoother will, it is reported, do a perfect job of punching a perfect set of new teeth in an old handsaw in less than one minute. The retoother consists of a punch and die mechanism, a drive wheel, a feed mechanism, guide blocks, and clamps with adjustable spring tension, all assembled and mounted on a base. A ¼ horsepower electric motor furnishes the necessary power. Five index bars are supplied to provide any desired retoothing for either cross-cut or rip.

To retooth any hand saw, the handle is first removed. The proper index bar is selected, placed in the saw carrier and tightened in place with two C clamps. Next, the bed-plate is swung to the proper angle for cross-cut or rip saws and tightened. The saw and carrier are then inserted into the machine from the left until the index bar is under the pawl, and power is applied. The teeth are punched out one at a time in rapid succession (240 per minute) until complete retoothing is accomplished. It is unnecessary to cut or grind off the old teeth—they come off as chips. The new teeth are ready for setting and filing.

### VERSATILE WELDERS

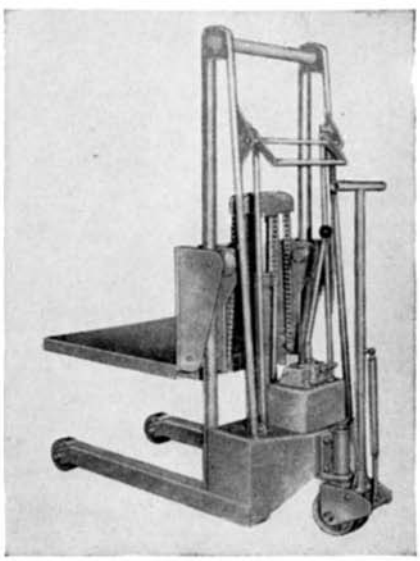
TWO "post-war" additions to their new storage-battery powered line of resistance welders have been announced by Progressive Welder Company. The first of the new additions is an "economy" spot-welder of the rocker-arm type, completely self-con-

tained, with storage batteries, contactor-controller, and infinitely variable heat-control regulator all enclosed in the base. The second machine is of the heavy-duty type and designed so that both spot- and roll-welding can be performed on the same machine with but minor changes. Batteries for this type of machine are housed—with contactors, battery chargers, and controllers—in standardized "power-pack" units.

In addition to ability to weld conventional steels with these welders, both models are designed to handle spot welding of such important "post-war" materials as stainless steel, aluminum, and so on.

### HIGH-LIFT TRUCK

WHAT is said to be a definite departure in material handling equipment, developed and introduced by Lyon-Raymond Corporation, is a combination of a lift truck and a tiering machine. This hydraulic high-lift truck is exceedingly light in weight compared to equipment designed to do this one phase of material handling, which accounts in a degree for its movability. It turns readily within its own length. It is made of special tubular and formed steel construction and is Timken equipped. A powerful floor lock and fingertip controlled lowering device are features.



Light in weight, easily maneuverable

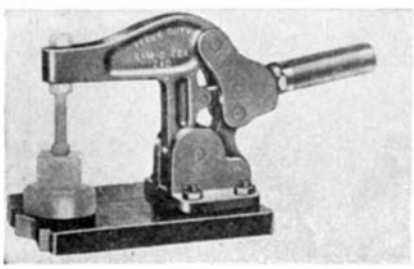
### COMPRESSED AIR PURIFIER

DESIGNED to eliminate free moisture, oil, and all foreign matter with a heavier specific gravity than air from passing through compressed air lines, a new purifier has just been developed by the Bird-White Company.

Known as the Model A-1 Pur-O-fier, this new unit uses positive centrifugal action as a medium for purification. It weighs only 1¼ pounds and is just 3⅛ inches in diameter by 5 9/16 inches deep including plastics and transparent entrainment sump. No maintenance is required on the unit other than draining the sump, which can be easily accomplished by opening the petcock in the bottom. For intermittent operations the new Model A-1 Pur-O-fier is extremely sensitive to the slightest movement of air and provides positive purification of air lines at all times. It can be used in connection with many air-operated devices, more specific applications being dental machines where absolute cleanliness is a requisite; production lines where parts must be kept clean for assembly; and compressed-air units for offset spray devices.

### CLAMP

THE Cam-O-Lok clamp, developed by Mechanics Engineering Company, is made in three types, for light, medium, and heavy duty. The clamp is instantly adjustable over the entire range of its vertical holding capacity. When objects to be held vary in thickness, no adjustment of the hold-down bolt is necessary to obtain the desired clamping pressure. Locking and unlocking are accomplished by means of a threaded element in the positioning handle. Lubrication is provided for the threads.



Readily adjustable over wide range

### APRONS

LIGHTWEIGHT laboratory and industrial aprons made with high-grade cotton fabric and a vinyl-resin coating are particularly well suited for operations in laboratories, battery shops, tanneries, canneries, machine shops, and on the farm.

The vinyl-resin coating makes the Goodrich aprons water-proof, acid-proof, alkali-proof, and oil and grease resistant. They are flexible and constructed with hemmed edges and reinforced neck and waist tapes.

### PAINT STRIPPER

A HIGHLY efficient water-soluble paint stripper that loosens paint for speedy removal with water has been developed by Turco Products, Inc. According to the manufacturer, the hosing off of an application of this stripper leaves a clean, paint-free surface requiring very little after treatment to prepare for further processing.

The new material, known as Turco Stripper L-780, is claimed to be non-corrosive on metals, making it safe for use on any aircraft part or assembly and recommending it for the removal of zinc chromate primer as well as other paint coatings. It is said to be safe for use on wood and to cause no tendency to warp.

Due to the water-soluble characteristic of Stripper L-780, brushes and

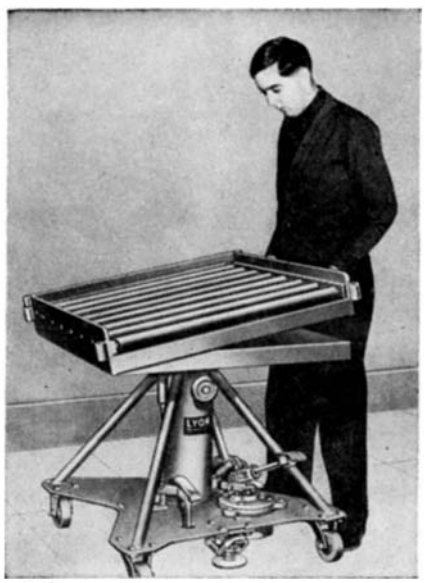
cleaning equipment can be cleaned for re-use quickly and completely by a vigorous churning in a bucket of water.

Applied with brush or spray, the material is left on the surface until it tests ready for removal (5 to 20 minutes). Loosened paint is scrubbed with a water saturated brush to form a slurry. Slurry is then removed by hosing with water, steam, or air and water gun.

### ROLLER TOP

For use with the Lyon-Raymond hydraulic elevating table, a new removable and reversible roller top is now available. Instant installation or removal of the roller top is possible since the framework fits down over the permanent top, eliminating any necessity for bolts or other fastenings. The roller top consists of a rigid, welded framework, supporting ball-bearing conveyor rolls.

Since the table top is square, the roller top can be placed to convey from front to back, or from side to side. This understandably increases the



Useful in conveyor systems

table's usefulness for a great many applications. With the roller top, the hydraulic elevating table is commonly used in conveyor systems to accomplish a change in level or direction. It is also highly desirable in many die handling and feeding operations.

### SWITCH BREAKER

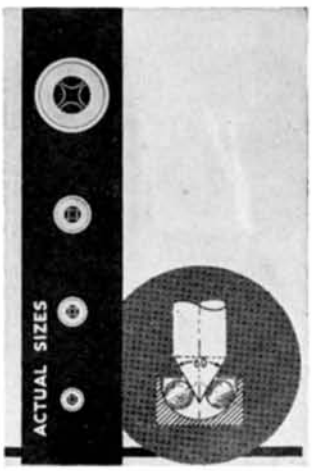
Relatively free from the effects of extreme high and low temperatures, a new circuit breaker is announced by Littelfuse Incorporated. The actual trip temperature of the new breaker without flow of current is 350 degrees, Fahrenheit, ambient temperature. This outstanding resistance is accomplished by new bi-metal design. There is, of course, a clear distinction between operating and ambient temperatures. The high differential between operating and breaking temperatures is a distinguishing characteristic of this circuit breaker.

The bi-metal is used as the finger that pulls the trigger. No appreciable mechanical load is exerted on the bi-metal as it trips the breaker. Thus a new degree of dependability and uniformity of performance is reported.

While primarily designed for military uses—aircraft, tanks, ships, landing craft, and so on—the high time lag of the breaker well adapts it to protection of motors and other equipment having high starting surge currents.

### PIVOT BEARINGS

Pivot type ball bearings are now available from Miniature Precision Bearings in sizes ranging from 2 to 10mm outside diameter and made of beryllium,




Small bearings now available

stainless, or chrome steel as required for the application. The bearing races are machined from solid bar stock and highly finished on raceway and exterior surfaces. Each bearing is equipped with four balls of the same material as the cup and fitted with a retaining cap.

### BLACKENING PROCESS

Chemical blackening of ferrous parts can now be accomplished by a new and simple process which utilizes immersion equipment that can be set up quickly in small manufacturing or plating plants with equipment that is already available or obtainable at very small cost.

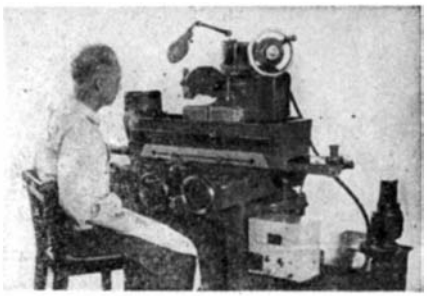
The Ferrotone bath, developed by Turco Products, Inc., operates at a temperature considerably below that re-

quired by oxide finishing baths. Ferrotoning, an entirely chemical process, provides a gleaming black or rich matte finish which is integral with the metal itself and is extremely durable. It does not chip, flake, or peel even under repeated flexing. It will not blister and can not be removed under routine cleaning operations by the action of solvents or degreasing agents. The process neither increases nor decreases the dimensions of the treated metal.

### SURFACE GRINDER

LATEST developments in balance and construction give the new model G-1 DoAll surface grinder a dependable accuracy which enables even "green" operators to rely on the machine for constant fine work. With standard grit wheels, the machine produces a fine finish to within six micro-inches. An innovation in design permits the operator greater convenience and closer inspection of the work while grinding.

Built for tool room use and light production work where accuracy is paramount, it has a table travel of 21 inches and transverse travel of 7½ inches with a vertical wheel head adjustment of



**Grinding accuracy is built-in**

12 inches, using a 7 by 1¼ inch wheel. Extreme rigidity, so important to precision finish, is inherent in the 2200-pound machine. This is almost double the weight usually found in a tool room surface grinder. This great weight, while helping to absorb vibration, is also used to advantage at all vital points.

An especially constructed combined hydraulic control unit eliminates all piping usually found in a surface grinder of this type. This one unit controls the five hydraulically actuated movements of the machine.

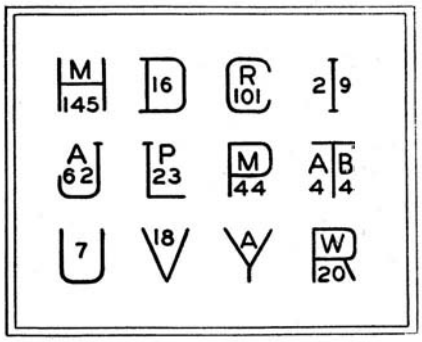
### PLATING ON GLASS

THE UNUSUAL adhesion obtained by Electro Plastic Processes in plating on plastics materials has been further adapted for application to glass and ceramics. Laboratory and field tests indicate greatly improved hermetic sealing. Tests on Pyrex glass have been conducted by heating the solder-sealed piece to 350 degrees, Fahrenheit, and immersing it immediately in dry ice, indicating the adaptability of the new process for all temperature ranges. Adhesion obtained is reported to be much better than that of other commonly used methods.

Any normal soldering method is satisfactory—hot iron, oven soldering or electronic, and no special solders are required. Either glass or ceramic cases can be plated with a metallic band for soldering to metallic end caps, or insulators plated for solder sealing to metallic containers.

### IDENTIFICATION STAMPS

HAND stamps by which even more information can be conveyed than by conventional hand stamp designs are now available from New Method Steel




**Possible variations almost unlimited**

Stamps, Inc. These new "Letter-Outline" stamps are particularly suitable, for example, where several sub-contractors may be making the same part and shipping them into the contractor's plant in quantities. With the new hand stamps, not only is it easy to identify the company which supplied the parts, but the latter company can also identify the individual operator or inspector responsible.

All such information can now be included on one hand stamp by a design which utilizes a large initial letter as an "outline" on the stamp, while other pertinent information as to operator and operation performed on the part is included within that character outline.

### PRESSURE REGULATOR

A NEW regulator, designed to hold air pressures constant regardless of changes in flow as well as variations in

**To hold air pressures constant**

supply pressure, operates on the pneumatic "null" balance principle and may better be described as a pressure controller, since the main air valve is operated by a detecting nozzle. This nozzle operates with a constant differential pressure to hold the manual load-

ing spring at essentially the same position, regardless of variations in flow or in supply pressure.

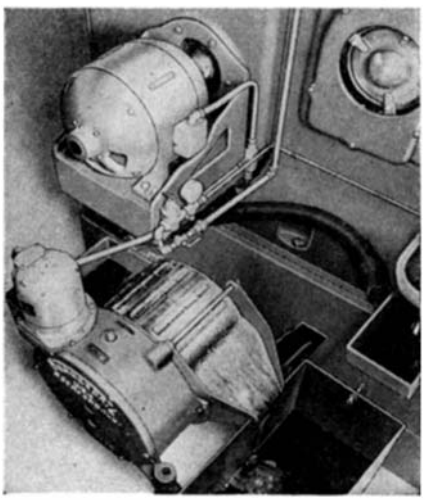
An automatic bleed is provided, to operate when a reduced regulated pressure is required. The automatic bleed also serves to permit reverse flow when the regulator is used as a limit control on industrial instrument applications.

### COOLANT SEPARATOR

EMBODYING an entirely new method for automatically removing harmful magnetic metal and abrasive particles from honing coolants having a non-soluble base, a magnetic-automatic coolant separator has been brought out by the Barnes Drill Company. No filters are employed by the separator and all magnetic particles are automatically removed through magnetic attraction.

The separator is a self contained, motor driven unit, employing a magnetic rotary drum, which attracts metallic particles as they pass through the coolant and carries them out as the drum rotates. The drum is constructed of a series of permanent magnets mounted all the way around the inside and rotating with it.

The coolant flows rapidly in a thin

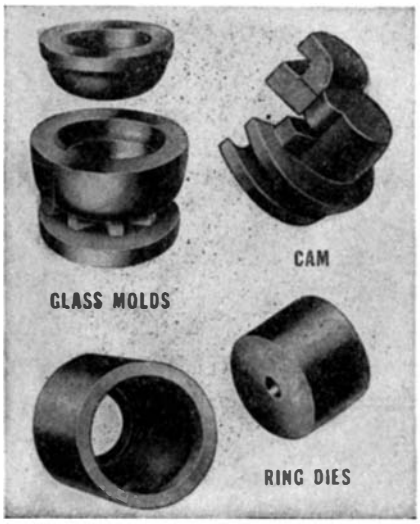


Magnetic drum does the trick

wide channel through the lower part of the separator in a counter direction to the slow rotation of the drum. The metal and abrasive particles adhere to the drum and extend on end in a definite brush-like pattern. Then, as the drum rotates, the entire sludge mass is scraped off and discharged through a chute into a movable pan. Constant swarf removal maintains reservoir storage. There is no temperature rise and the coolant returns to the reservoir into the base of the machine, ready for immediate recycling.

### CAST-TO-SHAPE STEELS

TOOL steels are now being cast-to-shape for commercial applications by the Cast-to-Shape Division of Jessop Steel Company. Finding wide application in industry, cast-to-shape tool steels are used for dies, forming tools, glass molds, gages, hobs, gears, cams, and numerous other items. Advantages that may be obtained by using this process include savings of time, labor, material, and machining costs. These savings are most noticeable in the case of tool steel dies needed for immediate production, for the die is cast to the shape in which it will be used and re-



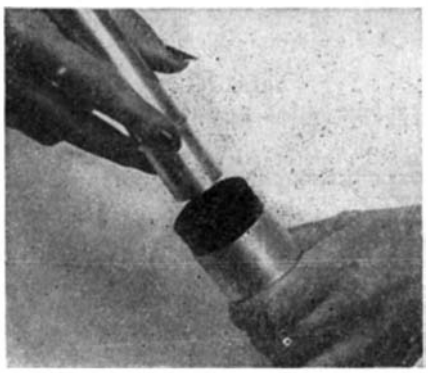

Examples of cast-to-shape parts

quires only a minimum of machine finishing. All castings are furnished in the annealed condition to facilitate machining.

Standard types of tool steel castings are regularly being made, in the latest types of casting equipment, of air hardening, oil hardening, flame hardening, stainless and heat resistant analyses. Many other analyses of specialty steels are available and even the user's "tailor-made" specifications may be cast to shape.

### COUPLINGS

RUBBER couplings which have had conspicuous success in many parts of the pipe-laying field have now been adapted



Rubber couplings serve as seals

to other uses, it is announced by The B. F. Goodrich Company. The coupling is effective as a seal or as a flexible joint, and is particularly valuable in applications where vibration might cause metal-to-metal couplings to fail.

The Flexlock coupling is a gasket or ring having ribs or fins running circumferentially both inside and outside. Inside fins not only grip the outside surface of the smaller pipe but also furnish a maximum sealing pressure. The outside fins are so designed that deformation of pack takes place

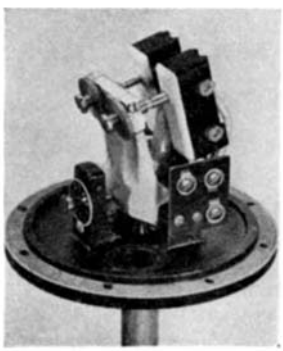
and they grip to the bell or sleeve of the outer pipe. They also set up strut action through the cross section of the coupling, driving the joint tighter.

The result of the gripping action of the inside fins and the sectional thrust caused by their deformation is an absolutely tight joint. Through the design of the outward lips, the only effect of internal pressure is to drive the gasket up the tapered seat, wedging the rubber into a position for even tighter packing.

The couplings can be made of either natural or synthetic rubber, depending upon service conditions. Various compounds to meet specifications have heat ranges from —50 degrees, Fahrenheit, to 150 degrees, Fahrenheit, and can be made resistant to petroleum products and aromatics, as well as hot and cold gases and liquids, the latter including commercial acids, alcohol, water, gasoline, and oil.

### TEMPERATURE LIMIT SWITCH

A NEW temperature limit switch offers all of the well known features that have made Burling switches famous, plus the following new ones: Water- and vapor-tight sheet metal cover; switch adjusting screws have locking screws instead of disks to lock adjustment; main temperature can be easily locked in place with a screwdriver instead of the usual wrench.



Interior of new temperature control switch with wide working range

Burling Temperature Limit Switch Model VD-20 can be used for any temperatures from minus 100 to plus 1400 degrees, Fahrenheit.

### POLISHING-WHEEL CEMENT

AFTER extensive research, Michigan Bleach and Chemical Company has announced a new synthetic polishing-wheel cement, "Gripmaster," which promises to find wide use in many metal polishing operations.

Due to a high-heat-resisting ingredient, Gripmaster does not "glaze" on the wheel. Moreover, it is reported that its adhesive action "locks in" the grains of emery with a positive "vise-tight" control never before believed possible.

A time-saving and inventory-reducing advantage of Gripmaster, it is said, is that all grains—250 to 20—may now be applied with just one grade of cement. It is now no longer necessary to stock several different grades of adhesives for different metals, different flexibilities, or different temperatures. Gripmaster's one grade fits them all.

## Current Bulletin Briefs

Conducted by K. M. CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

A PLAN FOR AMERICA AT PEACE is a 44-page booklet profusely documented with color charts and graphs, all aimed toward promoting smoothly functioning relations between labor and management. Employment statistics, past and present, are analyzed and lengthy discussions devoted to demobilization, reconversion, full employment, and other industrial problems. *Electronic Corporation of America, 45 West 18th Street, New York 11, New York.—Gratis in the United States and Canada.*

ENGINE BEARING MANUAL is a 96-page well illustrated manual for mechanics and others interested in automotive engine maintenance. It contains information on the proper selection and installation of bearings, with tables showing crankshaft and bearing dimensions, tolerances, and oil clearances for all makes of cars, trucks, buses, and tractors. *Clawson and Bals, Inc., 4701 West Lake Street, Chicago 44, Illinois. —Gratis.*

TRACER-CONTROLLED ARC ETCHERS is an eight-page booklet describing in detail single- or multiple-head etching machines for use in light or deep etching of all metals of many sizes. Request bulletin 1635-B. *George Gorton Machine Company, Racine, Wisconsin.—Gratis.*

SPRINGS DESIGNED FOR THE JOB IMPROVE PRODUCT PERFORMANCE is an eight-page booklet which defines and illustrates the five basic types of springs and a variety of shapes and sizes into which they can be designed. *Muehlhausen Spring Corporation, 201 Michigan Avenue, Logansport, Indiana.—Gratis.*

THE VISMETER is a 24-page brochure presenting an exposition of a device for the continuous measurement of the viscosity of fluids, with automatic recording. *Carl D. Miller, Ph.D., 327 Salem Street, North Andover, Massachusetts. —$1.00.*

SAFETY IN ELECTRIC AND GAS WELDING AND CUTTING OPERATIONS is a bulletin compiled to provide safety to both personnel and property in welding, cutting, brazing, and lead burning operations. *American Standards Association, 70 East 45th Street, New York 17, New York.—40 cents.*

SPEEDAIRE WORM GEAR REDUCTION UNITS is a 14-page catalog outlining in detail the principle of the Speedaire fan cooled system by means of photographs, charts, diagrams, and engineering tables. Carefully detailed instructions for planning installations of Speedaire units are included, together with rating tables, dimensions, and shipping weights. *Cleveland Worm and Gear Company, 3301 East 80th Street, Cleveland 4, Ohio.—Gratis.*

TURBINE CLEANING MANUAL is a 16-page booklet outlining a new technique for solvent-cleaning of turbines by the use of Shell Turbo Cleaner. With good dehydrating properties and high solvency for oil deterioration products, this new cleaner has a high concentration of anti-rust agents and can be used on both new and old installations. *Shell Oil Company, Inc., 50 West 50th Street, New York 20, New York.—Gratis.*

WELTRONIC HEAT CONTROLS—Number WTH-44—is a technical bulletin containing descriptions, applications, specifications, and features of an improved line of unit heat controls, available for many resistance-welding processes. *Weltronic Company, 19500 West Eight Mile Road, Detroit 19, Michigan.—Gratis.*

THE USE AND CARE OF MICROMETERS is a 24-page illustrated booklet which describes in detail the various parts of a micrometer, explaining how to use and take care of it. The importance of frequent checking to insure accurate readings is emphasized and suggestions for prolonging the life and serviceability of the instrument are listed. *Sav-Way Industries, Box 117, Harper Station, Detroit 13, Michigan.—Gratis.*

ECCENTRIC DRIVES is a 20-page catalog describing a new counterbore and special high speed steel cutting tools. A full description of each type is presented, including tables of sizes, cross-sectional views, and decimal and millimeter equivalents. *Moreland Tool Company, 16935 West McNichols Road, Detroit 19, Michigan.—Gratis.*

REX FLAT SPRAY NOZZLES is an eight-page folder outlining the uses of nozzles in cleaning, cooling, and washing operations, with tabular information concerning their discharge in gallons per minute, their dimensions, and available sizes. *Chain Belt Company, Milwaukee, Wisconsin.—Gratis.*

BL METALLIC RECTIFIERS is a four-page bulletin containing pertinent information on the characteristics and applications of metallic rectifiers adaptable to electronic, radar, and automotive battery charging equipment. *The Benwood Linze Company, 1815 Locust Street, St. Louis 3, Missouri.—Gratis.*

DESIGN AND CONSTRUCTION OF PNEUMATIC TIRES is a 50-page manual published for United States Army training schools and now available to civilians. The basic principles of pneumatic tire design are described and illustrated. Data and tables are given on the important classifiications of heavy-duty military and civilian tires. *B. F. Goodrich Company, Akron, Ohio.—Gratis.*

# Our Book Corner

**THE BOOK DEPARTMENT of Scientific American is conducted, with the co-operation of the Editors, to make available for you a comprehensive book service. Each month the Editors select and review in these columns new books in a wide range of scientific and technical fields. In addition, they are ready at all times to advise you regarding the best available books on any subject. You are invited to use this service freely. Tell our Book Department what kind of books you want, and you will be furnished with the names of available books, including prices. When inquiring about books, please be specific; remember that we can be of the greatest help only when you tell us just what you are looking for. Books listed in these columns may be ordered from our Book Department. Add 25 cents per book for mailing outside U. S.**

**TO MAKE CERTAIN that books ordered by or for men in the Army, located in the United States, or men in the Navy, Marines, or Coast Guard, located anywhere, will be delivered, insurance fees should be sent with orders, as follows: To $5 in value, 10¢ additional; from $5 to $25, 20¢; from $25 to $50, 30¢.**

### PRODIGAL GENIUS: THE LIFE OF NIKOLA TESLA

**By John J. O'Neill**

THAT Nikola Tesla gave to the world the fundamentals of the alternating current power system is indisputable; but that he should be credited with the discovery of the modern radio system, the planning of present broadcasting methods, the invention of fluorescent lamps, and a dozen and more other things that Mr. O'Neill ascribes to him is something that is open to serious question. Beyond a shadow of doubt Nikola Tesla was a mental genius whose powers were far greater than those of even some of the most brilliant men of today. Lacking in practical business ability, however, he becomes an eccentric figure in the world of science, alternately ignored and acclaimed. The story of Tesla needed telling and it is told here in complete detail. If the reader will overlook the mysticism that is woven through the book and will forgive the author for "superman," "dazzling scintillations," "intellectual incandescence," "a single mighty burst of invention," and similar gasps of amazement, he will be able to mine out of the pages of this biography a picture of one of our truly great scientists who all too often fell short of fulfilling his lavish promises to humanity. (326 pages, 6 by 9 inches, a portrait of Tesla.)—$3.85 postpaid.—*A.P.P.*

### ELEMENTARY MATHEMATICAL ASTRONOMY

**By Barlow and Bryan**

OLD favorite, a half century in existence, lately out of print and unobtainable, but now back in a fifth edition revised by the Astronomer Royal, who has rearranged it and brought up to date the exposition of the basics. Mainly, however, mathematical astronomy is timeless. Those who do not love mathematics regard such books as bleak. This one for the beginner requires only algebra, geometry plane and solid, trig, no calculus, and isn't downright wantonly, perversely, and maliciously bleak but only tenderly bleak, as if the authors had said this hurts me worse than it hurts you. Coverage: celestial sphere; time; earth; sun's apparent motion in ecliptic; atmospheric refraction and twilight; geocentric and annual parallax; aberration; eclipses; planets; precession and nutation; observatory; earth's position; solar, stellar distances; rotation of earth; gravitation. (387 pages, 5½ by 8¼ inches, 170 illustrations.)—$5.10 postpaid.—*A.G.I.*

### LAKE SUPERIOR

**By Grace Lee Nute**

ANOTHER of The American Lakes Series, under editorship of Milo M. Quaife, this book treats with the discovery, settlement, and commercial growth of the Lake Superior region. The fur industry, timber, fishing, and vast mineral resources of the area are faithfully and accurately described from early days to the present in relation to their economic and political aspects. Author is Curator of Manuscripts of Minnesota Historical Society and professor of history, Hamline University. (376 pages, 5½ by 8½ inches, 33 illustrations, index, bibliography.)—$3.60 postpaid.—*A.D.R., IV.*

### SAMPLING INSPECTION TABLES

**By Harold F. Dodge and Harry G. Romig**

PROBLEMS of inspection are encountered in so many phases of industrial production that the choice of method too often becomes a matter of chance rather than design. In this solid text the various factors to be considered for quality control are brought forth, together with an approach that will enable the engineer to decide upon an adequate inspection procedure. The mathematical background is given upon which are built the sampling tables. (106 pages, 5½ by 8½ inches.)—$1.60 postpaid.—*A.P.P.*

### THEY HOP AND CRAWL

**By Percy A. Morris**

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# Telescoptics

## A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

**Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"**

IN 1931, Daniel E. McGuire, a Shadyside, Ohio, farm lad then 17, hit on the use of a slit in place of a pinhole in the telescope mirror maker's Foucault knife-edge test and for this his name has been in the book "Amateur Telescope Making" (page 380) since the edition of 1933. Later, McGuire became a precision optical worker for several professional producers. In June, 1943 he hit on something which he now, by invitation, describes after using it a year and becoming closely familiar with it—the employment of spacers of scotch tape in connection with the air-spaced test plate for optical surfaces. From 15 Lincoln Ave., White Plains, N. Y., he writes:

IT is commonly believed by opticians that interference fringes appear between optical surfaces only when they are in close contact with each other. This is the earliest form of optical testing in which the interference of light waves reveals minute irregularities on the surfaces. This method prevails to the present day. It has many disadvantages, but they can be overcome to a great extent through the use of air-spaced test plates.

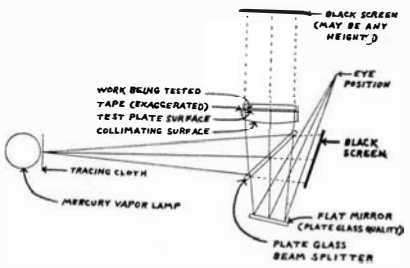


**Figure 1: Inverted method**

With the use of monochromatic light, a surface may thus be tested when removed many thousands of wavelengths from the test-plate surface. While there is no need for going to this extreme, there are many advantages in separating the two surfaces as much as 100 wavelengths (0.002"). This reduces the risk of scratching poorly cleaned surfaces, and increases speed many times over that of the conventional method.

The ideal material for separating the surfaces is scotch tape. This material is uniform in thickness and, when properly applied at three equidistant points on the test plate, it is easy to maintain parallelism between the surfaces. For 2" to 4" test plates the tape is cut to ¼" to ⅜" width and about 1" lengths. The cleaner end is applied to the surface, and the other end, because it has been handled when cutting to size, is folded down over the edge of the test plate. For this critical work the scissors must be kept clean. Any dust particles that are sealed under the tape add to the thickness of the air space, hence cleanliness must be the rule when applying the tape. For the same reason air bubbles under the tape must be avoided.

To prevent curling of the edges and corners of the tape the test-plate surface must itself be cleaned with great care. When removing a grease film from the area near the tape rubbing must begin near the center of the tape and proceed outward to the glass. Dust is removed with a soft brush.

An ordinary test plate, whether flat or curved, cannot be used with the increased air space without proper collimation of the light. The rays can be focused upon a flat, or on a curved surface by a lens system (Figure 1) on the back of the test plate, so that all rays will have normal incidence upon the surface being tested. The rays return in the reverse direction, and the collimating lens system refocuses them upon the light source.

Test plates of the usual type, optically modified by using the proper collimating systems but without spacers, are thereby decidedly improved. The fringes are more plainly visible on the steeper curves, and the readings are more dependable. Distortion due to oblique reflection angles of marginal rays does not exist in any collimating test plate unless there are serious errors in the collimating system.

An off-axis point of view distorts the fringes. To maintain alinement of the axis a small spot of paint is applied to the center of the back surface of the collimator. When its reflection is hidden by the spot itself, the point of view is on axis. Only one eye can see the undistorted pattern, since both cannot be on the axis together.

A beam splitter is essential to viewing the test plate on axis. This is a piece of glass, plane-parallel, polished on both sides, which reflects only a part of the light and transmits the remainder (disregarding the small portion that is absorbed by the glass itself). It works best with a thin coat of silver or aluminum on one side, but an uncoated beam splitter is satisfactory when the room is darkened. It makes no difference on which side it is coated, but the under surface is the more protected from dust. A piece of clear plate glass is good enough for this work. Figures 1 and 2 reveal the function of the beam splitter.

It is important that the light source be made large enough to allow for changes in the alinement of the test-plate axis; the same applies to the size of the beam splitter. An excessive amount of spherical aberration in the collimator also requires a large light source to provide even illumination of the test plate surface.

Any light source which radiates a small number of different wavelengths, concentrated into very narrow lines in the spectrum, is suitable for air-spaced test plates. Low-pressure mercury vapor lamps are better than high-pressure lamps, although the latter work well when the air space is not too great. Sodium vapor lamps are very good. Neon and fluorescent lamps can be used, but they are not recommended.

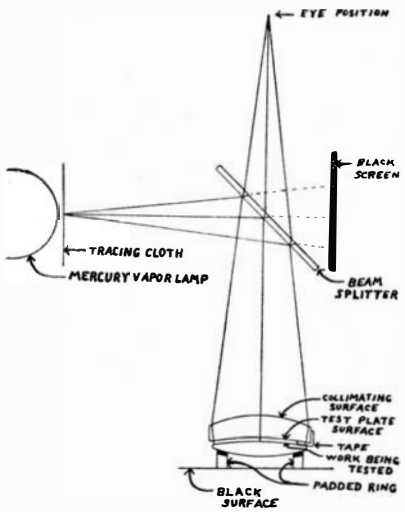


**Figure 2: Direct vision testing**

Other types of lamps have not been used by the writer.

The separation of two flat surfaces, tested in parallel, monochromatic light, has little effect upon the reading of the fringes but with all curved surfaces the readings go concave with a widening separation of two matched surfaces, the change in the reading being in direct proportion to the amount of separation. The steeper the curves, the greater the number of Newton's rings for a given separation.

When curved test plates are air-spaced, the test-plate surface must be altered from the true radius to a new curvature. In order to produce straight fringes, when testing the opposite curvature of the true radius, the change in radius is always made equal to the thickness of the spacers. Convex air-spaced test plates are made steeper, concave ones are made flatter, than the true curvature.

When the new curvature is established, the air space must remain constant in order that the test plate can be relied upon. In practice this cannot be guaranteed, but there is another way to be sure of the test-plate reading. Although the spacers are not reliable in their thickness, the master test plate is reliable in curvature. The air-spaced test plate for steep curves therefore must always be accompanied by the master test plate. Straight fringes are no indication of the true reading unless they are seen when

testing the master. When the master appears to be wrong, due to an error in spacing, this "wrong" reading is the correct reading for the work.

The scotch tape spacers never grow thinner with use, although they may be compressed through excessive pressure and show temporarily a convex reading. It is quite normal for the tape to collect dust around the edges while in use; it becomes lodged underneath the tape and the air space is increased. The error in spacing may change the reading as much as three fringes before it is necessary to renew the tape. When the master shows a concave reading of three fringes, the work must read the same in order to be correct. Straight fringes on the work, in this case, are three fringes convex. An excessive amount of dust is avoided when the most accurate work is desired. In flat work, or with shallow curves, it is not so necessary to check with a master.

A sodium vapor lamp, radiating light in wavelengths of 0.00002", permits the convenient use of round numbers. A surface having 18 degrees of curvature shows a change in reading of one fringe for each 0.001" change in separation. (Collimated light, having normal incidence over the whole surface, is always used in this demonstration.) Spacers having 0.002" thickness change the reading two fringes from the contact reading. A further change in thickness, while the tape is in use, changes the reading in a direct proportion with the error in spacing. A 10 percent increase in spacing changes the reading only 0.2 fringe. When testing a surface having three times the curvature, or 54 degrees, the same change in spacing causes the reading to change nine ($3^2$) times as much. The 0.002" spacers change the reading 18 fringes from the contact reading, and a further change of 10 percent changes the reading 1.8 fringe.

The following procedure is used when correcting the test-plate surface. The spacing material is selected first, and a fair quantity is held in reserve for future replacements. The separation of the surfaces is established by the thickness of the spacing material at hand. Testing is done on the master test plate with spacers temporarily applied to its surface. The test-plate curvature is altered until the concave readings, due to separation, are reduced to zero.

Most of the alteration can be checked by contact readings when the number of fringes is predetermined. The test plate is made to read convex. The testing is done in the usual way, without collimation. The test plate is blocked for polishing by machine, and only the finishing touches are left for hand work. The back surface is cleaned to allow testing of the final work by collimated light. Spacers are used as described above.

Spherical aberration in the collimating lens system has some effect upon the straightness of the fringes. The air-spaced test plate cannot be made spherical unless the collimator is corrected for spherical aberration. It is easier to compensate for the aberration in a simple type of collimator by producing an aspheric test plate. Ordinarily the aspheric surface is produced, without awareness of it, in striving to duplicate the master curve and produce straight fringes; and there is no need for estimating its value.

The collimating lens system has an infinite variety of shapes. Every different test-plate curvature, diameter, thickness, and refractive index of test plate and auxiliary collimating lens requires a different design.

A steep, convex test plate requires one or more concave surfaces to diverge the rays and form a virtual image of the light source at the center of curvature. The turning point, from a concave to a convex collimator, is found where the radius of the convex test plate is $n$ times the viewing distance, where $n$ equals the refractive index of the test plate. A flat test plate requires a convex back surface to collimate the rays parallel to the optical axis. All concave test plates require one or more convex surface to converge the rays and form a real image of the light source at the center of curvature.

A constant viewing distance is maintained for all work of the same diameter, and it is used in the calculation of the curves for the collimating systems. The usual ratio of viewing distance to diameter of test plate is about six to one for the larger test plates. Ten to one, or longer, is better for the smaller surfaces. The viewing distance is never less than 10", on the smaller surfaces, unless a magnifier is used.

Variation of the viewing distance has some effect upon the reading of the test plate; but the tolerance for errors in collimator design is not very exacting. A greater air space makes greater accuracy necessary. It is most practical to keep the air space to the smallest amount consistent with safety.

It is not necessary to test any of the collimating surfaces for figure; but flaws in the glass are more noticeable than with contact test plates.

McGuire's article will be concluded next month with a discussion of the design of the collimating lens system and of the methods of using the test plates.

To forestall possible objections that the general method of using separated test plates may have been used in several large precision optical industries for some time, and that McGuire therefore cannot claim it categorically, it is to the point to state that his main contribution is the scotch tape spacers—which, however, in actual shop production greatly speed up the test and therefore the work. You can put the work on the tester, test, remove it and go on working, quickly; so you will test oftener. He contributes something else — the article. It does the public little good to hear that a given method has already been in use in some shop if nobody who is qualified to do so by experience with it takes the trouble to write it up and publish it for the benefiit of others. McGuire has greatly improved the method and he here makes it available, also, to all.


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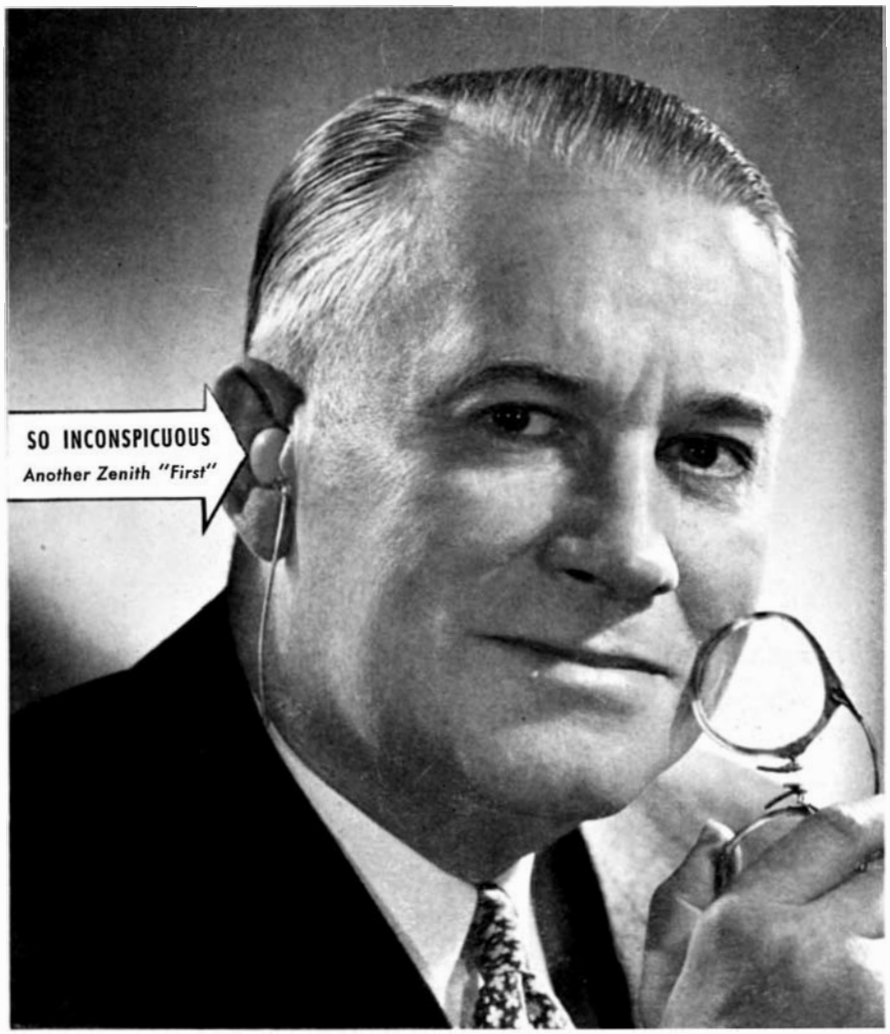


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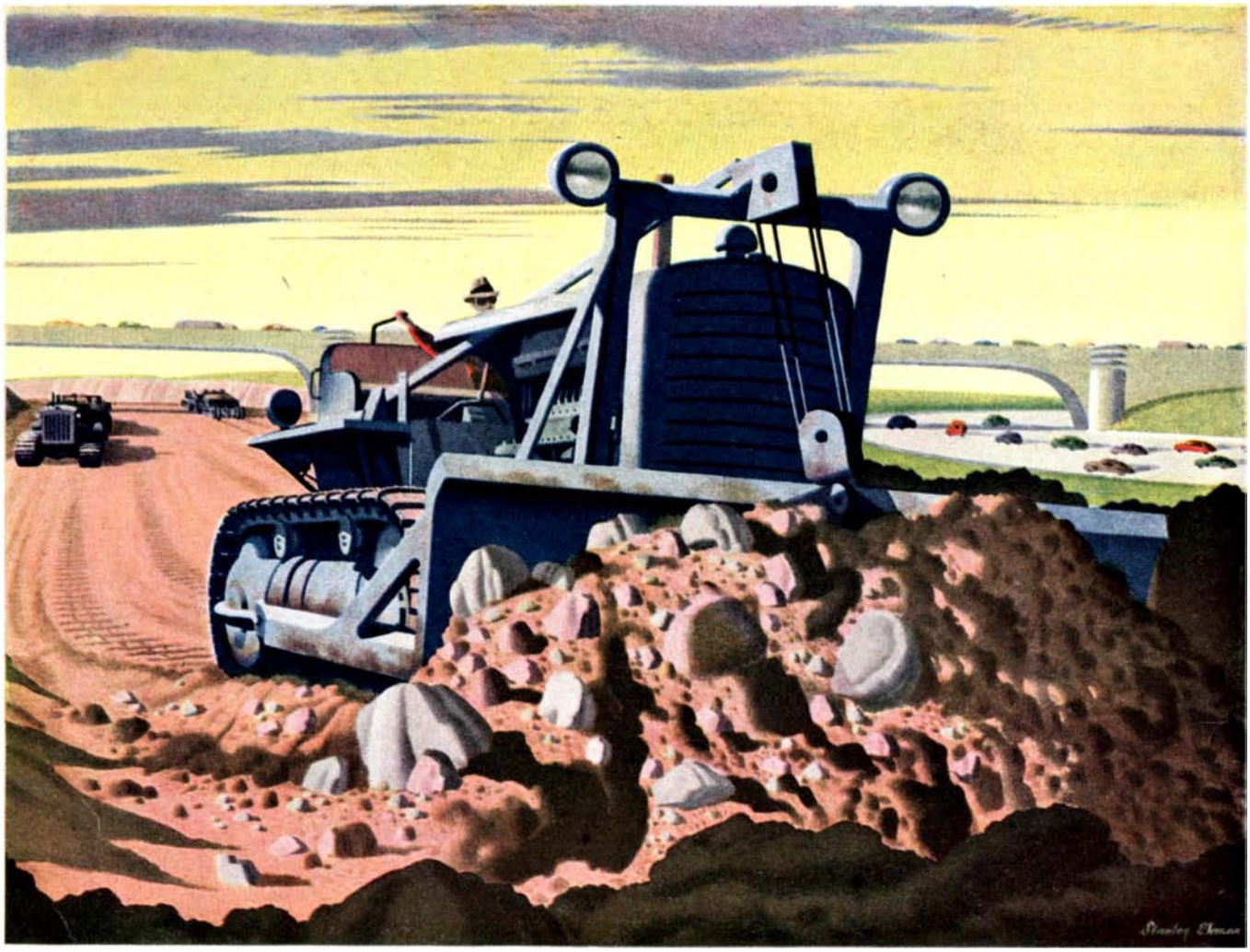

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