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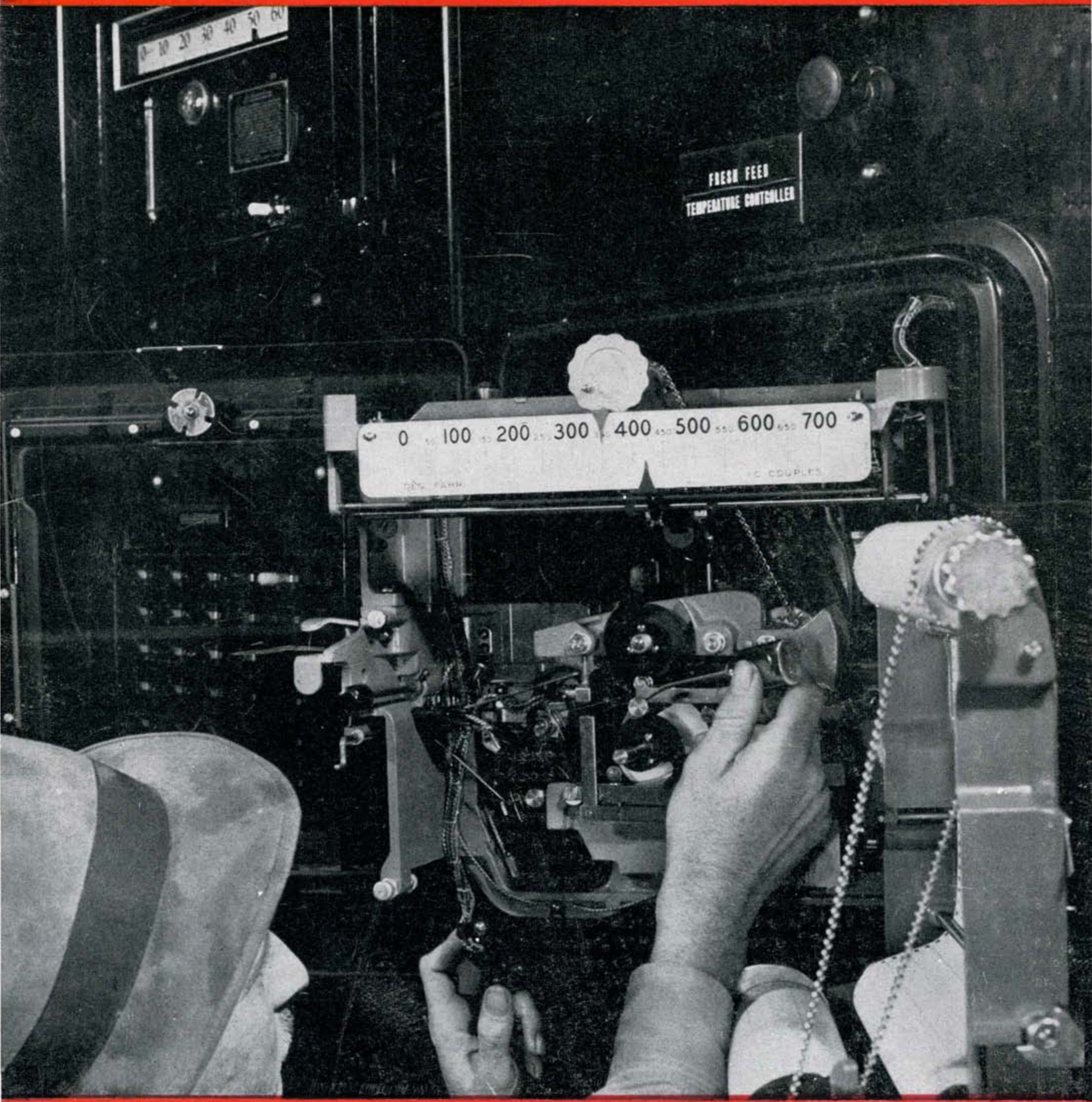

For Automatic Temperature Control . . . See page 241

MEET YOUR NEW NEIGHBOR . . .

Java stands right at the crossroads of one of the most exciting corners of the world. It is one of the string of important stepping stones to Asia and the East —steps that include the magic sounding islands of Madura, Sumatra, Borneo and the Celebes. These help make the bridge from Australia to our own Pacific outpost, the Philippines. Today Java is Jap held. Tomorrow the Japs will be blasted out of there. Hallicrafters short wave radio equipment in the first assault wave will help do the job. The day after tomorrow Hallicrafters will help introduce Java into the widening circle of new, world neighbors. On that day, and through this medium, new knowledge, new understanding will help secure the peace we're fighting for. Hallicrafters radios, constantly refined under fire of war will be ready for the peace with the finest short wave radio equipment available.

Here is a Hallicrafters 15 tube, six band communications receiver with an amazing range and capacity. Right now all of Hallicrafters production goes into war communications equipment. But the time will come when you can own a set like this, a set that has been tried under fire and refined and perfected to the highest degree. Keep an eye on Hallicrafters to keep you in touch with the exciting new world to come.

THE HALLICRAFTERS COMPANY
Manufacturers of Radio and
Electronic Equipment
CHICAGO 16, U. S. A.

BUY A WAR BOND TODAY!

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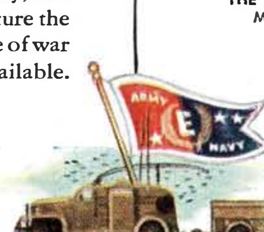

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COVER: An instrument repair man at work oiling one of the automatic temperature controllers in the control room of a fluid catalytic cracking unit now producing high-octane gasoline. The fluid catalyst technique, as pointed out in the article on page 250, holds promise for other uses in the chemical industry. Photograph by courtesy of Standard Oil Company (New Jersey).

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Previews of the Industrial Horizon

By A. P. Peck

In 1945, Scientific American will be 100 years old. Plans for celebrating this anniversary have been perfected, are well underway. To attempt here to tell you all about the celebration would spoil a surprise, even if space permitted details. Regular readers will open their eyes; new readers will do well to reserve copies in advance, because war-time restrictions will limit numbers of copies available of the 12 special Anniversary Issues that will begin with January.

That much can be said now, and this much more: Two new sections will be added to each issue and three new contributing editors will join the brilliant group of specialists who now bring to Scientific American readers the broadest view of progress in science and industry obtainable in any periodical.

The two new sections will be "Plastics in Industry" and "Transportation." Editing Plastics will be Charles A. Breskin, Editor and publisher of *Modern Plastics,* who probably has done more for the plastics industry as a whole than any other one man.

Transportation will be divided into Railroad and Highway transportation, with Contributing Editors alternating from month to month. In January you will find the first railroad article by C. B. Peck, Managing Editor of *Railway Mechanical Engineer,* who has been identified with railroading for so long that he knows his subject thoroughly from ballast to whistle.

In the February issue will come Leslie Peat, Managing Editor of the *S.A.E. Journal,* writing on the general subject of highway transportation. Mr. Peat has an intimate daily contact with automotive transportation, and a faculty of digging deeply into the real meat of his subject.

These new sections in Scientific American are "plusses" in the sense that they will start coincidentally with the first of our Anniversary Numbers. The real treat of the year will be a series of monthly inspirational surveys of the background, the present, and the probable future of various phases of industry, as seen through the eyes of experts in the fields, culminating in one bang-up issue which, it is predicted, will become a collector's item because of its unique content.

PLASTICS' CONTINUING STORY

WHILE there is no thought of making a book-review section out of this page, it is impossible to resist the temptation of "lifting" a quick view of the plastics horizon from the book "The New Plastics," in an attempt to show quickly and in one glance the extremely broad fields that these industrial materials can and will cover.

One plastic is called a "synthetic mica"; another is more nearly like glass than any other plastics: still a third is a synthetic rubber with high resistance to oil, gasoline, heat, light, and oxidization: one more has a strength-weight ratio in one direction higher than that of stainless steel; others make ideal adhesives for other materials.

Even such a brief listing as this acts as a spark-plug to start the imagination going along the plastics highway of the immediate future.

THE UNSEEN IN THREE DIMENSIONS

TO THE tremendous advantages of extreme magnification offered to science and industry by the electron microscope has now been added the feature of three-dimensional viewing. With these three-dimensional pictures, made available by the application of the Polaroid vectograph system, it becomes possible to study and measure the shape and space characteristics of invisible structures that are extremely difficult or impossible to see in ordinary electron-microscope photographs.

The three-dimensional vectographs were first demonstrated recently by Robert D. Heidenreich, of the Dow Chemical Company, where they are being used in the investigation of corrosive phenomena in magnesium alloys. Says Mr. Heidenreich: "We can now examine the shape of micro-structures just as we can examine the formation of rock in a quarry. The increasing store of knowledge of new characteristics of metals will doubtless be utilized in the development of new alloys that perform even better than those we have today."

POST-WAR MOTOR-CARS

MORE modest than a maiden with her first boy friend are most of the motor-car people when pressed for definite statements regarding their plans. General Motors has nothing to say except that they can get into production in a hurry, once they get the green light. Nash has ordered machine tools and factory plans for post-war production, but remains quiet on details. Graham-Paige comes the nearest to being the Sunday-supplement writer's delight by saying that they will by no means be the first to get into production but that when they do it will be with a motor-car that will be "as modern as tomorrow." Ford, it is reported, has big plans for little automobiles but will not enlarge on that statement. Ex-Ford-man Sorensen, now president of Willys-Overland, is plumping for the jeep and predicts that that great little vehicle will have a brilliant post-war future; in fact, he foresees it as repeating the history of the Model T after World War I.

All this makes good but still somewhat unsatisfactory food for thought. From this vantage point, any money to be bet still goes on the probability that motor-cars post-war will pick up where they left off with war-born refinements, and carry on through sane, reasonable developments. Old Man Public is a funny fellow about his automobiles, as quite a few manufacturers have learned who attempted to produce and sell "futuristic" motor-cars in competition with established, tried-and-true designs.

FOR FUTURE REFERENCE

HOME-FURNACE fuel, in the form of three-inch cubes composed of anthracite and bituminous fines, held together with an asphalt binder, is in the offing. . . Companies that give attention to the eyesight of their employees are finding that it pays dividends in increased production and contented workers. . . If you are thinking about the highly efficient aircraft heaters now in use as a possibility for heating your post-war home, forget about it; it just isn't in the cards until many of the bugs have been eliminated. . . The better the fuels developed for internal combustion engines, says Charles F. Kettering, the greater the improvement that can be made in them by the addition of ethyl fluid. . . Agriculture and industry are coming closer together; more and more agricultural products are finding pharmaceutical and industrial use. . . Developments in fuel injection for gasoline engines foreshadow a possible return of the two-cycle system and direct competition with the Diesel in power and economy. . . Electronic devices, now multiplying like the proverbial rabbits, must, if they are to be successful, be regarded as something to be engineered into the whole rather than as gadgets to be attached at will. . . If you want to stir up an argument with a marine shipping man, bring up the question of what is to be done with the relatively slow Liberty ships after the war; right now they look like fodder for a peace-time scrap drive.

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of December, 1894)

AIRPLANES — "Experiments with Prof. Langley's flying machine have been in progress for some time past. . . This in connection with Maxim's work, goes far to indicate the possibility that we may yet see a successful aeroplane flying machine."

ALPINE ELECTRICITY — "An American traveler in the Tyrol and other Alpine countries gives an interesting account of the manner in which the Alpine torrents are being utilized in the Swiss villages. . . The streets in many cases are as brilliantly lighted as Broadway. There are clusters of incandescent lights strung across the streets every few yards. . . . It is probable that extensive manufacturing interests will soon spring up and the mountain torrents will turn saws and spindles as well as dynamos."

WELDLESS CHAINS — "Mr. O. Klatte, the manager of the Walzwerk Germania, at Neuweid-on-the-Rhine, has recently successfully worked out a system of manufacturing weldless chains, in which all the tedious operations of repeated heating, forging, and punching are avoided. This is effected by simply rolling the chains. . . The original form is a bar. This is passed between four rolls. . . After leaving the rolls, the chain bar is passed through a punching machine, with automatic feed, by means of which the webs are removed. . . The chain bar, of which the links are still connected by a slight web where inaccessible to the punches, is reheated to a red heat and passed under a press, by which the links are reduced to the specified width."

ALCOHOL — "Vivien and Dupont have experimented as to the manufacture of alcohol from apples. One hundred quarts of apple juice, weighing 233 pounds, contained the usual water, 0.03 percent of ash, 2.04 percent of pectin bodies, and 2 percent of cane sugar, 2.97 percent dextrose, 8.50 percent levulose, and 0.84 percent of other sugars; total sugars, 14.31 percent. On adding phosphoric acid, potash, and ammonia (or sodium nitrate) the fermentation proceeds as quickly and completely as with turnip juice, and by this means 5 percent of alcohol is obtained from the apples."

SODA — "California is one of the few localities in the United States where natural soda is found. The geographical occurrence of this substance in the United States is principally confined to the arid regions of the Great Basin, especially to the soda lakes near Ragtown, Nev.; Mono Lake, Mono County, and Owens Lake, Inyo County, Cal.; and Albert Lake, Ore.; and to many dry deposits and incrustations in the same region."

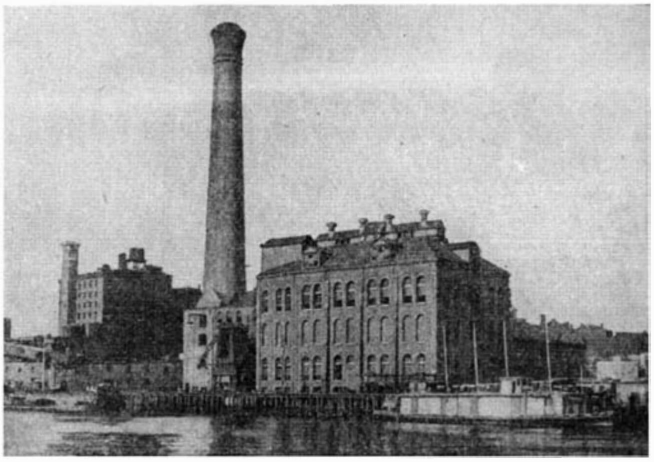
TALL BUILDINGS — "The contour of the city of New York is undergoing a very striking change in the increasing number of tall office buildings now being erected. The construction of these buildings is made possible only by the use of steel frames. . . The modern tall office building has a steel frame. This carries nearly the whole weight, and the walls, solid and massive as they appear, do not support the structure, but simply fill the interstices."

FLY WHEEL — "Among the most recent and novel applications of wire, perhaps none has greater interest to the mechanical world than that presented by the new wire fly wheel lately erected at the Mannesmann Tube Company's Works. . . The wheel . . . consists of a cast iron hub or boss to which two steel plate disks, about 20 feet in diameter, are bolted. The peripheral space between the disks is filled in with some 70 tons of No. 5 steel wire, completely wound round the hub, and the tensile resistance thus obtained is far superior to any castings."

POWER LOOMS — "In mechanical weaving the progress . . . has been great, not only in the quality and character of the work done, but in the amount of production. There is scarcely a woven design that cannot now be produced on the power loom. But the advancement in power loom weaving is more appreciated in the speed at which the loom can be run and the facility with which it can be tended."

STEAM DEFENSE — "A simple and effective method of repelling train robbers by discharging jets of steam upon the attacking party has recently been patented by William H. Reeve, an old tugboatman, of New York. . . A further use of steam as a means of defense, the inventor claims, would be in protecting banks against thieves. . . A more ambitious plan, however, is to utilize steam in the defense of forts, armories or arsenals."

POWER STATION — "The Eastern Power Station of the Brooklyn City Railroad Company, situated on the banks of the East River, in Brooklyn, N. Y., from the electrical and mechanical aspect is undoubtedly one of the most perfect steam and electric plants in existence. . . Thirty-six Babcock & Wilcox tubular boilers are eventually to be introduced. The chimney is of brick and rises to a height of 296 feet,



and contains a circular shaft 17 feet in diameter. It is not only available for natural draught. Into its base a species of nozzle or intake is built, to which are connected two 12 foot Sturtevant blowers. When these are in operation, a torrent of air is injected in the base of the chimney and acts injector-fashion to produce a draught. The advantages of this system are that it dispenses with the necessity for closed ash pans or boiler rooms."

CAR CLEANING — "A novel use of compressed air has recently been made by some Western railroads. Jets of air discharged from flexible hose are made to do the work of brooms, whisks and cloths in removing dust and cinders in passenger cars."

NIAGARA POWER — "Engineers have estimated . . . that the total water power of Niagara Falls is 7,000,000 horsepower. This estimate, to be sure, is in the main only a guess, but when the area drained into the lakes above Lake Ontario, and passing through the Niagara River, be considered, the guess or estimate does not seem to be too large."

INVENTION — "'One of the best opportunities for a young man to make money quickly in these days,' said a self-made millionaire, . . . 'is to rack his brains until he has invented something useful or that the public wants. A general impression prevails that it takes a skilled engineer or a man of phenomenal inventive ability to develop anything useful to manufacturers in this age of machinery. But there is a wide field open to shrewd amateurs, so to speak, to supply little articles of convenience to housekeepers, shopkeepers, etc.'"

If You're Waiting for a Home Telephone

If you are waiting for a home telephone, we think we know how you feel.

You'd like a telephone now—not weeks or months from now. And we'd like to install it for you now.

But due to the war we are short of switchboards and telephones, so there will be unavoidable delays in filling orders for home telephones.

The delay will be as short as we can make it. Meantime, we are genuinely grateful for all your patience and co-operation.

BELL TELEPHONE SYSTEM

POST-WAR PROSPERITY

under wraps

Machines for making passenger cars were stored away when America went to war. Soon they will produce civilian automobiles and jobs again—and here's why they will be better automobiles than ever before!

▶ Producing 6,000,000 automobiles a year will provide many a postwar job.

The metals, rubber, fabrics, glass, ceramics, plastics, electrical parts and other materials consumed by such production will help to stimulate many industries.

Every car manufacturer will produce to the limit at first—and for some months after "the wraps" are taken off. All cars will be "easy to sell." But after most of the essential replacements are made—what then?

Early in the post-war period, cars will undoubtedly become better looking, more comfortable, easier to handle and drive. But the most significant progress in motorcar design will depend—in the future, as in the past—*upon the development of engines that get more work out of each gallon of gasoline.*

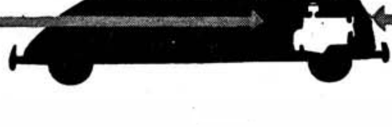
A big step in this direction has already been taken. Immediately after the war the petroleum industry will be able to supply gasoline of far higher quality . . . gasoline that *in engines designed to utilize it* will give more power, more mileage, better performance. Thus, the *foundation* for more efficient engines is already laid.

ETHYL CORPORATION

Chrysler Building, New York City

Manufacturer of Ethyl fluid, used by oil companies to improve the antiknock quality of aviation and motor gasoline.

ETHYL BRAND OF ANTIKNOCK COMPOUND — ETHYL CORPORATION — TRADE MARK REG. U.S. PAT. OFF.



Wartime progress by America's petroleum industry has paved the way for fundamental progress in post-war automobile engine design.

ENGINEERING

Conducted by EDWIN LAIRD CADY

Courtesy International Harvester Company

The power transmission is completely enclosed for safety

Power Transmission Tamed

Factory Power Transmissions, Once Great Accident Producers, are Now Among the Safest Things in the Shop. Further, they are Quieter, More Efficient, More Accurately Controllable than Ever Before. They Absorb Vibration and Shocks, Protecting Machines and Power Sources Alike

When the dust of battle finally settles, and industrial historians look back to see what changes have been made in factory practices, the advances in the mechanical engineering of power transmission are going to be found among the most valuable.

Only an old timer looking back at the factory of yesterday and comparing it with the one of today could see how great those changes have been.

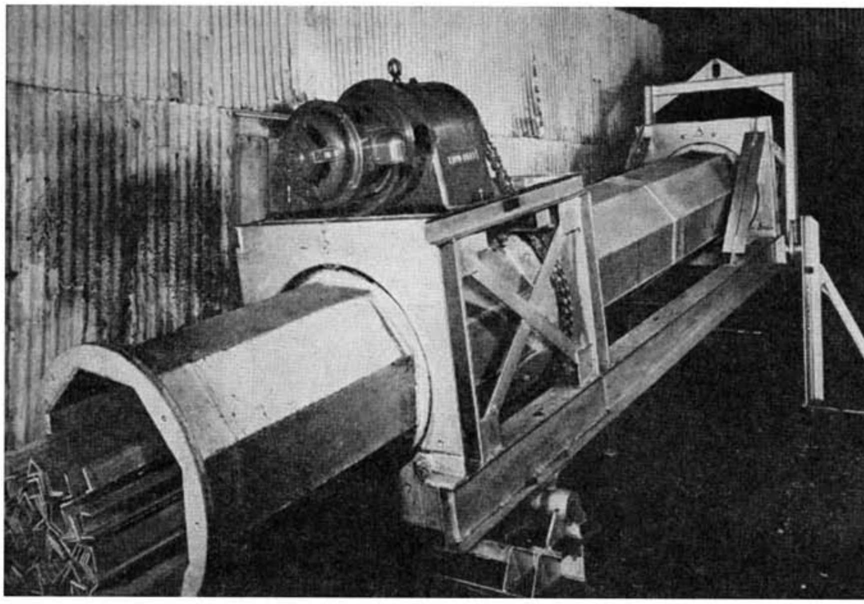
Power transmission, for example, used to be one of the three greatest producers of accidents. Now, modern guards and casings have made it one of the safest things in the shop.

Much of the noise once considered so necessary to industry used to come from the whirring, slapping, squealing, grinding, and vibrating of power transmission devices. Now, power transmission is not only one of the quietest elements, but it actually is used to absorb and dampen noises made by other equipment.

Shop lighting once was made very difficult by power transmission which got in the way of any attempt at flood lighting or indirect illumination. Optical illusions caused by the movements of power transmission devices used to cause errors and accidents. Now the power transmission is out of the way, arranged so it causes no optical illusions, its guards and casings especially painted to promote the effectiveness of shop lighting.

The portability of powered tools, drills, welders, grinding machines, and the like, used to be held down to the negligible point by the difficulties of connecting such machines to sources of power. Attempts to build individual engines or other power plants into this equipment were beaten by the sizes and bulks of the power transmissions involved. Now there is no basic type of production machine which has not been made fully portable. Machines which never were intended to be portable, such as drill presses, milling machines, furnaces, looms, are kept permanently mounted on skids so they can be moved from point to point in the production line or from one production line to another whenever the product to be made is changed enough to make a changed production operation sequence desirable.

One of the largest automobile makers, for example, keeps thousands of machines on semi-permanent mountings. If a machine breaks down and has to be repaired, or its tools need replacing, it is unbolted from the floor, picked up by the shop crane and taken to the repair department. The crane then picks up a fully tooled similar machine and places it in the production line. The production never is interrupted for more than a few seconds. Such tactics would have seemed impossible to the manufacturer of a few years ago. But modern power transmission with its easy adaptability has removed



Courtesy Link Belt Company

The revolving drum of this rotary cleaning and coating machine for hot rolled steel imposes tough shock loads, but the motorized chain drive takes them

Cog-belts were chosen for this job (right), because they operate on short centers, provide close speed control, and deliver smooth power flow at high speeds

Courtesy Dayton Rubber Manufacturing Company

the production tie-ups which used to be taken for granted when key machines ceased to function.

Portable powered tools were really born in the desperate production problems of ship building and aircraft building during days of World War I. Power sources such as compressed air, electricity, hydraulic pressure, or even steam were all ready for these tools. But users took short life on the job for granted. The motors or engines would stand up, and so would the hammers, chisels, drills, or other tools which were being driven. It was the power transmission—the bearings, gears, clutches, and the like—which failed after a few hours of service.

Now these same tools are out of the "emergency" class, and into the "taken for granted" group. Their bearings and gears have been made more accurate, because anything which moves can be strengthened enormously by measuring to the order of .00001 inch instead of .001 inch. Metallurgy has supplied alloys and heat treatments which can take the shock loads, the temperature differences (a shaft in a portable powered tool may be hot enough to turn carbon steels blue at one end, but be ice cold at the other), the metal rending torques which the power transmissions of portable machines must handle within the smallest possible spaces. Electric, pneumatic, and all other kinds of motors have been greatly increased in power while being reduced in size and weight, gasoline engines with their pulsating loads on the power transmissions have been made in tiny sizes for portable powered tools, and still the modern power transmissions stand up and take it.

PRECISION POWER—The exactness with which modern power can be made to function is one of the brightest promises to the machine designer of the future.

Electric motors of today take advantage of this exactness. They can be made to deliver torques (twisting forces) which are within a few pounds or ounces of the amounts desired. With such motors the machine operator can work right up to the limits of power which his tools and materials can take, knowing that no sudden surge of power from the motor will come along to break anything and that no diminishing of power will throw his calculations out of whack. But all of this exactness would be useless to him if he did not have similar accuracy in the performance of his V-belts, flat belts, chains, gears, hydraulic devices, clutches, and other power transmission members. The only power that counts is the power applied at the point of work. Exactly controllable and functioning power transmission is what gets the exactly controlled motor power there.

Metal cutting makes use of this exact control. The modern machinist determines the depth of cut in inches he will make, and knows that this, times feed in inches per minute, times surface feet per minute at which the tool will be in contact with the work, times a constant which varies with the metal to be cut (see table), equals the horsepower required for the cut. With this knowledge he can mount an electrical gage on the motor which drives his machine and if that gage does not show that the right amount of power is being used then he knows that something is wrong. But all such devices would be useless if the power transmission would not deliver the power exactly as the motor produces it or exactly as it is required. The old-fashioned machinist with his non-uniform power transmissions and his fluctuating sources of power had to work by judgement and instinct; he had to keep within safe limits and could not approach the outputs on similar operations which his modern competitor obtains.

Ability to protect both the driven machines and the prime movers (motors, engines) is engineered into modern power transmission.

Such power-driven tools as saws, milling cutters, and even some reamers, can set up destructive vibrations. The individual teeth of these tools strike the work with shocks which are like hammer blows, and those blows can come at the rate of hundreds a second. Results might be loosened bolts and nuts, unbearable noises, quickly worn or "peened down" bearings, and plenty of other troubles. But with each blow individual members of power transmission sequences stretch slightly, slip a little, compress a few millionths of an inch, bend like springs, or take some other cushioning action. The result is that the vibration forces are absorbed by causing the members to do this work and only a slight amount of vibration escapes to do damage elsewhere.

Old style belt drives could—and still do—absorb plenty of vibration. The point is that in modern belt drives, as well as in all forms of power transmission, the exact amounts of vibration to be absorbed and the exact methods by which it will be dampened, all are engineered right into the designs of the drives.

And if the duties of the driven machines are changed, the vibration absorbing abilities of the power transmission can be changed too. One shipyard put some quick-acting, highly elastic belts into the power transmission sequence which took power from the motors to the points of work on drill presses, and found that the production rates could be upped by more than 10 percent, with longer drill life than ever had been obtained in its experience.

On heavy shock loads the power transmission also takes the rap. A saw may abruptly run into a hard knot, a punch press deliver its flywheel force to the heaviest part of its cycle, the parts inside of a tumbling barrel all suddenly bunch up and fall so that their whole weight is thrown against the direction of the barrel's rotation, and so on. When these things happen, the entire machine could be affected as if it had been struck by a giant hammer. But the power transmission sequence is designed with just these shocks in view. Its members stretch, slip, bend, and compress just as they would for vibrational loads, the only difference being that their action is slower and the amount of "give" generally is greater.

SHOCK COMPENSATION—Here again the action has been deliberately engineered; engineered as only modern power transmission permits it to be. For slight shock loads the transmission may refuse to compensate more than an infinitesimal amount, rather being designed to force the tools to ignore the shock and get on with their work. But at an exactly calculated amount of shock the transmission members take their cushioning action, save the machine and its tools, give the motor the little extra time it needs to pick up the added load and get the machine back to smooth functioning.

Electricity would be far more hazardous than it is if power transmission sequences were not designed to help in the control of it. The power transmission can insulate; prevent stray or leaking currents from motors from getting at the machines. Flexible couplings between motors and gear reducers, chain drives, and so on, are made with members which are excellent insulators. Nearly all belts are either excellent insulators or at least very poor conductors.

Power transmission can be an excellent conductor, too, to take static electricity or vagrant currents away from fire-dangerous materials. Rubber belts, for example, can be made into excellent conductors. Originally developed to dissipate harmlessly the static electricity in powder mills, these belts now are used in flour mills (flour can go off like gunpowder if ignited while mixed with just enough air) and to furnish similar protection wherever flammable gases or vapors are found. In these ways power transmission joins non-sparking wrenches and static-conducting floors to bring safety to processes which otherwise would be terribly dangerous.

One of the greatest advances in power transmission is its ability to protect itself against its own former enemies.

The fact that modern transmission systems can be encased or enclosed, whereas many of the older ones had to be left exposed so they could be watched for wear and defects, is a great help in protection.

Chain drives, gear trains, and others which need lubrication, often are enclosed. At high speeds they could not be lubricated properly if left exposed; the lubricant would fly too far and do too much damage. But, enclosed, these drives may work at such loads and speeds that their casings become too hot to be touched by the bare hands—the heat coming mostly from fluid friction within the lubricant itself. Yet with modern metals and the accuracies possible with them, these drives take such conditions and keep on going for years. Naturally, they have far more capacity for the same size or bulk than had old time drives.

Material	Power Constant
SAE 1010 —1025	6
SAE 1030 —1095	8
SAE 1112 —1120	6
SAE X1314—X1340	6
SAE T1330—T1350	9
SAE 2015 —2320	7
SAE 2330 —2350	9
SAE 3115 —3130	8
SAE 3135 —3450	9
SAE 4130 —4820	9
SAE 5120 —5210	10
SAE 6115 —6195	10
Bronze (Hard)	10
Bronze (Soft)	4
Aluminum Castings	3
Aluminum Bar	4
Copper	4
Cast Steel	9
Cast Iron (Hard)	4
Cast Iron (Medium)	3
Cast Iron (Soft)	3
(Alloy) Cast Iron (Hard)	4
(Alloy) Cast Iron (Medium)	3
(Alloy) Cast Iron (Soft)	3
Malleable Iron (Hard)	5
Malleable Iron (Medium)	4
Malleable Iron (Soft)	3
Brass (Hard)	10
Brass (Soft)	4

Courtesy *Mill and Factory*

Use the simple formula in the text, apply these constants, and metal cutting power requirements are known

Enclosures protect the power transmission members against dust, chemical fumes, water, moisture, oil splashed from machines, and plenty of other enemies which used to add large figures in plant maintenance bills. And where enclosure is not practical, a host of special materials have been used to withstand whatever conditions are found. Belts, for example, once were made slippery and short-lived by oil; now they are impregnated with Neoprene and will stand up indefinitely. Gears are made of special materials to run in acid baths. Stainless steel, Monel, all sorts of corrosion-resistant materials are employed.

Perhaps the greatest advance in power transmission has been in the controllability of speeds at the work points.

A few short years ago, the machine operator had at the most two or three speeds to apply to his tools, and he had to do what he could with them. Now he is more likely to have a high limit and a low limit, but between those two his choices are infinite. The speed of an entire bakery production line or of any machine on it can be changed as varying weather changes the behavior of the flour. A brass mill, a paper mill, or a chemicals plant will have speed changing power transmissions from end to end.

Henry Ford is quoted as saying: "A machine is a device for submitting power to the control of a man." Modern power transmission does that so much better than it ever has been done before that the ability of men to control mechanical power is becoming the only problem which gives machine designers no headaches at all.

⊕ ⊕ ⊕

BETTER PUTTY

Is Result of Aircraft Needs

EVEN as industry produces higher accuracies in all assemblies, tighter joints and smoother surfaces, so that far less putty may be needed, research comes back with puttys which are more flexible, more adhesive, and will stand up under greater strains.

Some of the most advanced puttys were specially developed to fill indentations on aircraft wings and bodies and produce more aerodynamically perfect surfaces. Puttys which will take the abuse that warplane service gives them, will solve many problems of factory maintenance and repair.

MORE MARKINGS

Graduated Scales Increasing On Machine Tools

A WAR-BORN stunt which promises to carry over into the post-war designs of machine tools is putting more graduated scales on more control parts.

Much of this has come from the more complete guarding of moving parts necessary for women employees. The shield which prevented cutting oil from splashing and eliminated the flying of hot chips toward the operator, often would cover up the scale which had to be read to operate the machine.

Scales accordingly were scribed on the rims of hand wheels, along cross slides, on other controls. Supervisors soon found that these scales helped in the instruction of green hands. Then it was noticed that old time machine set-up men used the new scales in preference to the old for much of their work—the new scales were in positions easier to see.

Much of this development is still in the "kink" stage—shops are working it out on their own production-line machines. But the machine-tool makers are watching closely, and the best of the kinks will find their way into original tool designs.

Petroleum's 'Big Three'

Basic Processes Which Have Been Developed for Production of High-Octane Gasoline are Certain to be Turned to New Uses. Plastics, Perfumes, and Insecticides Are Only a Few of the Materials Which May Someday be Produced by One or More of the New Catalytic Processes

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

OUT OF the mighty program of the United Nations for producing high-octane aviation gasoline will come many new methods and processes that will serve all industry well in the years to follow. War-time need has speeded petroleum research and output. What might normally have been accomplished in years of hard work, the investment of "patient money" in a comprehensive investigation of basic problems has succeeded in doing in a short space of time. Seldom has any industry increased production facilities as rapidly as have the petroleum producers in recent years.

From this envious period of expansion have come new chemical tools for America. Three important basic operations, new and potent, are almost certain to be retained and expanded to new uses when peace again returns. These processes are fluid catalytic cracking, Thermofor catalytic cracking, and hydrogen fluoride alkylation.

The fluid catalyst cracking process is one of our most important catalytic processes for making high-test fuel. It might be noted that all three processes mentioned above are catalytic in nature, for the chemist of today has made such precise investigations into the nature of catalysis that he can formulate and produce mixtures of chemicals that will catalyze the most difficult of reactions. This is also the case with the fluid catalyst which, incidentally, is not a fluid, but a powder. It is such a finely divided powder, however, that it resembles a fluid; it pours easily, and when gas is passed through a bed of the catalyst, it bubbles and moves much as a liquid might.

The process was developed by the chemists of the Standard Oil Company (New Jersey), as a peace-time expedient for the improvement of motor fuel. However, its easily recognized importance made for a rapid expansion when the need for aviation gasoline became acute.

After laboratory work was completed, Standard proceeded with the construction of a pilot plant which had a capacity of 100 barrels of gasoline a day. This pilot plant, built to obtain data to design a large plant, cost approximately $400,000. The first commercial sized unit was begun in 1940 and was finished in 1942. The commercial installations are huge, towering some 280 feet. Gasoline made by the fluid method is reported to be above 92 octane.

Courtesy Standard Oil Company (New Jersey)
Control room of a fluid catalyst cracking plant

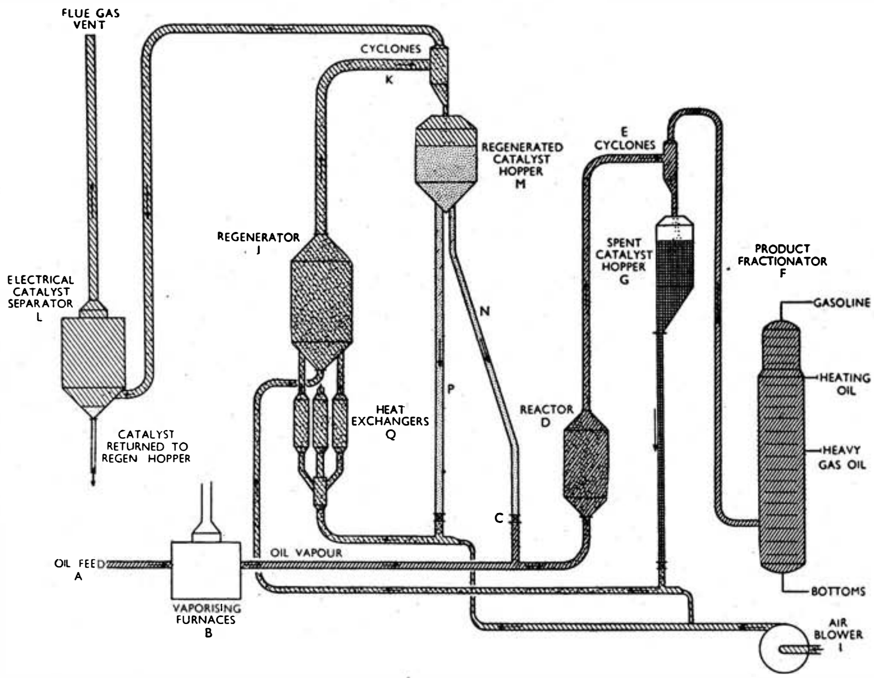
The application of the fluid technique to the petroleum industry holds promise for other uses. In practice, the catalyst is blown by a gas or air stream through processing apparatus, and at certain points the catalyst may either be regenerated, or it may be drawn off and replaced by fresh catalyst. The chemists, in working out this process, made use of the gas lift principle in which a falling stream of solid may be kept in approximately the same place by an upflowing, powerful stream of gas. Another way of illustrating this is to imagine yourself walking down an ascending escalator and staying at the same height from the ground because of the two opposing motions. Imagine now that the escalator is speeded up. Theoretically a point is reached at which, no matter how fast you try to run downstairs, you will be carried to the top despite your exertion. So it is with the gas carrying the catalyst powder—by speeding the gas the catalyst may be transferred to another point in the system. The opposite effect is also possible, and the catalyst can be settled by decreasing the gas velocity. The important feature pointed out here is the controllability the technique gives over catalyst rise, fall, or transportation.

In petroleum cracking by the fluid process, oil is vaporized by heat and forced through pipes to a huge cracking reactor where the actual chemical change occurs. The catalyst is drawn into the oil-gas stream just before the petroleum gas enters the reaction chamber. It is drawn from a standpipe filled with regenerated catalyst. From the reaction chamber the mixture of cracked oil products and catalyst flows through cyclone separators where the powder is collected. The petroleum gas passes on to regular separation equipment found in petroleum refineries where gasoline fractions are recovered, but the fluid powder flows down a standpipe, and at the bottom of the pipe it is picked up and carried along by a blast of air. The air moves the catalyst to regeneration chambers where coke, deposited on the catalyst during the cracking process, is burned off. From the regenerator the catalyst again passes to another cyclone separator where it is removed from the air (now flue gas) stream and returns to the standpipe for injection, as fresh catalyst, into the oil stream. Thus the cycle is completed, and nowhere has production been halted. The process is continuous and the complete transfer of catalyst has been accomplished by moving streams of gas or air. This is a unique process and affords control of heat, density of catalyst, and ease of catalyst transportation, never before obtained in chemical processes.

Thus, concerning the density of catalyst, the inventors of the process state that it has been possible, through extensive investigation of the properties of systems of solids and air, to so adjust velocities of gas as to create points in the process where there were high concentrations of solids. The densities which can be attained are functions of the gas velocity, particle size, solid feed rates, and composition.

HEAT CONTROL—Because of the high turbulence involved, the temperature in the various reaction and regenerating chambers will not vary more than 5 degrees, Fahrenheit, from top to bottom. This is an achievement of note, for in burning off the coke in a typical commercial unit, the heat liberated will be 120,000,000 Btu per hour. One hundred and twenty million Btu is equivalent to five tons of anthracite coal or about 900 gallons of fuel oil—about half your winter fuel requirements—and this heat energy is released every hour with a variation in temperature throughout the whole mass of less than 5 degrees, Fahrenheit.

FLUID CATALYST CRACKING PLANT



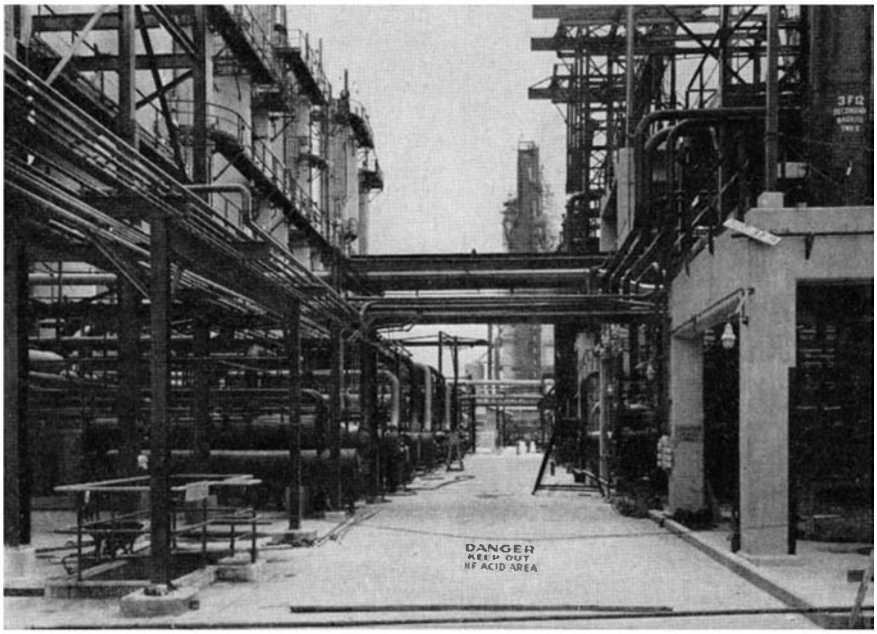
Flow of catalyst and gases in a fluid catalyst cracking plant of Standard Oil Company (New Jersey). Beyond point *C* the powdered catalyst, areated by the oil vapor, flows in a manner very similar to liquid flow. Air is used to carry the spent catalyst to the regenerator chamber, *J*, where deposits on the catalyst are burned off. The catalyst then is returned to the hopper *M*, for recirculation

Mechanically speaking, the fluid processing technique is essentially the transportation of a solid much in the same manner in which liquids themselves are handled. There are many more fields of industry which will benefit from this development. It is thought that it might be applied to organic chemical reactions which give off quantities of heat, and in which control of temperature is extremely important. The principle might also be applied in metallurgical processes for reducing ores, and to numerous other types of reactions involving control of gases, vapors, or solids.

The operation of these plants is entirely automatic—controlled by instruments which respond to and control conditions existing in the processing unit.

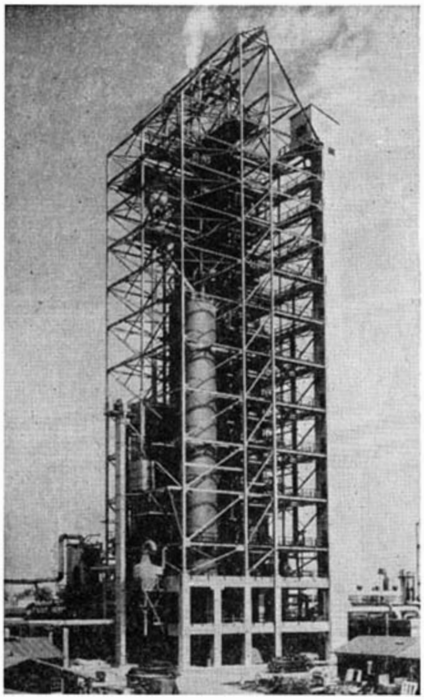
THERMOFOR CATALYTIC CRACKING—The second important tool to come out of war-speeded research is Thermofor catalytic cracking. Technically the process is similar to the fluid and other catalytic processes, except that the catalyst is not a powder but a small bead or pellet, similar to the pellets used in the older Houdry catalytic units. The Thermofor is a continuous system, just as the fluid catalytic process is a continuous system; both are to be distinguished from the Houdry process which is a stationary catalytic bed type. The bed of catalyst moves right through a reaction zone, in which vaporized petroleum is changed to aviation fuel, through an air burning regenerating zone, and back again to do more work as an active catalyst.

This particular development is the work of the Socony Vacuum Oil Company and resulted from research done in 1939 in burning coke out of the clay used in filtering lubricating oils. The commercial equipment is tall—some 200 feet high, and this is explained by the fact that equipment is mounted on top of the piece next in the processing line. The reactor, in which the gas meets the catalyst, is 30 feet high. Surmounting this is a catalyst feed leg —70 feet high—which delivers the catalyst to the reaction chamber. The feed leg is fed by a hopper for catalyst storage, and still above the hopper is the discharge end of the elevator which delivers the regenerated catalyst to the storage hopper. After passing through the reaction chamber, a bucket



Courtesy The Lummus Company

Aviation gasoline plant in Gulf Coast area, showing HF alkylation, isomerization, and gas plant areas, with a Thermofor catalytic cracking unit in background



Courtesy The Lummus Company

Section of a unit using the latest Thermofor bead synthetic catalyst

type elevator picks up the catalyst and delivers the spent catalyst, (so called because it is covered with carbon and cannot react properly with the petroleum gases), to the top of a regenerating unit in which the coke or carbon is burned out. The intense heat generated in this portion of the system is removed by water cooling systems which generate immense quantities of steam. The catalyst tumbles slowly through the regenerator and is purged of all carbon. At the bottom of the chamber an elevator, bucket type, collects the catalyst and returns it to the top of the unit to the storage hopper as active catalyst—and the cycle begins again.

Though this may seem a simple operation, it is in reality possible only because many complex mechanical problems were solved. One of the tough operating stumbling blocks was overcome by the construction of a special bucket which can operate at high temperature.

Gasoline of fairly high octane is realized by this process, and though Thermofor's future lies mostly in the petroleum industry, chemical engineering has a new tool for catalytic operations requiring solid catalysts. Adaptation will be easily accomplished and one of its very important advantages is its simplicity of operation.

HYDROGEN FLUORIDE ALKYLATION—Not the whole importance of the use of hydrofluoric acid for alkylation lies in the fact that it represents the use of a highly dangerous, corrosive chemical in commercial quantities. Prior to its adaptation to the petroleum field, its application lay mostly in the etching of glass. Now, freed from a typed part in the industrial drama, it may rise to leading roles in organic chemistry.

Briefly explained, alkylation, in chemical language, is the combination of isoparaffins and olefins to give branched chain chemical compounds of higher molecular weight. This means, really, the combination of two hydrocarbons to form iso-octane—which is commonly called 100-octane gasoline. In the preparation of 2,2,4,-trimethyl pentane, which also is 100-octane gasoline, isobutane and propylene are combined—and hydrofluoric acid is one of the catalysts that may be used in this operation. This difficult chemical operation is being done on a huge scale today for the war effort—but there is the strong possibility that other reactions made possible by this acid will, in the future, form the basis for other chemical enterprises.

Hydrofluoric acid, HF, is a dangerous material. It requires constant supervision, the best design, and the most corrosion-resistant materials to keep it within bounds. Bad burns are caused to personnel who are unfortunate enough to come in contact with the acid, but under properly supervised work such accidents may be prevented. Other acids, notably sulfuric acid, can be used for alkylation reactions, but the power of HF is such that much more is expected of it. It causes, with ease, reactions which, under ordinary circumstances, would never occur, or which occur with the greatest difficulty. HF is the newest wonder-working tool of industrial chemistry—a tool which was constructed during the days of peaceful research, but one which was sharpened in the crisis of war.

Someday the citizens of this country will blandly use plastics, gasoline, perhaps perfumes and insecticides, all made through the use of catalysts of one form or another. Today our aviators are winning air battles through gasoline made powerful through the process of catalyzation. Such is the power of chemistry.

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ION EXCHANGERS

Find New Uses in Producing Substantially Pure Solutions

Ion exchangers, used extensively in the softening and demineralization of water, have a new chemical use. John W. Ryznar, of the National Aluminate Corporation, in a report to the American Chemical Society, tells of using a cation exchanger to remove the sodium from a solution of sodium silicate. The resulting product was a pure silicic acid substantially free from electrolytes.

The process may be used for the exchange of other minerals; for, in addition to sodium ions, calcium, magnesium, and aluminum may be removed and a hydrogen ion substituted for them.

Reversing the process, anions can be exchanged also through the use of an anion exchange material. Thus a solution of aluminum chloride can be changed to aluminum hydroxide by the simple expedient of passing the chloride through a bed of the chemical exchanger.

Solutions made in this manner have high purity. Tungstic oxide sols containing 99 percent tungstic acid and 0.5 percent sodium oxide have been formed by this method, the report states.

CONTINUOUS POLYMERIZATION

May Almost Double Capacity of Rubber Plants in United States

The potential production of 1,338,000 long tons of rubber from the originally designed capacity of our rubber plants of 735,000 long tons is fully possible if a new discovery for continuous polymerization is utilized.

The new rubber technique is the invention of chemists and engineers of the Goodyear Tire and Rubber Company. Prior to the development of this process, which represents the culmination of two and a half years of research and experimentation, the limiting factor in the total capacity of synthetic rubber plants was the batch polymerization of the buna-S latex.

The possible production of 1,338,000 long tons is larger that the total prewar world consumption of rubber. The additional investment involved to install the process in rubber plants is only about 1 percent of the original capital cost.

POST-WAR RUBBER COSTS

Will be Lowered by Petroleum-Alcohol Competition

Post-war prices of rubber have been estimated by the Office of the Rubber Director. According to the information released, actual cost at present of buna-S rubber is 12.2 cents a pound and butadiene and styrene are 8 cents and 7 cents respectively. Post-war cost of buna-S will be 10.7 cents with butadiene at 7 cents and styrene at 5 cents a pound. These figures do not include amortization, sales expense, profit, or interest on investment.

Plantation rubber during the period 1935-1938 was about 10 cents a pound. Neoprene rubber is said to cost 24 cents at present with a future cost of 19 cents possible. Butyl rubber is quoted at 21½ cents now, with a 10 to 14 cent spread for the future.

NEW SLIDE RULE

Simplifies Vapor-Pressure Calculations

A vapor-pressure slide rule, useful to chemists and chemical engineers using distillation processes and enabling vaporization calculations to be performed in a fraction of the time usually required, has recently been invented. The critical point is marked, and the latent heat of vaporization is given on another scale. The slide rule performs gas law calculations directly, and conversions of temperature, pressure, and heat units are shown. Calculations are accurate to one degree, Centigrade.

The vapor pressure curve for any liquid can be estimated from a single vapor pressure value—for example, the boiling point.

Steel Treating

Wartime Advances in the Heat Treatment of Munition Steel Not Only Assure Higher Quality Steel Parts at Lower Cost for Peace-Time Products, but Will be Responsible for Widespread Changes in the Design and Performance of Lighter or More Powerful Engines and Machines

HEAT treatment, as recently as 25 years ago a combination of blacksmithing and black magic, is today our most "scientific" metal-working process and is the chief reason why American munitions and machines are individually the world's most powerful.

There are still heat treaters who, by dint of years of painfully acquired experience, are able to harden a familiar part or tool by heating it (one at a time) to a temperature that is estimated with varying degrees of precision from its color when hot, holding it at temperature for "one hour per inch of cross-section," dunking it in oil, water, or brine and then tempering by heating until the steel turns blue or straw or some other predetermined hue known to represent the "temper" sought.

But the modern shop operating on a high-production basis to stiff quality and precision requirements employs all the known devices that the metallurgical, electrical, and mechanical sciences have most recently evolved: automatic-temperature-controlled and closely-timed cycles and processes; special treatments that make the necessary transformation painless instead of violent; electrical, electronic, and direct-flame processes that permit rapid, versatile, and *selective* heating; non-reacting gas atmospheres that keep the steel bright and unchanged chemically although heated white-hot; continuous-furnace designs that substitute space for time, and mechanisms that automatically raise, lower, start, stop, transport, straighten, heat, cool, drench, or dry the steel; quench-oil or -water systems that scientifically cool, clean, and circulate the quenching liquid, and so on.

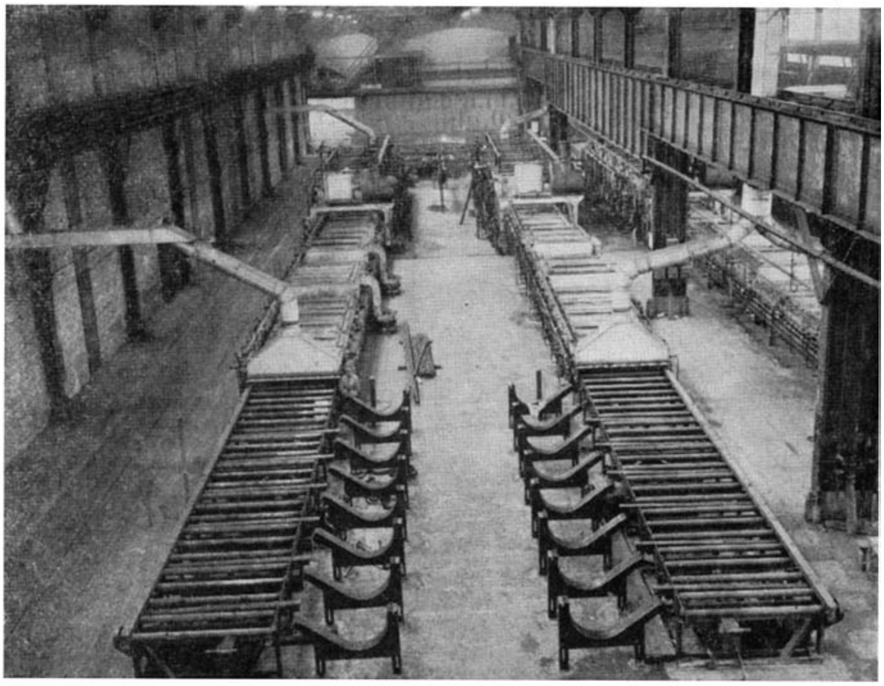
In the more precise lexicon of the metallurgist the most important of these time-saving, quality-insuring, and design-simplifying methods or processes are known as automatic or continuous furnaces, isothermal (constant temperature) heat treatment, induction hardening, controlled-atmosphere systems, and regulated quenches. All are outstanding as processing developments but in addition most of them have special significance for the design engineer.

For example, if you were a machine designer blueprinting a reciprocating engine and its parts, you would be enormously grateful for some means of obtaining complicated crankshafts that could be made of inexpensive low-alloy or plain carbon steels, which could be machined easily and *then* heat treated, and which would not thereby be so warped as to be unacceptable without further machining.

INDUCTION AND FLAME HARDENING—That is exactly what induction and flame hardening frequently make possible, because they provide a means of selectively heating and hardening just the wearing surface of locally restricted regions (crankshaft journals, for example) without the cost and time for, and the warping always associated with, heating and quenching the entire piece of metal. Internal stresses and the danger of cracking or of early failure in service are also avoided by these surface-hardening methods; in fact, induction or flame-heating may be employed to soften or stress-relieve locations or areas already overstressed mechanically.

Several types of induction heating equipment have been highly developed in recent months. In all of them, of course, the workpiece is placed inside a conductor coil carrying high-frequency (usually from 9600 up to several million cycles) alternating current. The reversals induce current flow and therefore heat in the surface of the work; the higher the frequency used, the thinner is the surface-skin that is so heated. The time required for each operation is, of course, a function of the power applied, the size of the part and other factors, but with induction heating the time is so short—often a fraction of a second up to a few seconds—that production rates are startling and in addition the work is at temperature too short a time to be more than slightly darkened by oxidation.

Many units now in use are specially designed, self-contained, automatically timed machines that feed, heat, spray-quench, and eject the parts according to a predetermined cycle with astonishing uniformity of results. The electronic tube converters, supplying frequencies of 100,000 up to several million cycles, have enjoyed a wave of war-time publicity and well-deserved technical interest, but the motor-gen-



Courtesy Surface Combustion

Continuous roller hearth furnaces for annealing and normalizing aircraft tubing

erator-powered sets (up to 12,000 cycles) continue to supply a large part of the total power used for induction heating and are responsible for some of the most advanced automatic and continuous jobs. A third type—the spark-gap converter—is an old and popular standby able to do many smaller jobs in extremely versatile fashion.

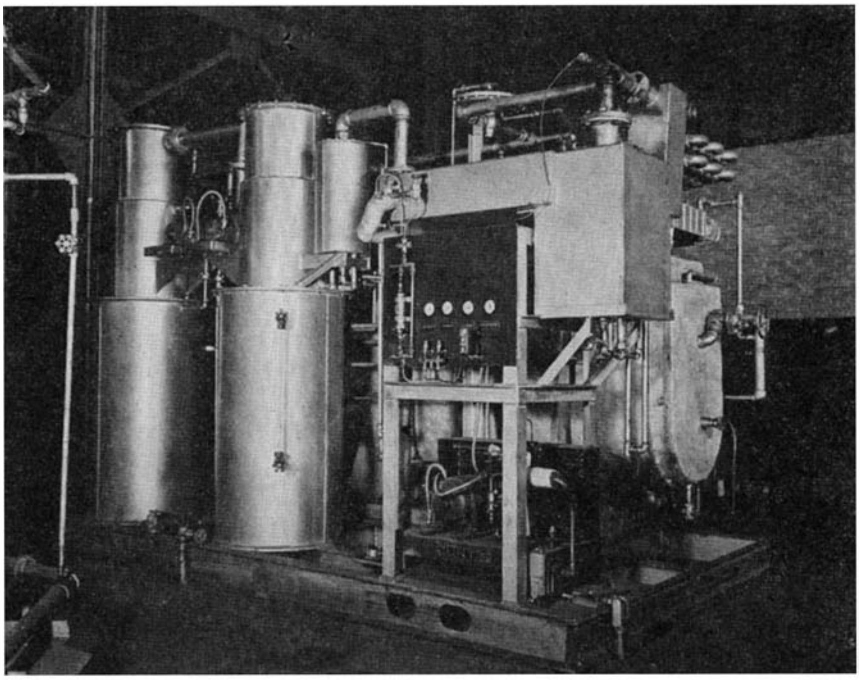
Induction hardening has thoroughly established itself as an ideal method for economically hardening various types of large and small shafts, pins, gears, bearing races, cams, levers, and other machine parts, especially where only the surface is required to be hard. The use of the method for the continuous hardening of steel bars was described in Scientific American, October 1944, page 169. One of the war's outstanding uses of induction was for the differential hardening of armor-piercing shot of several sizes.

FLAME LESS EXPENSIVE—Flame hardening (the manual or automatically controlled application of an oxyacetylene flame to the surface of a steel part, followed immediately by a regulated spray of water) has been used for many jobs similar to those on which induction is employed. Flame hardening is not so expensive as induction but it is also less versatile and less adaptable to special shapes and problems—and especially to straight-line continuous production work. Recent flame-hardening trends were highlighted in Scientific American, September 1944, page 103.

A very recent development in gas heat treatment is the ceramic burner, in which pre-mixed gas-air mixtures are combusted at extremely high rates to give an intense, directed, and patterned heat. Heavy steel parts can be brought to temperature and heated throughout in time periods so short as to make a mockery of the old "soak one hour for each inch of thickness" rule (a ceramic-burner-fired furnace of this type can heat an eight-inch steel billet to 1650 degrees, Fahrenheit, throughout in just 14 minutes), and in addition the furnaces can be surprisingly small, according to the usual standards. Finally, the ceramic burners can be shaped or hooked-up in such a way as to heat the surface of steel bars, tubes, or parts with much the same effect as induction, and they are already successfully competing with induction equipment for some surface-heating jobs.

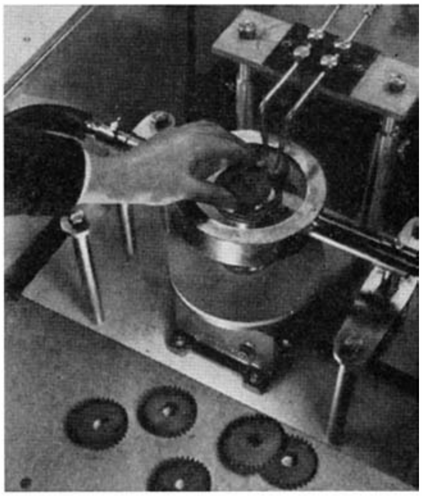
CONSTANT-TEMPERATURE TREATMENTS—Fastest comers of all the heat-treating processes recently have been the isothermal or constant-temperature treatments, which make use of a metallurgical concept formulated less than 15 years ago and only now "catching on" generally. Known as "Martempering," "Austempering," "Interrupted Quenching," and so on, the isothermal treatments are based on the principle that the transformation responsible for the hardening of steel does not necessarily have to be effected by the conventional but often non-uniform and distorting practice of heating to a high temperature, quenching in oil or water, and then reheating to an intermediate temperature, but may instead be carried out by heating to the same high temperature, *quenching into a molten salt or lead bath held at an intermediate temperature,* and then cooling to room temperature.

In the second procedure most of the transformation occurs while the steel part is at a constant temperature, instead of while its temperature is rapidly falling, as in the conventional method; hence all portions of an intricate steel part pass through the volume-changing transformation at approximately the same moment and are not subject to the serious warping that would result if it were quenched-and-tempered.



Courtesy Surface Combustion

A typical controlled-atmosphere generator used in heat treating alloy steel



Courtesy Lepel High Frequency Laboratories, Inc.

Set-up for induction hardening of gear teeth. The pedestal on which the gear rests may be revolved to improve the uniformity of heating

The isothermal processes have received special impetus during the emergency because of the necessity of using low-alloy or plain-carbon steels for many parts. Such steels require drastic quenches to harden them properly by conventional means, and the drastic quenches in turn produce prohibitive distortion and even cracking. By using the salt-bath-quenching process superlative physical properties can be obtained, without any warping or cracking.

One outstanding application of isothermal treatment is the hardening of fuses made of S.A.E. 4140 (chromium-molybdenum) steel. The salt-bath process in one installation (several are in operation) cut the operating time from 1.5 to 3 hours by the conventional method to 40 to 48 minutes by isothermal treatment. This unit handles over 165,000 pairs of fuse parts per month and, despite rigid government inspection, has yet to have a single lot rejected because of heat treatment.

The rise of this process has further extended the use of molten salt baths as heat treating media, and especially of electrically heated salt-bath furnace equipment, which lends itself admirably to the quick, clean, mass-production requirements of such work. The electrically heated salt baths had already earned a special place in the hearts of war production men through their applications to the rapid, minimum-decarburization hardening of high-speed steel, to the case-hardening of steel, and to the neutral-hardening of many parts; two notable special cases have been the successful use of salt-bath methods for the differential hardening of armor-piercing shot (in competition with induction) and for the simultaneous brazing and carburizing of steel assemblies.

CONTROLLED ATMOSPHERE FURNACES—The virtual revolution in heat treating represented by the now wide-spread use of controlled atmospheres is of as much interest to engineers and designers as are the possibilities in induction heating, previously outlined. The use of controlled atmospheres can mean more reliable or smaller, stronger, and cheaper parts, and ultimately lighter or more powerful engines and machines.

It is as simple as this: When steel is heated, either for rolling, forging, annealing, or hardening, in the presence of air or oxygen it oxidizes and in many cases becomes decarburized—that is, some or all of the surface-carbon content is lost. This low-carbon skin remains soft instead of developing the desired hardness when the piece is subsequently heat treated and as a result the part has lower hardness, lower tensile strength, and particularly lower fatigue strength (resistance to failure in vibrating or repeated stresses). Extra thickness must therefore be provided either to bulk up the part and enhance its strength or to permit the machining away of the soft decarburized surface. Sometimes the part before machining off the soft layer is weaker than the same (but thinner) part after the decarburized skin has been removed.

Machining for this purpose alone is expensive and wasteful of metal. The designer would much prefer to manufacture to something very near final size and using steel analyses that involve no wasteful incorporation of alloys just to correct for surface weakness. His end result would thus be smaller, lighter, and stronger parts able to operate at higher stresses and loads, in keeping with the general trend toward faster, more powerful machines and engines.

Controlled atmospheres are now making all this possible. If during its heating at the mill and its subsequent hardening the steel is surrounded in the furnace by a special non-oxidizing gas atmosphere that is also *non-decarburizing* to the steel, it will come out bright and hard and no extra thickness or alloy need be provided.

Several atmospheres are used industrially for this purpose, many of them designed specifically for a particular set of steel composition-temperature circumstances. They represent today a sizeable portion of the heat-treating equipment industry; some atmosphere generators are sold separately from the furnace while others are designed into the original heat-treating system and are an integral part of it.

PROCESS DESIGN—Mechanization has made heat treatment a mass production operation in many shops that once considered it a hand-craft process. Conveyorized systems embodying special heat resistant alloy parts take the work into and out of furnaces, dump them into quench tanks, move basket-containers out of the tanks and into cleaning systems, and so on. Elevating mechanisms carry the work from one level to another where advantageous or necessary.

Many units now incorporate zone control, the furnace being designed with three or four different-temperature zones; the work moves continuously and progressively, for example, through a preheating zone, a soaking zone, and a controlled cooling zone, all at accurately regulated temperatures, with the time in each zone controlled by the physical length of the zone.

"Fancy" quenches of various types, many employing mechanical systems to keep the hot part from warping during the drastic quenching period, are increasingly used. In fact, the importance of quenching as a major factor in both the efficiency of the heat-treating operation and the success of the entire part-manufacturing process is just starting to receive general recognition.

Better quenching oils are now available and temperature-controlled, often refrigerated, quench tanks are found in the more advanced shops. Water quenching of plain carbon and low-alloy steels can be increasingly used in place of oil quenching of more expensive high-alloy steels because of efficient fluid-circulating or part-agitating systems and the chemical treatment of quenching water to provide instantaneous and uniform heat-extracting behavior and thus to avoid soft spots or cracking.

But the broadest and therefore the most significant heat-treating development has been the tremendous increase in the use of heat treating itself. Steel armor-plate castings, for example, are now liquid-quenched and tempered to produce the necessary ballistic resistance, instead of just being made thicker or doped up with alloys as formerly. In the future, many cast and wrought steel products will similarly be heat treated with considerable improvement in quality and performance of the product and saving in weight or alloy-cost as well.

CERIUM IN ALLOYS

Improves Mechanical Properties And Casting Behavior

EXTENSIVE research by Russian metallurgists has established the fact that incorporation of 0.3 to 0.35 percent cerium in aluminum alloys results in substantial improvement in both mechanical properties and casting behavior.

In aluminum-silicon-copper casting alloys, for example, tensile strengths were 20 to 30 percent higher when cerium was present than with cerium-free alloys, and elongations increased more than 15 percent. Rejections of pistons for cracking, unsoundness, blowholes, and so on were considerably reduced when cerium was present.

NAVY SMOKESTACKS

Have Been Redesigned For Mass Production

AN interesting example of the skill and ingenuity of modern stamping engineers is the redesigned naval smokepipe. These smokestacks usually consist of an outer and an inner pipe with an air space between. Before the war the conventional method of building them was to use the inner pipe as the strength member and the outer casing as the cover.

Lightness of weight is essential, strength must be maintained, corrosion should be resisted, and design must be such as to reduce overhaul time to a minimum. It was found that molybdenum-bearing stainless steel gave the greatest resistance to corrosion for this use and was adopted for the inner pipe, with ordinary "18 and 8" stainless used for the casing.

In the redesign the inner pipe is made the strength member for only three feet above its foundation. At that point the stresses are transferred through intercostals to the outer casing, which then becomes the strength member. The inner casing above the transfer point is only 0.040 inch thick and is sectionalized to permit removal of an upper section without disturbing these below it.

This redesigned smokepipe not only met all naval requirements but speeded production.

SPONGE IRON

Now Being Experimentally Produced in the United States

SPONGE iron—iron produced directly from ore by reducing the latter in the solid state, without smelting—has not previously been manufactured in this country, although a moderate tonnage had always been imported from Sweden and used as an ingredient of certain high quality steels. Recently there has been considerable interest in the possibility of making sponge iron from low-grade ore on a large enough scale to compete with blast furnace pig iron as a raw material for general steel making.

Despite the counsel of experienced metallurgists, that American ores are just not suited to the economical production of sponge iron that can efficiently be used for steelmaking, several proposals have been kicking around Washington and elsewhere, designed to set up numerous direct-reduction sponge-iron plants and eventually to circumvent on a large scale the blast furnace stage of iron- and steel-making. Most of them smell slightly of politics but a few that are based on fairly large units using specially favorable ores have possible merit.

At least one plant is already in operation—a Defense Plant Corporation plant operated by Republic Steel Company at Warren, Ohio. The ore used is an Adirondack magnetite and the process involves reduction of the ore by hydrogen at 1200 to 1300 degrees, Fahrenheit, in a Herreshoff furnace, in which the hot gas is bubbled up through the fine ore on a bottom hearth and moves upward, over, and around other hearths at various levels while ore drops downward from hearth to hearth.

The projected capacity of this plant is 100 tons a day. The hydrogen is obtained from coke oven gas, the total amount of gas handled being roughly equal to that in a blast furnace.

Engineers and politicians alike are watching the plant's performance with great interest, although their conclusions may be quite different.

A Miracle Of Production

Under Vastly Increased Demand, Aircraft Engine Builders Stepped Up Production Squarely in the Face of a Diminishing Supply of Skilled Labor. One Manufacturer's Methods, Which Successfully Accomplished the Impossible, Involved Many Special-Purpose, High-Production Tools

ONE OF the marvels of American effort in the present war has been the enormous increase in the production of powerful aircraft engines, in spite of shortages of skilled man-power. The even greater wonder is that this increase in production was not achieved by mere multiplication of hands at work and of standard machine tools on the floors of our factories. It was achieved rather by intelligent planning; by almost revolutionary changes in the design of machine tools so that their functions and capacity were multiplied many times while the skill required to operate them grew less; and by the careful training of novice operators, women for the most part. The Wright Aeronautical Corporation has, perhaps, achieved the most signal success in this aspect of the war effort, and this article is restricted to a study of the work of Wright Aeronautical in building the huge Cyclone engines which equip our bombers and many other military airplanes in all parts of the world. It is not necessary to emphasize what the availability of vast numbers of engines has meant to America in the war. But it is proper to emphasize the lessons which a production-minded nation can draw from this supreme effort in production.

It was the construction of special-purpose, high-production machine tools that has been, more than any other factor, responsible for the tremendous increase in the production of aircraft engines. The first cost of these machines is high, but in most cases the cost has turned out to be lower than the cost of a large number of standard machines required to give equal output. And in all cases the actual production costs have been far lower than the costs which resulted from earlier methods.

Far more important than any reduction in costs has been the enormous savings effected in man-power and production hours. For example, the Greenlee Automatic Transfer Machine used in the manufacture of cylinder heads took the place of 42 standard machines which would have required the employment of 107 skilled and semi-skilled workers per day. Only eight operators per day, working only one shift, are needed for the Greenlee. Since the work of these operators consists mainly of loading and unloading, with the accurate placing of parts and all the rest up to the machine, they are usually women who have been given only a few days' training. One set-up man is the only skilled operator needed to keep the machine running. Thus, a direct saving of 99 persons was effected by the introduction of this single tool.

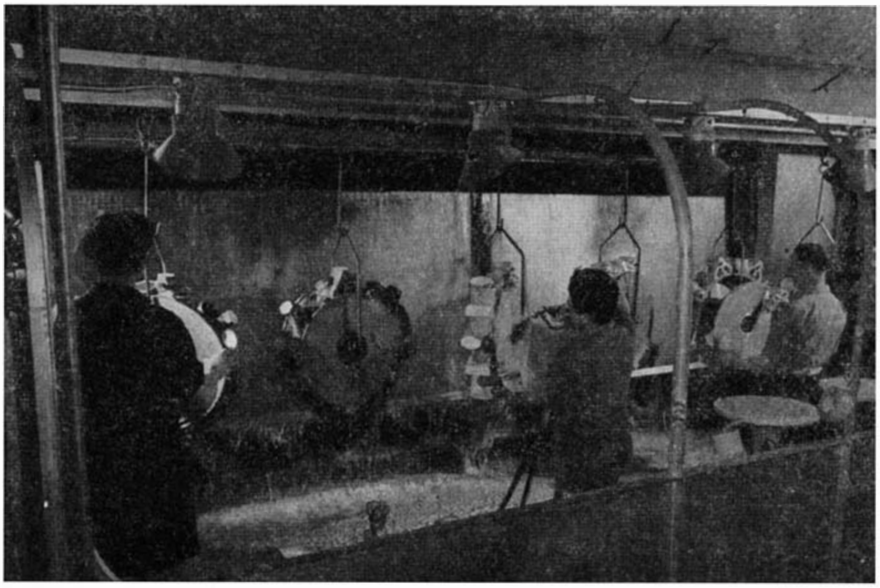


Figure 1: Supercharger sections passing on conveyors through a paint spray room

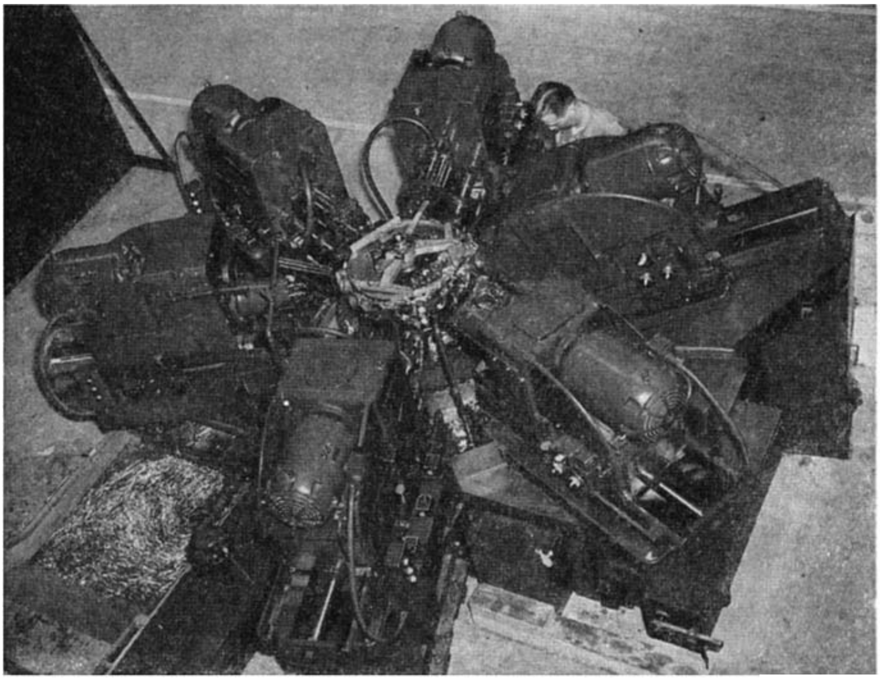
A subsidiary but still important saving was effected in the construction of these tools. In many cases, it took little longer to build the special machine than to build one standard machine. With the great reduction in the number of machines to be built, there resulted a formidable decrease in the number of man-hours in building the equipment itself. Moreover, this equipment was so designed that unskilled women could be employed, again saving man-power.

SUBSTITUTE FOR A MAN—In heavy industry, the main objection to female labor has been the lack of physical strength for lifting heavy parts into and out of machines. This was overcome through the installation of mechanical lifting devices such as hand or electric hoists at each machine, or by the use of overhead traveling cranes. Conveyors of both the roller and power types simplified still further the handling of heavy parts for women workers, and also effected enormous savings in floor space by eliminating the usual temporary storage at each machine. Thus, the one Greenlee Transfer Machine, previously mentioned, saved more than 3000 square feet of floor space. The steady flow of parts also saved aisle space, and reduced trucking operations and the number of supervisory personnel.

An engineering or manufacturing effort rarely starts from scratch—nor did this one.

To begin with, the Wright Aeronautical production engineers counted upon and secured the help of a magnificent machine-tool industry, accustomed to meeting the needs of heavy industries such as steel, automobile, Diesel, railroad, and so on. After the Wright people decided what they wanted to do, they called in the representatives of the machine-tool industry and secured the most skilled and complete co-operation in the way of special layouts. What was deemed at first impossible merely took a little longer.

Furthermore, the Wright Technical Production Unit had the example and precepts of the automobile industry before it. For years automobiles had been produced in large quantities with



trundle on into the baking ovens.

Figure 2 shows a six-way Greenlee horizontal and angular 14-station automatic indexing machine for rough and semi-finish boring, facing, and drilling radial holes in a supercharger front section. At the first loading, this machine rough faces and bores 14 intake ports and seven mounting pads, and rough bores three holes in the oil sump pad. This same machine is also used to semi-finish face and bore 14 intake ports, semi-finish bore the seven mounting pads, finish bore three holes in the oil sump pad, drill two holes in each of the seven mounting pads, drill seven holes in the oil sump pad, and drill four holes in each of the two breather pads. The Greenlee machine, used in conjunction with an eight-way horizontal and angular 14-station automatic indexing machine, finish reams, chamfers, and taps radial holes in the supercharger front section. The two machines replace four; namely, a radial drill, a radial tapper, vertical mill, and rotary table. The two special machines cost $25,400 more, but they saved 276 square feet of area, five handling operations, 17 men, and 121.6 production hours a day.

a high degree of precision whenever necessary. The methods which were successfully applied to automotive practices were closely studied and formed the basis for much of the aircraft engine effort. The Technical Production Unit, though fully acknowledging its debt to motor-car builders, went much further than to transplant automotive practices into aircraft engine factories. A review of general industrial practice was also made. New equipment was studied, new processes and practices were investigated, and current methods were re-studied. In particular, the conviction that skill would be short led to "automaticity" in the machine tools.

Figure 2: This Greenlee six-way horizontal automatic machine performs a number of simultaneous operations in the front section of a supercharger

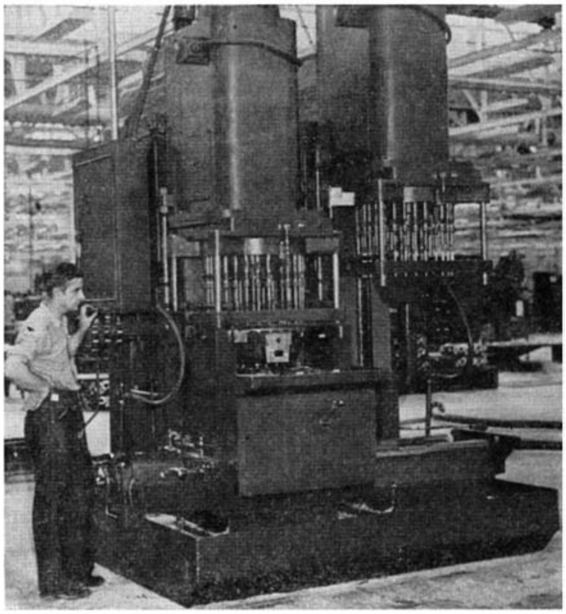


Figure 3: Duplex hydraulic feed Baker drill putting 38 holes in the crankcase nose section of a Cyclone

SYNTHETIC SKILLS—Just because multiple operation combined with a minimum of skill was the goal, worker training was not neglected; indeed, it was very effective. Many thousands of men and women were brought into the aircraft industry. In general, the work which the newcomers had to do was different from that which they had done before the work tolerances required had become generally smaller, the finishes better, the care in handling greater, and the inspection methods more complex and more exacting. Nevertheless, it was proved that a training program could be devised whereby unskilled men and women could become, in a relatively short time, members in good standing of a team producing the best aircraft engines in the world.

These workers, with specially designed multiple-operation equipment, achieved greater production speed, greater precision, few mistakes, and fewer rejections than at first thought possible. Not only that, but it was shown that, relieved of its physical exertion, women actually liked machine-tool operations better than men.

When the details of machines and processes are considered, there is an embarrassment of riches. It is impossible to describe more than a fraction of the many and remarkable tools and methods, selecting a few striking examples, with the assurance that many others, almost as striking, remain unrevealed.

Perhaps the best plan is to concentrate attention on the production of a few representative parts of the famous Wright Cyclone. All comparisons of savings in time and man-power are based, incidentally, on a monthly production of 1000 engines, using a 720-hour month with 20 percent allowance for contingencies, scrap, and set-up.

Of course, no Cyclone would be complete without its supercharger, and the manufacture of the supercharger front section serves to illustrate very well some of the points of this article.

Thus, Figure 1 shows automatic conveyors carrying supercharger sections and other parts through the initial paint spray booths for the priming coat and into the baking ovens. Without any additional handling, the parts then pass through two finishing paint booths and

AND SAVED MONEY—Surely, Figure 3 is another convincing proof of the marvels of modern automatic methods. The duplex hydraulic feed Baker drill is used for drilling 38 holes in the hub and flange of the crankcase nose section. When this operation has been completed, the drill table carrying the part is traversed by power into position under the second head where the holes are reamed. The one machine cost $15,000 *less* than three radial drills, and saves 67,414 production hours a day.

Perhaps one of the most remarkable developments of all is in a huge Greenlee automatic transfer machine which drills, reams, counter-sinks and taps all the holes in a Cyclone cylinder head at the rate of one part every 50 seconds. A conveyor at the rear carries the completed parts to the final operations. The manufacture of the Cyclone

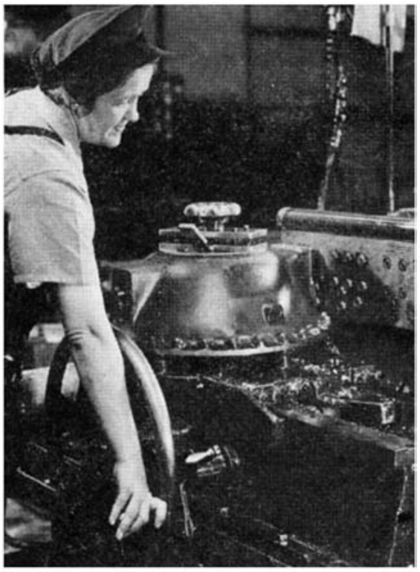


Figure 4: Like it more than men

cylinder head necessitates the performance of a large number of comparatively short operations but, because of the many different angles, the employment of individual jigs and standard tools was the logical procedure. Loading and handling consumed a greater amount of time than the actual machine operations, and this particular part, therefore, offered unusual opportunities for savings through the application of continuous automatic equipment. Experimental work with special multi-spindle machines demonstrated the possibility of retaining the desired accuracy. The development of the transfer machine was responsible for a saving of 3768 square feet, also of 15 handling operations, 99 men, and 789.7 production hours a day, *plus* a saving in cost of equipment of $6234.

In Figure 4 Edna Boehmer, a woman evidently at ease in her work, is operating a special horizontal Baker drill equipped with manual index and hydraulic feed. The 15 holes in the governor pad of the nose section are drilled, reamed, and counter-sunk, all in one set-up. On the basis of the 1000 monthly engine production, the Baker drill saved, as compared with the standard radial drill, 12 square feet of floor space, two men, and 19.34 production hours per man. Cost of the machine was $1000 more.

LESSONS FOR ALL—There are many lessons to be learned by American industry, and even by the nation as a whole, from this stupendous effort.

Other industries can profit by the experience of Wright Aeronautical. The huge micromatics and other tools developed during the war will serve builders of Diesels, of tanks, of steel rolling mills, of gear manufacturers, of sugar machinery. And even the automobile industry could learn a good deal from this work.

All industry can take this lesson to heart. When seeking to increase production or reduce costs, the solution is not necessarily merely to have more rows of machine tools, more hands at work. The path may be, rather, toward greater skill in the design of the machine-tool equipment, in multiple-operation tools, in more automaticity.

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PROPELLER TESTING

Carried On in Huge Laboratory

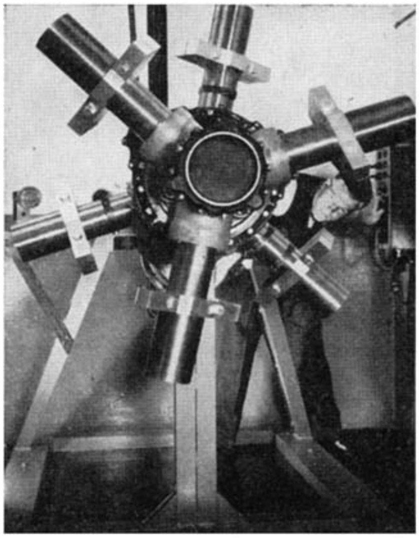
A GIGANTIC propeller laboratory, in which it will be possible to test airscrews up to 30 feet in diameter and air-cooled and liquid-cooled engines of more than 5000 horsepower, has just been completed by the Propeller Division of the Curtiss-Wright Corporation. These dimensions and powers are a little ahead of the practice of today, but they are certain to be attained within a very few years.

There are three characteristics of the propeller, in addition to efficiency and low or moderate weight, which must be determined before it is acceptable—safety, durability, and serviceability. The test cells in the new laboratory will give full information about all three.

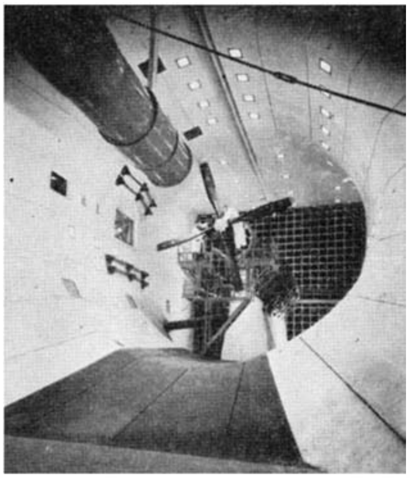
The cells are 38 feet square, with honeycombs and other devices to provide uniform air flow. As shown in one of our photographs, a 48-inch jet tube in the upper foreground slides forward to cool the air-cooled engines in operation. In the upper background may be seen the window of the control compartment from which all tests are directed. The tunnel in which the tests are made involves a huge Venturi tube, which is 31 feet in diameter at its narrowest point.

Since control of the engine is an essential part of the propeller tests, engine and propeller are tested simultaneously, and on the instrument panels in the control room all engine and propeller reactions can be charted.

Aircraft people can perhaps say with pride that they have taught other industries the art of large scale industrial research, no matter how complex or expensive. One line of investigation in particular has been pushed to the limit in aviation—the investigation of vibration and of structural endurance. Thus in one test of propeller blade stubs counterweights are used to simulate the twisting moment ordinarily exerted upon the power unit by the electric propellers while in actual operation. With these counterweights doing their utmost, the propellers are subjected to well beyond their maximum capacity for hours at a time.



Counterweights on propeller stubs simulate twisting moment under test



Looking down propeller test cell, with cooling tube at the upper left

BRITISH COMPETITION

Should Serve to Stimulate American Aviation

PARTICULARLY in aviation is there discussion of what British competition after the war will mean to the United States. It seems probable that British competition will be the best possible stimulus to American aviation. Competition from our British friends should be welcomed. In the matter of cargo and transport design they are at present handicapped because, while United States airlines are in full swing and carrying goods to the far corners of the earth, British airlines—for obvious reasons—have mostly suspended operations.

Nevertheless, the British are not asleep and quite recently the Air Secretary, Sir Archibald Sinclair, has announced that seven types of British air transports are now being considered or designed. These include transatlantic land planes, one of them of over 100,000 pounds with a pressurized cabin.

Here, perhaps, is a lesson for American aviation. Fying boats are costlier to operate than land planes of the same size, and their price of daily utilization is less. Perhaps airlines of the United States should also use land planes across the Atlantic.

This revival of British interest in commercial aircraft should be welcomed. Friendly rivalry between America and Britain should always remain friendly rivalry and remarks to the contrary may be considered as propaganda.

Electronic Controls

Second-by-Second Measurements of Gas Content of Air; Constant Supervision of Rate of Flow of Liquid in a Pipeline; and Control of a Specialized Distillation System are Only Three Examples of the Possibilities of Electronic Control in Everyday Industrial Operations

By VIN ZELUFF
Assistant Editor, *Electronics*

MANY industries are concerned with the problem of controlling liquids or gases that are products or by-products of the manufacturing processes. Often these materials are inaccessible to the usual methods of measurement or control because they are confined in pipes or containers, are poisonous to personnel, or are vulnerable to impurities or adulteration. For solving such difficulties, electronic devices are particularly well suited since they can be adapted to fit the special conditions required.

Elaborate air-conditioning systems, special suction hoods, and so on, are employed in many manufacturing plants to draw off vapors and gases that force workers to wear gas masks during certain operations. In spite of these precautions, it is usually necessary to make periodic checks of the air in various parts of the plant to determine whether the concentrations of the volatile substance is being held within the safety level.

Most gas analyzers require 15 minutes or more to take an air sample, and show only the average concentration of the gas during that period of time. With this technique, momentary high peaks escape observation. An electronic instrument recently developed at E. I. du Pont de Nemours can run continuous samples, however, and give direct and instantaneous readings. This permits accurate second-by-second observation of the vapor level in each step of a manufacturing process.

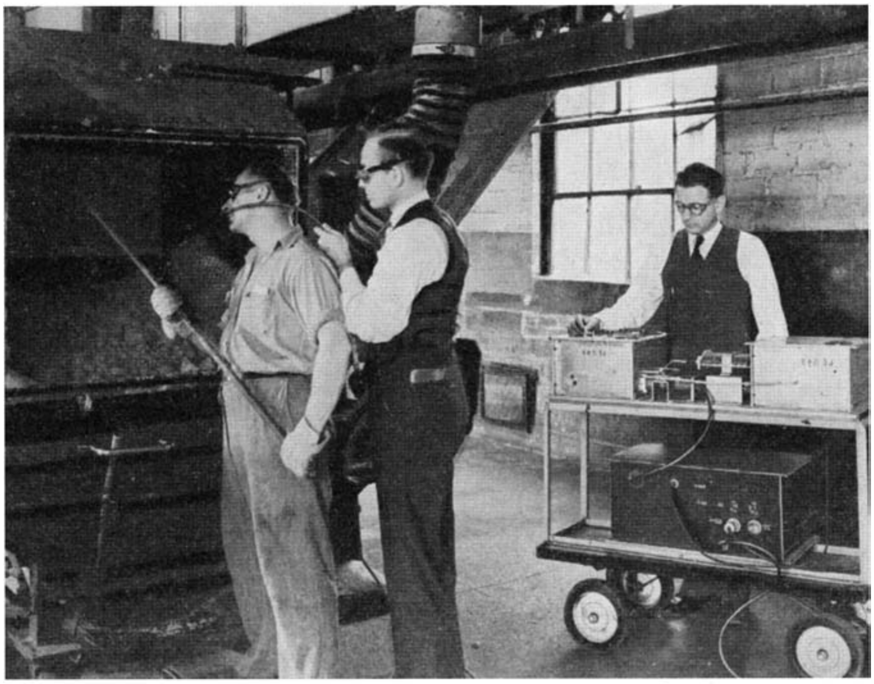
The new electronic gas analyzer, called an ultra-violet photometer, is based on the phenomenon of light absorption by gases. Most gases absorb light of some particular wavelength, in effect casting a shadow where that particular wavelength line would otherwise have fallen. In a spectrum, that shadow is known as an absorption line. Carbon disulfide, for example, strongly absorbs light having a wavelength of 3132 Angstrom units, in the ultra-violet range.

The instrument is so constructed that the air to be analyzed is pumped through several small chambers which filter out dust, oil, and moisture, and thence into a pair of parallel tubes, about 31 inches long. The contaminated air runs into the first tube and then through a canister of activated charcoal which removes carbon disulfide, passing purified air into the second tube. This permits a continuous comparison of the purified with the contaminated air and very minute differences may be detected.

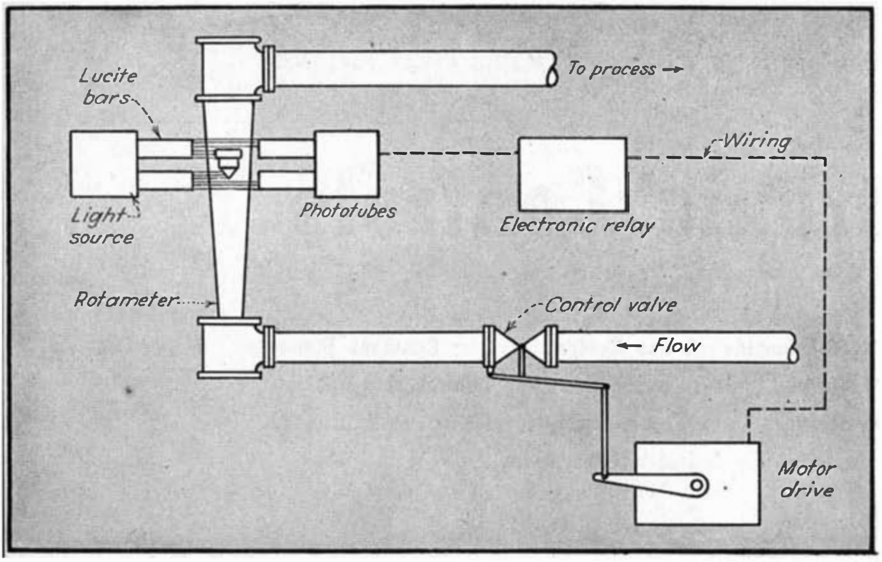
Rays of ultra-violet light from a mercury lamp pass through the two tubes and fall upon a sodium phototube mounted at the opposite end of each tube. A vacuum-tube amplifier follows the phototubes and actuates a micro-ammeter for readings.

Filters in the optical system have been so selected that about 60 percent of the photometric response of the phototube is due to light of 3132 Angstrom units in wavelength, the light which carbon disulfide absorbs. No other atmospheric element has been found in plants where this instrument is used that absorbs either this band of light or the 3650 Angstrom unit band which accounts for most of the remainder of the phototube's response. One part of carbon disulfide in a million parts of air will produce an absorption of 0.02 percent.

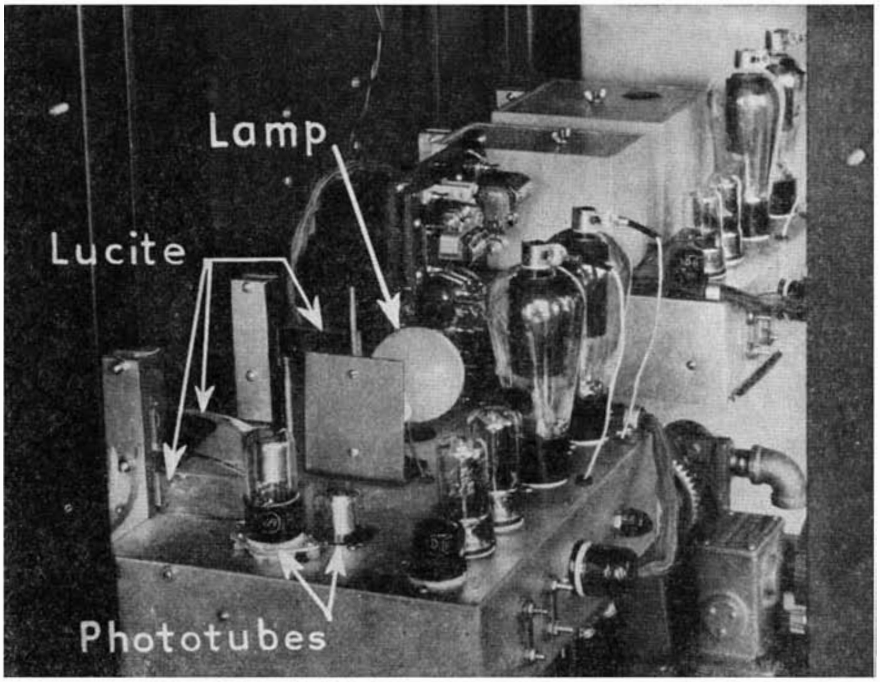
TESTS IN SECONDS—In one test, 61 readings were made during the nine minutes required to open, dump, and clean out a large vessel in which material was treated with carbon disulfide. During most of the operation, the concentration of gas remained below 20



Engineers in the Du Pont plant are shown here using the new electronic gas analyzer to check the efficiency of a hood system used to draw off fumes during a production process. The intake of the analyzer is held at operator's nose level

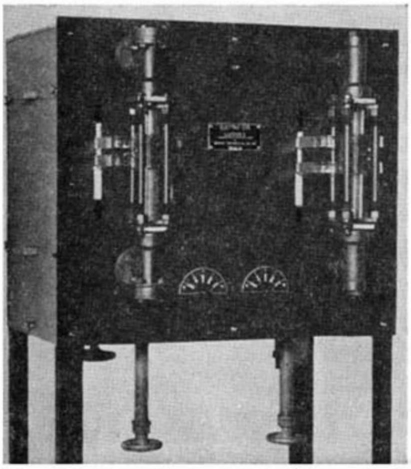


Above: Block diagram of phototube control system for fluid flow. The valve is opened or closed by the electric motor which in turn is controlled by the relay and phototubes



Right: Close-up of the interior of the electronic flow control unit. Plastic bars transmit light from the lamp through the panel and through the rotameter glass, then back through the panel to the phototubes

Below: The complete electronic flow control unit. Note the plastic light-transmission bars projecting through the slots in the face of the panel



parts per million. Here older methods of analysis, which could give only the average for this entire time interval, would have shown no danger points. However, the ultra-violet photometer revealed that the concentration rose to 50 parts per million at one moment and to 40 at another. The ventilating equipment was therefore modified in order to eliminate these peaks.

For many years there has been a demand for automatic control to be applied to the rotameters used to indicate the rate of flow of liquid or gas in a pipe line, so that changes would cause a motor to open or close a valve and thereby correct the flow rate. Brooke Engineering Company recently developed a control for this type of meter for a large refinery that had a process in which they wished to maintain the flow rate of a fluid to within ¼ percent of a predetermined value. It was decided to use an electronic relay, receiving its signals from phototubes positioned near the rotameter. This instrument consists of a vertical, transparent, tapered glass tube and a float-type metering element inserted inside the tube. The small end of the tube is at the bottom, and the float (also called the rotor) is free to move up or down along the axis of the tube. The position assumed by the float directly indicates flow rate. The gas or liquid being metered flows from the bottom to the top of the tube. The forces on the float are in balance; weight of the float minus buoyancy equals the area of the top of the float times differential pressure. If the flow rate increases, the differential across the float will increase, and the float will rise to a new position to maintain a fixed differential pressure across it. Rate of flow is thus accurately indicated by the position of the float.

For the rotameter application, it was decided to use two light beams, one shining across the top of the float, and the other across the bottom of the float. Each light beam was applied to a phototube, and the outputs of the phototube amplifiers were electrically balanced against each other to cancel out the effects of voltage changes and color deviation of the liquid.

If the float in the rotameter moved due to a change in flow, one phototube received more light and the other less light. This unbalance caused a thyratron tube to operate a motor which changed a control valve in the correct direction to restore the float to the set value.

The rotameter is mounted on a stand in front of a panel, and the electronic relay, with its light source common to both beams, and its phototubes, amplifiers, thyratrons, and allied equipment, is mounted behind the panel. Lucite or Plexiglas bars are used to transmit light to the rotameter and to the phototubes. The electronic relay is mounted on an elevator assembly which permits the operator to raise or lower the entire assembly to change the rotameter control setting which determines the flow rate.

Another feature that may be included in the electrical circuit provides for automatic shut-down if any of the fluids in the process cease flowing or go beyond predetermined values, or if tubes or light source fail.

A lock-in circuit is employed to return the float within the range of the light beam if the characteristics of flow are such that an occasional surge in the fluid will raise or lower the float out of the light beam. Essentially, it consists of electromagnetic relays which are actuated by the phototube amplifiers just before the float leaves the light beam. The lock-in feature discerns which way the float moved and operates the motor at full speed to return the float to the light beams where the thyratron can come into operation.

The light source is a 120-volt bulb directed through two pieces of Lucite or Plexiglas to form two light beams shining across the rotameter. They are spaced so that when the float is in balance, one half of each light beam is blocked out and the other half of the beam passes through the fluid and metering tube to other bars of Lucite, and thence to the phototubes.

Circuit values are so chosen that if the float moves at a great distance, the motor will run at full speed without interruptions. As the float approaches neutral, the motor begins to step (stop and start) at a rate proportional to the distance from neutral.

Thus the motor always has full torque, regardless of how close the float is to balance. This is important for sensitive controls—otherwise, should the valve stick, the torque delivered by the motor near the neutral point would be insufficient to restore the float to the original balance point.

Successful field operation of 64 of these units for several months has shown that an extremely accurate control can be applied to devices where it is necessary to maintain a movable body in a fixed position.

Electronic control of liquids has another new industrial application, wherein a system of stills for producing pure water is operated automatically, with heat being turned on and more water added as demanded by laboratory requirements.

ONE PART IN A MILLION—With some of the materials used in the field of electronics, such as phosphors, electron-emitting coatings, and photosensitive surfaces, the presence of one part in a million of a given impurity may alter some specific property by several orders of magnitude. Since water is used in large quantities for almost all chemical manipulations, it is essential that a sufficient supply of very pure water be available for manufacturing processes involving these materials. Three distillations will serve to produce water suitable for most uses.

In RCA Laboratories, an industrial requirement of approximately 10 gallons per day of double-distilled water and five gallons per day of triple-distilled water made it desirable that some sort of continuous system be employed which would operate with very little attention. Here the primary distillation takes place in a conventional commercial still which feeds its product into a large glass-lined storage tank. From there the water is fed by gravity to the second stage of distillation. The second and third distillations are carried out in all-Pyrex stills, completely protected against airborne dust.

The problem involved automatic control of electric heater current and control of the water level in the glass boiling flasks. Two platinum probe wires were sealed into the system at the desired minimum water level, and connected to an electronic relay sensitive enough to respond to the extremely small current that flowed between the probes through the water. When the water level drops below the probes, the electronic relay then operates an ordinary electromagnetic switch controlling the electric heater current for the boiling flasks, and at the same time operates an electromagnetic valve located in the waterfeed pipe.

An electromagnetic valve of the vertical-lift type, utilizing a spherical ground-glass joint as seat and plunger, proved satisfactory. A soft-iron laminated core is completely sealed in a glass tube that extends into the center of a surrounding solenoid. Energization of the solenoid lifts the plunger, permitting water to flow without contamination by metal at the valve. When no current is flowing through the solenoid the weight of the core is sufficient to close the valve.

The electronic relay has been in operation without a single failure for nearly one year. No adjustments beyond those made during the original installation have been required.

FLUOROSCOPY

Speeds X-Ray Examination of Many Products

In the post-war world, the Government will not require x-ray inspection of airplane castings, tank welds, armor plate, and so on, although there may be safety regulations calling for x-ray inspection of parts of airplanes used as public carriers.

Many industrial x-ray users who started using the equipment because of government requirements will continue to use x-rays to improve quality, reduce costs, and save labor. One contribution to industrial x-ray expansion is the improvement of presently available types of x-ray machines and the creation of new machines and accessory devices. Progress thus far has been much greater along the lines of straight radiography than fluoroscopy, but nevertheless the fluoroscope has been used to spot the presence of foreign bodies in packaged products. One large manufacturer of chewing tobacco experienced labor troubles and when the strikers left their jobs they tossed nails, hairpins, and other articles into the pile of unpackaged tobacco. That tobacco company now has a fluoroscope and a girl observes and checks every package.

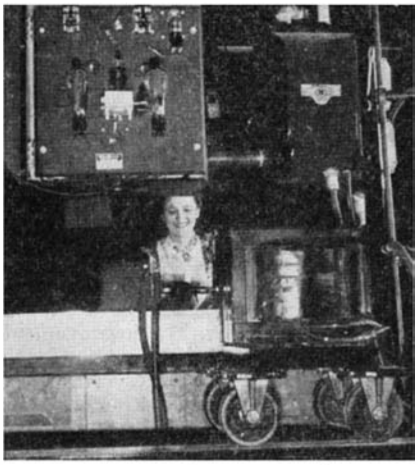
Fluoroscopic inspection allows instant separation of the good from the bad —no film, no dark room, no delay, yet complete inspection beneath the surface of a product.

FLAW FINDING

Made Less Expensive by Electronic Current Source

Bolts and other parts made of magnetic material are being inspected by an electromagnetic method at the Buffalo plant of Curtiss-Wright Corporation, using electronic equipment as the power source. This method shows up flaws and cracks and can handle part sizes ranging from small bolts to reasonably large castings.

When electric current is passed through a magnetic substance, a north and south pole are produced at each crack in the material. When finely divided iron oxide in solution is poured over the material, the oxide particles adhere at the cracks and make them readily visible. The importance of such electromagnetic inspection operations in the production of aircraft has long been considered a vital necessity as a safety measure.



Electronic tubes control flaw-finding current. Transformer at right is moved to different positions as required by the process operator

This method of inspection required a large amount of current from storage batteries. Maintenance costs on battery equipment were approximately $3000 yearly. To replace the batteries, the electronic equipment shown in the photograph provides a source of power which is constant, day in and day out, at a fixed amperage. By the use of thyratron and ignitron tubes a current impulse of 40,000 amperes is available, which provides deeper penetration and greater concentration of the iron-oxide particles. The estimated yearly maintenance costs of the electronic equipment is $50, principally for replacement of vacuum tubes.

LEAKERS SPOTTED

By X-Rays in Cathode Tube Plant

Before precious man-hours and material have been expended on final assembly, routine x-ray examination with a Picker 150,000-volt industrial unit is used in one cathode-ray tube plant to detect porosity, faulty welds, and other internal weaknesses that would affect performance of the tubes. When the trouble is found before final assembly and sealing of these costly tubes, it can often be corrected by simple application of heat, thereby salvaging many essential tubes. The "leakers" that would allow air to get into the tube after evacuation are generally found to have flaws at the terminal caps at which connecting wires pass directly through the glass walls.

Why Engines Knock

Fuel Knocking Can Threaten Destruction to Engines. Technologists Are Familiar With Some of the Answers to the Problems Involved, But Many More Data Are Required. New Research with a Full-Scale Engine Test Stand Is Pointing the Way Toward Better Fuels for All Gasoline Engines

By DR. W. J. SWEENEY
Associate Director, Esso Laboratories,
Standard Oil Development Company

THE CHIEF limiting factor in aviation fuel performance today is the familiar tendency of most petroleum hydrocarbons to knock under increased power conditions, and thus to threaten destruction of the very engines they operate. For this reason there is need for considerably more full-scale engine test data to guide our further improvement of fuel quality. The improvement may come through better knowledge of the anti-knock qualities of various individual hydrocarbons. This in itself is a complicated problem because there are possibly millions of different hydrocarbons present in petroleum. Alternately, the improvement may come through better engine design to meet knock conditions. In any case, the measure of this improvement must be made by closer reference to actual test data, obtained in representative aircraft engines.

To perform its function, the aircraft engine must produce the maximum amount of power, consume the lowest possible amount of fuel, and weigh as little as is consistent with the strength it must have to withstand the terrific stresses imposed upon it. Unfortunately, these things are to a considerable degree contradictory: for example, the power output of the engine when operating at its best economy (on the lowest weight, or quantity, of fuel) may be limited by knocking. To obtain maximum power, it is necessary to take steps to avoid this knocking. This is done by enriching the mixture —feeding to the engine a larger proportion of fuel to air than it theoretically needs to produce that power.

Before looking into the reasons why this is so, let us first see what knocking is. In Figure 1, top, is shown a tube of fuel-air mixture, ignited at one end by a spark plug. The following sequence of events occurs:

(1) Ignition of the mixture by the spark plug.

(2) Relatively slow burning of the mixture, progressing away from the spark plug.

(3) Rapid increase in pressure and temperature of the unburned portion of the mixture ahead of the flame front until a condition is reached which makes that unburned mixture explode violently or detonate (bottom of drawing).

(4) Pressure waves set up within the cylinder, resulting in knock; rapid scrubbing of walls by vibrating gas, rise in temperature of walls, loss in engine power, and eventual destruction of parts.

If fuels did not vary in anti-knock quality or tendency to knock, they could all be evaluated reasonably by one characteristic—the number of heat units (Btu) per pound. However, knock is a very bad actor. It limits economy (range of operation) and it limits power (performance).

Modern aircraft fuels are miracles of high anti-knock quality. They have permitted engines to be built capable of developing power outputs undreamed of only a short time ago. This great team of engine and fuel powers our fighting aircraft today. Nevertheless, these engines must still employ rich, relatively uneconomical mixtures in order to develop maximum power for take-off, climb, and high speed, yet during normal cruising operation to function on lean, economical mixtures.

Table A
ACTUAL VS. THEORETICAL ENGINE (7 to 1 COMPRESSION RATIO)

	ACTUAL		THEORETICAL	
Total heat in fuel, Btu/lb.		19,000		19,000
Heat lost to exhaust, Btu	6,500		8,500	
Heat lost in cylinder cooling, Btu	6,000		0	
Total heat lost, Btu		12,500		8,500
Usable heat: available to prod. work		6,500		10,500
Thermal Efficiency $\left(\frac{\text{Usable heat}}{\text{Total heat}}\right)$	34%		55%	
Theoretical pounds of fuel per brake horsepower hour (no heat losses)	(0.134)		(0.134)	
Actual pounds of fuel per brake horsepower hour at stated efficiency	0.394		0.244	

EMPHASIS ON AIR—An aircraft engine is a device for converting heat energy into mechanical energy or useful work. Its working fluid—that is, the expanding gases which perform work—is the nitrogen from air plus the products of combustion. These combustion products are the gases carbon dioxide, carbon monoxide, water vapor, and hydrogen, in varying proportions depending on the conditions of burning in the cylinders. It is a fact not generally appreciated that the power output of a gasoline engine is more nearly proportional to the amount of air (or oxygen in the air) burned than to the amount of gasoline consumed. This should be kept in mind. It is the reason why aircraft engines are supercharged or "boosted" to increase manifold pressure for take-off and for operation at high altitudes.

If the thermal efficiency of an actual engine is compared with that of a theoretical engine it is found that the actual engine is naturally much less efficient than the theoretical engine, since it has mechanically operated valves which require time to open and close, thus permitting dilution of the fuel charge with exhaust gases, and because the mixture will not burn instantaneously after ignition. Moreover, it is impossible in an actual engine to prevent heat loss from the gas to the walls, and the temperature that the

Table B

100 percent of Theoretical Fuel (Cruise or maximum economy lean mixture, fuel/air ratio = 0.067)

$$1\ CH_2 + 1.5\ O_2 \rightarrow CO_2 + H_2O$$

Heat evolved = 19,000 Btu/lb. fuel
or 1,270 Btu/lb. air

150 percent of Theoretical Fuel (Take-off or full-power rich mixture, fuel/air ratio = 0.10)

$$1.5\ CH_2 + 1.5\ O_2 \rightarrow 0.53\ CO_2 + 0.97\ H_2O + 0.97\ CO + 0.53\ H_2$$

Heat evolved = 10,900 Btu/lb. fuel
or 1,090 Btu/lb. air

metal parts of the engine can stand are limited. Therefore heat must be removed in order to keep temperatures of cylinders and pistons within safe limits. Heat likewise is removed by the lubricating oil. All this means fins for cooling cylinders and lubricating oil, which place an added drag on the airplane; special metals to withstand high temperatures; engine lubricants to function under these severe conditions, and many other problems which the designer, the metallurgist, and the oil refiner must solve.

Roughly, the total heat in a pound of fuel is divided as shown in Table A. This, however, applies only to operation with the theoretically correct ratio of fuel to air—typified in practice by cruising conditions at low power

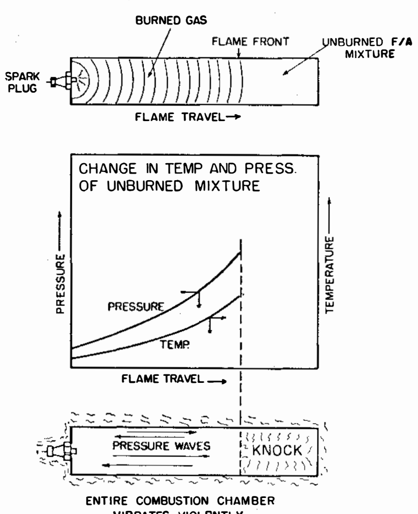


Figure 1: How knocking occurs

output. For high power output, as at take-off, an engine designed to give maximum fuel economy at cruising conditions must run with a rich mixture—a higher ratio fuel to air; for otherwise it would knock, overheat, and quickly be destroyed.

The simple chemical equations in Table B show why rich mixtures produce less heat, hence less knock. They show the relative volumes of gases produced and the relative quantities of heat evolved when a given volume of oxygen in the air combines with or burns a hydrocarbon in lean mixture and in rich mixture, respectively.

These considerations show that, with rich mixtures, the heat evolved per pound of fuel or per pound of air is reduced. This produces less temperature rise in the cylinders, and less tendency to knock. This permits an increase in air supplied to the engine by means of added boost or supercharging, and added fuel, and this in turn permits greater power outputs before knocking again occurs.

Although all fuels will knock less in rich mixtures than at the theoretically correct fuel/air ratio, some are better than others in this respect.

Table C shows what this means in terms of power output and fuel consumption in an aircraft engine of 2000 rated brake horsepower: Here it is seen that fuel consumptions at cruise, rated continuous, and take-off are 0.40, 0.525, and 0.67 pounds per B.H.P. hour and corresponding thermal efficiencies 34, 26, and 20 percent. For the increase of 600 horsepower to bring the engine to rated continuous power, fuel consumption is at the rate of 0.82 pounds per B.H.P. hour, and thermal efficiency is reduced to 16 percent. Fuel consumption for the increase from rated 2000 to 2400 take-off horsepower jumps to 1.38 pounds per B.H.P. hour, and thermal efficiency for the same range drops to 10 percent. Full power, rich-mixture operation is expensive.

POSSIBLE IMPROVEMENTS—This indicates where improvements in fuel quality can, in the future, help reduce airplane operating costs or improve performance. There are a number of ways that these benefits might be effected:

(1) Same cruise quality but better rich mixture quality, so that same power as at present could be obtained with less enrichment. Result: better economy.

(2) Same cruise quality but better rich mixture quality, so that greater power could be obtained with same enrichment as at present. Result: better performance. (Such performance helped win the Battle of Britain.)

(3) Better cruise quality and same rich mixture quality. Result: greater range of operation. (This fuel may help with the Battle of the Pacific.)

(4) Better cruise quality and better rich mixture quality. Result: greater range and better performance. (Such a fuel would be an improvement over (3) and would be even more valuable in the Japanese conflict.)

Figure 2 shows how knock affects economy or range of operation of an aircraft. The higher the compression ratio—and accordingly the higher the temperature—the better will be the resulting economy for a given power output. Neglecting mechanical considerations, the tendency of a fuel to knock limits the compression ratio with which it can be used, and hence

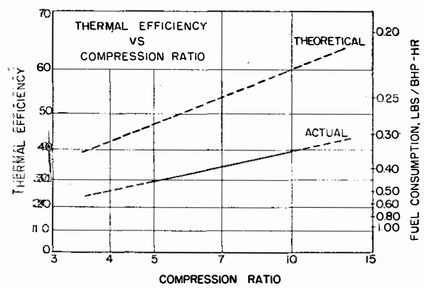


Figure 2: Knocking and economy

the economy or range that can be attained.

Figure 3 presents three schematic indicator cards showing the increased cylinder pressures, and hence greater powers, which are obtainable without knocking when richer mixtures are used. (For simplicity the power increase that is gained in practice by increasing speed has been neglected.) Three work areas are shown. These roughly represent the three conditions listed in Table C. In each case the limit of permissible power is due to knock; but different fuels will show different rates of change in permissible power with rate of change in the ratio between fuel and air.

The adjustments necessary to handle these changes in fuel/air ratio are complicated and to relieve the pilot the carburetor is designed to take care of them automatically. There are two

Table C

	CRUISE	RATED CONTINUOUS	TAKE-OFF
Horsepower delivered	1,400	2,000	2,400
Lbs. fuel consumed per hr.	560	1,050	1,600
Gallons fuel consumed per hr. (assuming 6 lbs. per gallon)	94	175	266
Fuel/Air Ratio	0.07	0.085	0.10
Total heat in fuel, Btu (assuming 19,000 Btu per lb.)	10,600,000	20,000,000	30,400,000
Heat to produce power, Btu	3,600,000	5,100,000	6,100,000
Heat lost, Btu (difference)	7,000,000	14,900,000	24,300,000
Fuel consumption rate, overall lb. per B.H.P. hr.	0.40	0.525	0.67
Thermal efficiency, overall	34 percent	26 percent	20 percent
Pounds of fuels per B.H.P. hr. (incremental)	———	.82	1.38
Thermal efficiency (incremental)	———	16 percent	10 percent

settings, "automatic lean" and "automatic rich," determined by experience, and the pilot has the choice of either to obtain economy or power as required. With these settings the carburetor automatically supplies enough fuel, based on the quantity of air passing through its throat, to prevent knock under any normal conditions when running on the proper fuel. In certain large long-range aircraft, however, the flight engineer may over-ride the controls manually and approach incipient knock as closely as he dares, in order to obtain maximum economy and hence greatest range.

A comparison of fuel quality on a lean-mixture performance and a rich-mixture performance basis is admittedly an over-simplification of the knock problem because other variables enter into the picture—such as compression ratio, spark advance, cylinder cooling, mixture temperature, speed, hot spots, and so on. Nevertheless, the wide differences in fuel quality under different operating conditions can readily be shown by such a comparison.

There are millions of possible hydrocarbons and the number present in petroleum is probably in the hundreds of thousands. Within the gasoline boiling range alone the number possible is around 5000. Of these, however, only a few dozen are known to be of superior anti-knock quality. Table D gives a comparison of relative knock quality of some of these hydrocarbons with pre-war commercial fuels (the completely arbitrary scale used is not to be confused with octane number).

These ratings are not necessarily true quality measurements, but do serve to indicate the wide variations in fuel performance that can be obtained by varying engine operating conditions. The great differences in the lean mixture and rich mixture ratings of some of these fuels show that it is extremely important that the tests used to evaluate the fuels determine their quality in actual flight.

TWO INTERESTING THINGS—The data in Table D show two things which are of particular interest:

(1) Existence of hydrocarbons that, with both lean and rich mixtures, exceed old-style 100 octane gasoline in anti-knock quality.

(2) The extremely great rate of change in anti-knock quality, in many cases, between lean mixture and rich mixture. Should the latter degree of severity more nearly represent average flight performance than the former, the actual relative performance would in some cases be the opposite from that derived from data based on lean mixture ratings.

Assuming that between the two extremes lie the actual knocking conditions experienced in flight, it is obviously important to know just where incipient knock is reached under different flight conditions and in different engines.

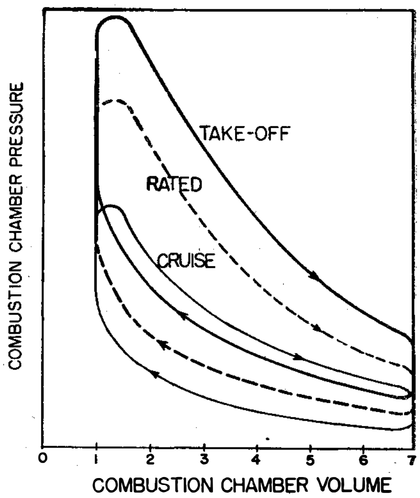


Figure 3: Richness and power

To redesign engines and aircraft to take full advantage of fuel improvements is no easy task. One phase of the job is to prove by adequate full-scale engine tests that the fuel has the added quality, to what extent and under what conditions of operation. Another is to determine what changes in superchargers, carburetors, ignition systems, coolers, and so on, must be made to get the most from the new fuel-new engine combination. The fuel and the engine are, in a sense, like the hen and egg—which comes first?

The engine manufacturer cannot build his engine in production quantities until the fuel it needs is commercially available. The refiner cannot build the equipment for making the fuel without knowing what its composition must be to meet the needs of the engine. The fuel designer in his laboratories must arrive at this composition on the basis of practical tests. To meet this need—the very foundation of fuel and engine improvement—Standard Oil Development Company has built a half-million-dollar full-scale multicylinder engine test stand.

It is quite impossible to do all fuel test work on engines in flight, for several good reasons. For example, flight conditions of air temperature to carburetor and air temperature to cooling fins cannot be reproduced from day to day. Also, it is desirable in rating fuels to approach knocking conditions—thereby occasionally developing true knock, a most dangerous condition in flight. While a good bit of flight data is absolutely necessary, it is generally desirable to obtain the background data on full-scale laboratory engines and then to check special points by flight tests. It is for such evaluations of presently available commercial blending agents and of promising experimental products that the new full-scale test stand has been built.

By present standards, petroleum as found in nature provides very poor aviation fuels. Broken down and synthesized, however, it gives exceedingly good fuels. As it will be produced in the future, petroleum gives promise of even greater improvements in anti-knock quality. Even now—in the midst of war—much can be done to improve fuel quality by selection of available product and modification of existing plants. Such improvements are the immediate aim of all of us operating the test stand; so that, no matter how long the war, the Armed Forces will have available the best possible fuels compatible with the huge amounts required.

⊕ ⊕ ⊕

Table D

COMPARISON IN ANTI-KNOCK QUALITY OF PURE HYDROCARBONS AND PRE-WAR COMMERCIAL FUELS

(All with same lead content except where indicated)

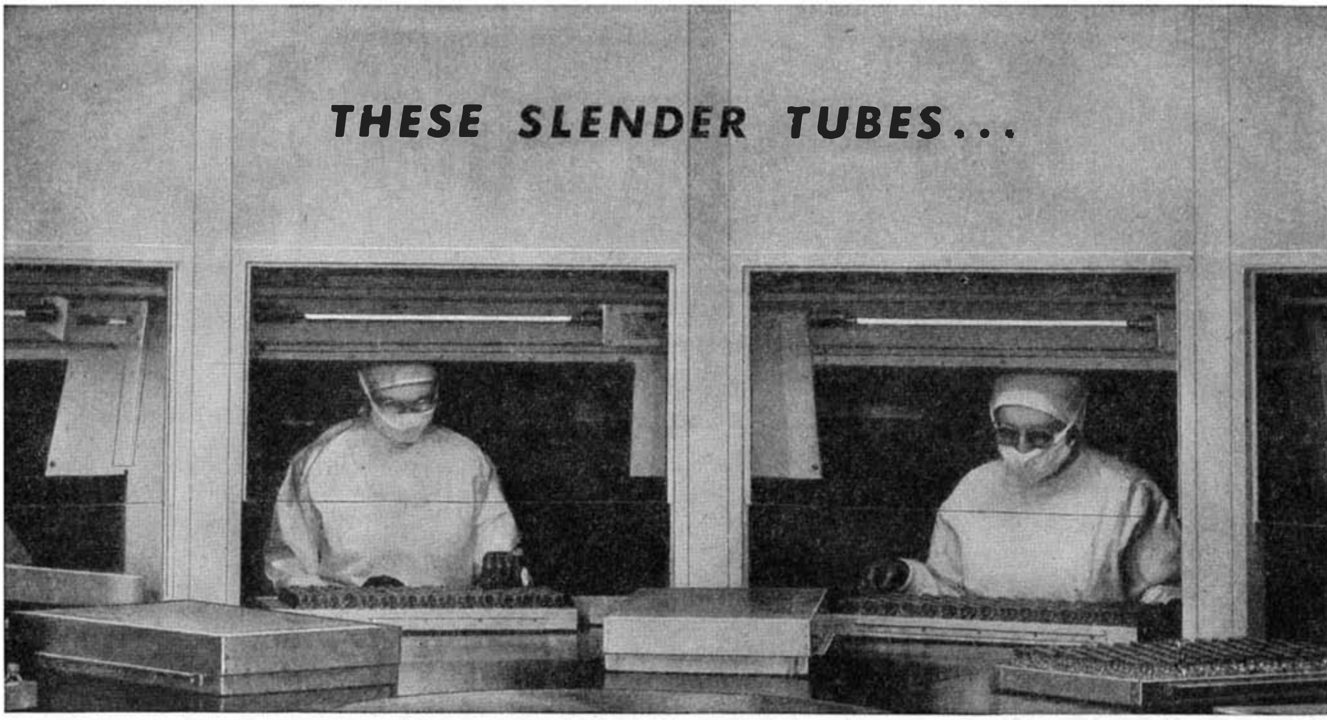
HYDROCARBON	LEAN MIXTURE	RICH MIXTURE	DIFFERENCE
A	77	100	+23
B	70	93	+23
C	57	99	+42
D	54	76	+22
E	47	49	+ 2
"100 Octane" (1938)	42	52	+10
F	42	46	+ 4
G	42	40	—2
H	31	34	+ 3
"91 Octane" (1938)	28	37	+ 9
I	21	19	—2
J	21	15	—6
K	14	14	0
"73 Octane" (1938) (no lead)	2	9	+ 7

WOOD IN PLANES

Used Because of Its Adaptability

More than 16 types of wood go into the building of the giant Douglas C-54. The woods used range from featherweight rattan to heavy mahogany. Chinese rattan, because of its lightness and flexibility, is used in beading upholstery. Paratroop benches are made from New England ash. Other woods go into assembly jigs, hand-form blocks, trim jigs, check jigs, and pattern work. Balsa is used as a filler in partitions and floor boards.

According to A. O. Schroeder, veteran Douglas woodcraft expert, about 30 percent more wood is used today in aircraft than just a year ago, largely because of metal shortage. "A woodshop will always be essential for the fabrication of planes," comments Schroeder.



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...helped make a miracle come true!

The miracle is the *mass production of penicillin*—the sensational new healing agent that is saving thousands of our fighting men from certain death due to deadly infection.

Two short years ago, penicillin was a laboratory curiosity. Today, it is being produced in *ample quantities* to meet our needs on every battlefront.

The Westinghouse Sterilamp*—*a slender electronic tube that deals sudden death to air-borne bacteria*—played a vital part in this miracle of production.

For Sterilamps are standard equipment in leading biological laboratories—protecting the precious *Penicillium notatum* mold from air-borne contamination that would destroy the curative powers of penicillin.

Thus the Sterilamp—perfected in the Westinghouse Research Laboratories—has scored *another* notable victory over the invisible enemies of mankind.

Westinghouse Sterilamps also stand guard against contamination in bakeries, breweries, wineries, canneries, restaurants, chicken hatcheries, laboratories—wherever air-borne bacteria must be killed or controlled.

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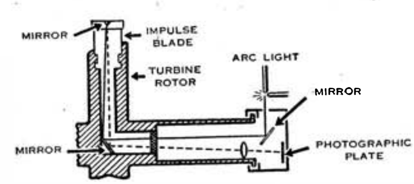
KEEPING UP WITH *Electricity*

USING A LITTLE LIQUID AIR and some warm water, Westinghouse engineers now "manufacture" pocket-sized clouds and snowstorms that would fit into your hat, to help the Westinghouse Research Laboratories speed development of more powerful electrical systems for American warplanes. In a glass flask not much bigger than a milk bottle, artificial clouds and snowflakes are used to test the effectiveness of electrical insulation under conditions encountered by real airplanes at altitudes up to 12 miles.

MIGHTY MIDGET . . . To save precious pounds for extra fuel and ammunition, Westinghouse engineers have developed a 35 kilowatt transformer, for alternating current aircraft systems, which weighs *only 25 pounds*—less than 1/25th the weight of conventional transformers of

similar rating. The secret of this weight-reduction is 400 cycle frequency, forced air cooling and the use of new, thin-gauge Hipersil steel in transformer core.



DONE WITH MIRRORS . . . To find out just what happens inside a steam turbine, Westinghouse research engineers worked out an ingenious system of mirrors—by which they actually photograph minute vibrations in turbine blades whirling at the terrific speed of 350 miles per hour. Result: important improvements in turbine blade design and greater insurance against turbine failure.

Glass In Textiles

Problems of Filament Formation and Lubrication Have Been Solved, and Extensive Experimental Work is Going Forward on Combinations of Glass and Other Fibers. Coated Glass Fabrics Open Entirely New Fields of Application, as Do Also Glass-Plastics Combinations in Laminate Form

By WILLIAM H. PAGE

NON-FLAMMABILITY and resistance to the effects of high temperatures are rare properties in textiles. It was partly due to the need for a textile possessing these properties that glass technicians, more than half a century ago, began to devote serious attention to the attempt to produce glass fibers sufficiently pliable to be woven into fabrics.

As early as 1893, Edward D. Libbey, of the Libbey Glass Company, succeeded in drawing relatively coarse fibers from the heated ends of glass rods. Using the glass fibers as the warp and silk threads as the fill, lampshades were made which were shown at the Columbian Exposition in Chicago. There a celebrated actress saw them and arranged to have a dress made of the same material. Great crowds flocked to see her in her glass dress. Many went away disappointed, for they had come believing the dress would be transparent.

This was not the only disappointment. Because of the presence of the silk, the fabric was not fire-proof, and it was too stiff to be creased or folded. A fabric could not be woven with the glass fibers alone. The result of Mr. Libbey's experiment was spectacular, and it attracted a great deal of attention, but it proved to be of no practical value.

The degree of pliability of glass is governed by the relation between its diameter and its length. This is also true of steel and many other materials. Steel is rigid in a thick, short piece, but heat it and draw it out into a fine wire and it becomes extremely flexible. The same holds for glass, but if glass is to be truly pliable, diameter must be much smaller, in relation to length, than is required in the case of steel.

Another factor that has to be taken into consideration in attempting to weave a glass fabric is that all fibers tend to abrade each other when they are twisted into yarns. Fibers such as wool, cotton, silk, or linen, contain a natural lubricant which minimizes abrasion. But glass contains no such lubricant, and glass tends to cut glass, just as a diamond will cut a diamond.

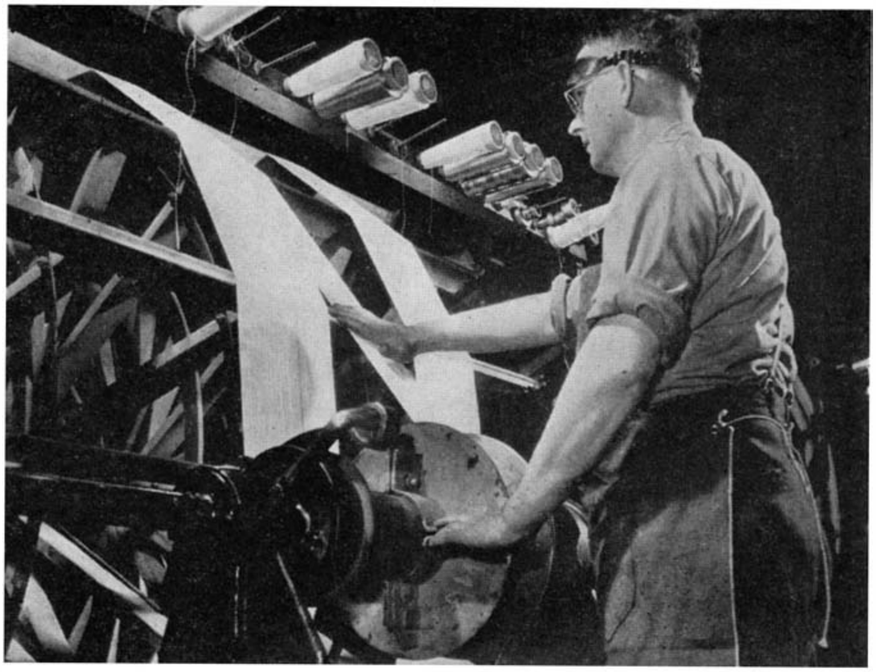
A third factor is expansion of surface area. It is generally assumed that, aside from breakage, glass is practically indestructible. But some glasses are more resistant to surface attacks than others, and the greater the surface area, the greater is the opportunity for these attacks to occur. When a mass of glass is drawn into fine fibers its surface area is increased immensely. The glass fibers must be provided with resistance to weathering, chemical action, and other influences to which they may be exposed.

Years of research and the expenditures of many millions of dollars were required to develop methods for producing glass fibers which would meet these and other requirements. When, in 1936, what is now Owens-Corning Fiberglas Corporation finally succeeded in producing serviceable all-glass fabrics, the methods employed differed radically from the crude process used by Mr. Libbey in his work in 1893.

These 1936 methods, with improvements which have made it possible to produce steadily finer, stronger, and more pliable glass fibers, are basically the same as those now employed to produce all Fiberglas textiles. The raw materials of the glass batch are mixed in accordance with formulas which give the fibers high resistance to surface attacks. Special lubricants, sprayed on the fibers as they are formed, minimize abrasion.

HOW FIBERS ARE FORMED—The fibers are formed either by high-speed drawing, for continuous filaments, or the yanking action of high-pressure steam, for staple fibers. Continuous filament textile fibers are produced by gathering together 100 or more filaments of glass as they emerge from as many tiny holes in the base of a melting chamber, and winding the strand on a winder revolving at high speed. Because the winder revolves much more rapidly than the filaments flow from the melting chamber, the filaments are attenuated to a fraction of the diameter of the holes through which they emerge.

Staple textile fibers are formed by the action of jets of high-pressure steam as they strike thin streams of glass emerging from holes in the melting chamber. The steam literally yanks



Warp yarns of glass being paralleled preparatory to weaving into fabric

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THE VAST new science of RADIONICS is a jealous wife. She demands undivided devotion from him who would share her secrets and master their application. Many of these secrets are still so sensational that they cannot even be made public!

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RADIONICS demands a degree of imagination in engineering and precision manufacture *unknown* in other mass production fields. That's why every Zenith worker has always been, always *will* be, a highly trained specialist in "RADIONICS EXCLUSIVELY."

BEFORE the war, this policy made Zenith one of the largest radio manufacturers in the world... with an unrivaled record of top performance in millions of sets, at lower service expense to owners than any other make!

In the war, "RADIONICS EXCLUSIVELY" has made Zenith Radionic military equipment famous in *every* branch of our armed forces! This has meant a wider, more intensive development by Zenith in High Frequency, the basis for all FM, Television and Short Wave advancements. It is a matter of record that years ago short wave communication was introduced into the U. S. Navy by Zenith!

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YES, your coming new Zenith Radionic Radios, Global Portables and Radio-Phonographs will bring miraculous tone of such clarity, brilliance and beauty as you've *never* heard before! They will combine advanced engineering, precision quality and low cost as *never* combined before!

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RADIONIC PRODUCTS EXCLUSIVELY—
WORLD'S LEADING MANUFACTURER

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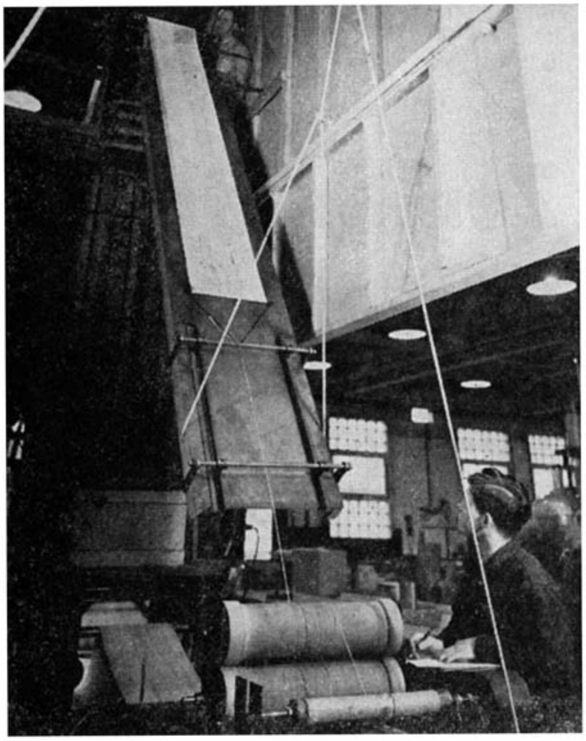

When Fiberglas is to be used as a reinforcement for plastics, the cloth must first be heat-treated to provide the required adhesion between the glass and plastics. Here a strip of the glass fabric is shown emerging from the heat-treatment hot-air tower

the glass into fibers varying in length from 8 to 15 inches. The fibers are driven down onto a revolving drum on which they form a veil resembling a cobweb. The gossamer web of fibers is wound on a tube in the form of a soft strand.

Continuous filament and staple fibers are twisted, plied, and woven on standard textile machinery adapted to handling glass textiles. The fineness and strength of the glass textile fibers are almost incredible. Fibers with a diameter of 23 one-hundred-thousandths of an inch have a tensile strength of more than 250,000 pounds per square inch. Experimental fibers have been produced with a diameter of two one-hundred-thousandths of an inch and with a tensile strength exceeding 2,000,000 pounds per square inch.

WAR-TIME USES—When impregnated with suitable varnishes, Fiberglas fabrics offer high resistance to the flow of electric current. The varnish-impregnated glass fabrics occupy little space, and are resistant to high temperatures. For these reasons, tapes, braids, and cloths made of these fabrics were already in wide use as electrical insulation before the war. Because the size and weight of an electrical unit required to do a given job is largely determined by the heat the insulation will bear, use of glass insulation has enabled design engineers to reduce the size and weight of motors, transformers, and other electromagnetic machines.

Other pre-war applications of Fiberglas fabrics were as widely divergent as their use as decorative fabrics and as filter cloths for the processing of chemicals. The fact that glass fabrics will not burn is their outstanding advantage when used for draperies, tablecloths, or bedspreads. Resistance offered by the fabrics to heat and acids (except hydrofluoric acid) makes it possible to use them for filtering hot, concentrated acid solutions.

Since the attack upon Pearl Harbor, practically the entire output of Fiberglas fabrics has been devoted to war uses. The fabrics are used as electrical insulation in equipment for ships, planes, and other machines of war, or production for war. One of the smallest but most vital motors in a plane is the pitch-change motor which changes the pitch of propellers that have gone dead, so that the blades are turned edgewise to the wind. These motors are insulated with Fiberglas.

Glass fabrics are employed in numerous other war applications where non-flammability and resistance to high temperatures are required. A spectacular war application has been their use as glare shields for the magnesium parachute flares of about 1,000,000 candle-power which are employed by the Army Air Forces to illuminate the objective of a bombing attack. Fiberglas tapes and cloths are used to wrap insulated piping on Navy ships and exhaust pipes on planes. Curtains of glass fabric have replaced certain doors on both Navy and merchant ships.

War requirements have been largely responsible for a number of developments that forecast new or broader peace-time uses of glass textiles. The needs of the armed forces have led to the development of Fiberglas fabrics coated with synthetic rubbers and resins. These coated fabrics have great tear strength, withstand repeated flexing, and have high dimensional stability—that is, high resistance to stretch or shrinkage. Other properties vary with the coating employed, but rubber-coated glass fabrics are being produced which are flame-proof and have high resistance to moisture penetration, decay, and the effects of contact with gasoline, oil, chemicals and greases.

High tear strength and dimensional stability, or resistance to heat, chemicals, or oils, are responsible for most of the present uses of the coated glass fabrics. These present uses include aircraft battery covers, oil pressure switch diaphragms, aircraft tape for expansion joints of hot air ducts, protective clothing for workers in chemical plants, and targets for alining aircraft gun and bomb-bay sights. Possible future uses include tarpaulins and other water-proof covers for machinery, water-proof containers for delicate instruments, and carburetor diaphragms. Another possibility is an awning that will not burn if a lighted cigarette is tossed upon it from an upper-story window.

FIBER COMBINATIONS—Glass and asbestos fibers, and glass and asbestos yarns, have been combined to form new glass-asbestos textiles for other specialized applications requiring resistance to high temperatures, together with high strength, light weight, and resistance to the effects of repeated flexing. The high strength of the textile is primarily due to the glass, while the asbestos enables the textile to withstand more flexing than can an all-glass textile.

A start toward combining glass fibers with fibers such as rayon, silk, and cotton was made before Pearl Harbor. Glass fibers were combined

Bobbins of glass yarn, ready for weaving

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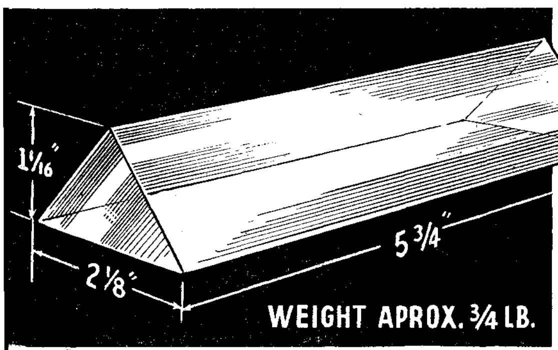
in LENSES & PRISMS

All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections which We Guarantee Will Not Interfere with their Use. All Lenses neatly packed and marked for Diameter and Focal Length.

OUR POLICY on WAR SURPLUS

1. We are cooperating to move surpluses while the war is on.
2. Our customers receive full benefits of all savings effected through our purchases of war supplies. We do not hold merchandise for high future prices.
3. We are making an effort to bring our items to the attention of all Schools, Colleges, Amateurs.



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.

WAR SURPLUS ACHROMATIC LENSES

Stock No.	Dia. in Mms.	Focal Length	Comments	Price
6016-S	*12	80 mm.	Uncemented	30¢
6017-S	*12	80 mm.	Cemented	50¢
6018-S	*15	41 mm.	Uncemented	40¢
6019-S	*15	41 mm.	Cemented	60¢
6022-S	*25	95 mm.	Uncemented	50¢
6024-S	*25	11 inches	Uncemented	60¢
6025-S	*25	11 inches	Cemented	75¢
6028-S	*30	64 mm.	Uncemented	70¢
6029-S	*35	60 mm.	Uncemented	70¢
6030-S	*36	171 mm.	Uncemented	70¢
6032-S	*36	178 mm.	Uncemented	70¢
6033-S	*37	51 mm.	Uncemented	70¢
6034-S	*38	178 mm.	Uncemented	70¢
6037-S	*41	57 mm.	Uncemented	70¢

Free Cement and Directions included with all uncemented sets.

*—Available with magnesium fluoride low reflection coating. Coated lenses will be priced at 10¢ more than the prices shown above. If you want coated lenses, mark "coated" after stock number and include 10¢ extra.

REDUCING LENS SET #1004-S .... $1.20 Postpaid
Contains a 2½" diameter and 1¾" diameter reducing lens of different powers.

70-PAGE ILLUSTRATED IDEA BOOKLET .... $1.00 Postpaid
Describes wide variety of uses for our lenses and contains much information especially designed for beginners in optics.

SCHOOLS & COLLEGES — Get on our mailing list. Keep regularly posted about our Optical Bargains. Send name, address to our Educational Dept.

WAR BARGAINS IN LENSES USED IN NAVY'S 7 POWER BINOCULARS

KELLNER EYE-PIECE LENSES with F.L of 27.5 mms. Comes uncemented with free cement and easy directions. Edged Field Lens has diameter of 26 mms. and edged Eye Achromat a diameter of 17 mms. Unedged Lenses about 2 mms. larger than edged ones. These are excellent for all sorts of telescopes.

Stock #6060-S — Uncemented and Unedged — 75¢ Postpaid

Stock #6061-S — Uncemented but Edged — $1.25 Postpaid

ACHROMATIC OBJECTIVE LENSES with F.L. of 193 mms. Have wider diameter than those used Army's 7 power binocular. Excellent for telescopes. Diameter of edged lenses are about 52 mms. Unedged about 53 to 56 mms.

Stock #6063-S — Unedged and Uncemented — Price 75¢

Stock #6064-S — Edged and Uncemented — Price $1.75

LOW POWER MICROSCOPE LENS SET — (May also be used to make Telescope Eye-Piece) Perfect Lenses, one with diameter of 9 mms., F.L. of 20 mms., and one with diameter of 14 mms. and F.L. of 39 mms.

Stock #1003-S — Price 70¢ — includes free copy of our Microscope Booklet.

PORRO ABBE PRISMS #3006-S ..... 25¢ each Postpaid
Size 9 mm. by 17 mm. . . . another war bargain. Normal prices would be 10 to 20 times above quotation.

LENS SET 120-S "The Experimenter's Dream" 60 lenses with 70-page illustrated booklet "FUN WITH CHIPPED EDGE LENSES" — $10.00 Postpaid.

The variety of lenses in this set will enable you to conduct countless experiments and build many optical gadgets.

FOR CHRISTMAS
Our Lenses and Prisms make SPLENDID XMAS GIFTS for the scientific-minded person or hobbyist.

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with silk and rayon fibers, for example, to form a necktie fabric. The war halted development of such combinations for non-essential civilian uses but, as war demands permit, further developmental work along this line is certain to be resumed.

Because glass fibers are strong and will not shrink or stretch, they can be employed in conjunction with other fibers to form decorative fabrics—and fabrics used for wearing-apparel accessories such as ties and scarves—which will hold their shape regardless of humidity conditions and the service strains and stresses to which they may be subjected. In neckties, the glass fibers help the fabric withstand the effects of repeated creasing.

Production of all-glass decorative fabrics—also halted by the war—will be resumed as rapidly as the war situation permits. Already limited quantities of Fiberglas yarns have been released for weaving decorative fabrics to be installed in places of public assembly such as schools, theaters, hotels, and restaurants, where the use of fire-proof fabrics can eliminate a serious fire hazard. Newly developed methods of dyeing and printing glass fabrics now make it possible to provide them in a wide variety of colors, shades, and printed designs.

The danger of mass panic due to fire is not as great in the home as it is in places of public assembly. The feature of fire-safety, therefore, is of lesser importance in the home—except, perhaps, in the case of tablecloths and other table coverings which are always in danger from a carelessly placed cigarette. But Fiberglas decorative fabrics—particularly in the form of draperies—possess other decided advantages for home use.

LONG-LIVED DRAPERIES—The above is especially true of seashore homes, where salt air, strong sunlight, and humidity play havoc with some of the older drapery materials. Fiberglas fabrics will not rot or disintegrate under the severest climatic conditions, nor will they stretch or sag under changes in humidity. Their colors are fast to sunlight and cleaning. Moths cannot eat them.

Need of the Army Air Forces for a high-strength, light-weight, easily fabricated material for load-bearing parts of planes has resulted in the development of a new structural material consisting of a combination of a plastic resin and glass textile fibers. The outstanding characteristic of the material is that it provides hitherto unattainable strength in proportion to its weight, and at the same time permits quick, low-cost fabrication.

The plastic used in the combination may be any one of a number of resins that can be molded under low pressures and cured at low temperatures. The glass fibers are employed as reinforcement, usually in the form of cloths woven of the fibers. Extremely fine fibers, with lengths measurable in millimeters, may also be dispersed in the resin to provide still greater strengths.

Layers of glass cloth are impregnated with the resin and placed, one on top of another, until a laminate of the desired thickness is built up. The laminate is then draped over the mold or shaped in it. The mold, with the laminate formed to the desired shape, are placed in an oven where the laminate is cured. Plastic-glass laminates have shown tensile strengths of from 50,000 to 80,000 pounds per square inch, compression strengths of over 50,000 pounds per square inch, and impact strengths of over 30 foot-pounds, as compared with two foot-pounds for ordinary plastics.

A basic objective in aircraft construction is reduction in weight. Weight affects rate of climb, maneuverability, cruising range, fuel consumption, and the amount of live or pay load the plane can carry. All these are important in varying degrees in both military and civilian planes. Every part of the plane, therefore, must be designed for minimum weight while supplying the required strength.

POST-WAR POTENTIALS—For every pound of increase in the weight of the plane there is a decrease of a pound in pay load. In passenger and cargo planes, taking the life of the plane into consideration, it has been estimated that every pound of weight saved means a saving of from $100 to $500. Using the lower figure, if only 1 percent of the dead weight of a 45,000-pound gross weight cargo plane can be transferred from empty weight to pay load, the saving during the life of the plane will be $45,000.

"Make it lighter and make it stronger" is an axiom of the airplane designer. Because glass-reinforced plastics provide extremely high strength in proportion to weight, they should be able to contribute materially to the reduction of dead weight, which is the goal of the aviation industry and upon the attainment of which may depend the ability of the plane to compete with other forms of transportation as a large-scale carrier of passengers and freight.

Aircraft provide the most spectacular application of Fiberglas-plastic combinations, but designers and engineers are already experimenting with the material for many other post-war civilian uses. These include strong, light-weight luggage, boats and canoes, furniture, kitchen and bathroom assemblies, refrigerators and radio cabinets, and dozens of additional products where attainment of light-weight combined with high strength and ease of fabrication is the goal.

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TWO-MILLION-VOLT X-RAY

Precision Tube Greatly Reduces Exposure Time

Development of a precision x-ray tube that operates at two million volts makes it practical for the first time to inspect by x-rays exceedingly thick sections of metal, reducing the exposure time in a particular instance from a week with a million volts to less than an hour with two million. Physicians will likewise welcome the new tube as a more effective tool for research in cancer therapy.

This new precision tube brings to the field of x-ray radiography the same sort of improvement in definition that the electron microscope, compared with the standard microscope, brought to the field of optics.

Mr. R. R. Machlett with the new precision high-voltage x-ray tube developed in Machlett Laboratories

In many ways the two-million-volt tube made by Machlett Laboratories, Inc., represents a radical departure from the previous art. It is completely sealed off, like an ordinary radio tube, and so the high vacuum within it does not have to be maintained by pumping. It is compact, and can operate at a constant potential with unvarying reliability of results.

Development of the tube was undertaken by the Machlett Laboratories for the High Voltage Laboratory of the Massachusetts Institute of Technology. The fundamental requirements were so severe that it became evident that the tube would have to be designed and constructed so as to achieve extremely fine focusing of the high-speed, two-million-volt electron beam. This necessitated not only a much improved electron source but, in addition and of greatest importance, a means of accelerating the electrons which, considering the high electron-velocities involved, would provide a constant rate of acceleration over the entire cathode-to-target distance, at the same time reducing to an absolute minimum the dispersion of the beam during its travel.

To accomplish this, the tube was designed to include some 180 sections, in order to provide uniform accelerating steps of 12,000 volts each. The mechanical problems involved in the design and construction of such a column of alternating glass and metal rings, tight to the vacuum within, able to resist high pressures without, and having adequate insulation, were almost insuperable in the light of the prior art of tube construction.

In order to appreciate the nature of the problem thus presented, it may be pointed out that in the average x-ray tube the total length of glass-to-metal seals is from two to three inches, whereas a column of the kind required in the new tube involves approximately 300 feet of such seals, or over a thousand times the length of the seals in even the larger standard tubes.

Early in the experimental work on the manufacture of this critical column it became evident that the usual gas-flame technique for sealing metal to glass would not do. Eventually the Machlett engineers developed a novel procedure, involving a combination of gas flame and high-frequency induction heating. This is now being successfully used. The metal rings are of Kovar, and have a special configuration to assure complete and homogeneous bonding with the glass.

SYNTHETIC RUBBER FOAM

Compares Favorably With Natural Foamed Latex

THE DEVELOPMENT of a process to produce foam rubber from synthetic latex was announced recently by The Firestone Tire and Rubber Company. This important discovery may mean new safety and comfort for millions of American fighting men. Because foam rubber previously could be made only from scarce natural latex, relatively unsatisfactory substitutes had to be used for tank shock pads, gunner pads, aircraft seat cushions, submarine mattresses, and many other vital war products.

The new synthetic product, as soft and fluffy as an angel food cake, also can be produced in medium and firm densities, and volume production of it already is under way.

Whipped into a creamy froth, much as a housewife beats egg whites for her cake, the synthetic latex traps innumerable interconnected tiny air bubbles, which give the foam rubber its softness and permit free circulation of cooling air.

The finished material compares so favorably with the natural foamed latex which Firestone made before the war that the same name—Foamex—has been given the new product. Foamex is extremely light; it is odorless, washable, and sanitary, and unattractive to moths or vermin.

The tensile strength of the synthetic material is equal to or greater than that made with natural latex, and it can be made to remain flexible at temperatures ranging down to 40 degrees below zero.

The ability of Foamex made from synthetic latex to resist gasoline and oil, which destroy natural rubber products, will give it many important new applications. When soaked in gasoline, the synthetic material increases slightly in volume, but returns to normal when dry. Oil affects it but little.

It is reported that after the war Foamex again will be used for mattresses, automobile and truck seat cushions, furniture upholstery, and similar products.

PHOTO-LAYOUT MATERIALS

Offer Many Advantages to Fabricators of Metal Parts

MATERIALS for a simplified method of printing working drawings directly on metal, recently announced by the Eastman Kodak Company, are known as Kodak Layout Paint and Kodak Layout Paint Primer. As the name of the latter implies, it acts as a base for the Layout Paint. The new method is said to be of widespread applicability for the production of flat metal parts.

Kodak Layout Paint is sprayed in ordinary room light directly on virtually any primed metal surface with a conventional spray gun, after the surface has been cleaned reasonably free of loose dirt and grease. Drying takes place rapidly and the prepared metal is ready for immediate use or it can be safely stored for a reasonable time in a dark place.

The drawing, which has been previously prepared with black ink on a transparent or translucent material, is next laid in contact with the prepared surface and an exposure of a few minutes' duration made to arc or mercury-

A spray of tap water removes all layout paint which has been light-struck, leaving only the lines and figures of the original drawing

vapor lights. The drawing is removed and the metal flooded with warm, weak ammonia water. A vigorous spray of tap water follows, which washes away the entire exposed coating, leaving only white lines where black lines appeared in the drawing. Another thin spray coat of Layout Paint Primer protects the finished product.

According to Kodak, parts so marked are as accurate as the original drawing. On metal, the new Layout Paint withstands bending, shearing, and punching without showing any tendency to loosen, and will actually resist the application of a cutting torch up to the point where the molten metal carries it away, provided that the metal does not scale.

The new method is said to have a distinct advantage over the scribing method because operators' instructions which are inked on the drawing are transferred to the part to be fabricated. Reductions in scrap loss are forecast because a layout can be prepared so as to include parts for several products. By so doing, maximum use of metal can be achieved. It was further stated that no critical steps are involved and that an inexperienced operator can learn the process rapidly. It is anticipated that the new process will be a boon to all fabricators who work with sheets of metal having uneven or oxidized surfaces.

STEEL SAFETY

Maintained Despite War-Time Problems

In spite of difficult conditions, which included a high turnover rate among employees, the steel industry held fast, during 1943, to its high rank in safety, according to statistics of the National Safety Council.

As in 1941 and 1942, the steel industry was third in freedom from accidents among leading industries. Only the communications and electrical equipment industries among 38 major industries stood above steel in safety.

The 1943 accident frequency rate in the steel industry was 7.4 per million man-hours worked, the same as in 1942. The average of all industries was 14.5 last year, compared with 14.9 in 1942.

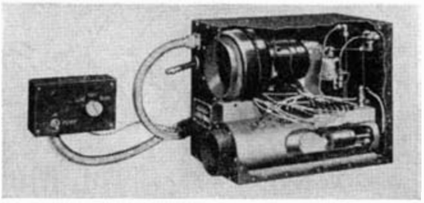
So many persons were hired as replacements in 1943 that a resultant increase in accidents might have been expected in the industry. At the same time, steel plants were operating at high speed to set an all-time record of yearly tonnage output, another obstacle to safety which had to be overcome.

The new employees hired to fill the jobs of workers who had entered the armed services were unfamiliar with their surroundings, but safety engineers and departmental officials conducted an unrelenting drive against unsafe practices and saw that every newcomer was adequately instructed.

TRUCK HEATER

Pre-Heats Engines for Quicker Winter Starting

New truck and bus heaters, announced by the Fluid Heat Division of Anchor Post Fence Company, combine the usual functions of cab heating and windshield defrosting with the addition



All-purpose truck heater that draws fuel from the vehicle's supply tank, with remote control panel at left

of trailer space heating and pre-heating of batteries, engine manifold, and crankcase if desired. Known as Model SAH, these heaters are made in several different sizes with outputs from 10,000 Btu per hour on low rate to 40,000 Btu per hour when firing at maximum rates. Controls are remotely mounted.

The combustion process of vapor entraining, successfully applied to aircraft heaters, is used. The heat exchanger has four compartments with "cross-over" passes between. Thus the flame and hot gases have a travel of four times the length of the heat exchanger with the maximum area of heating surface exposed to the heating air. Combustion air is pre-heated in a tube which extends through the length of one exchanger compartment. The flame is completely suspended to provide freedom from lead or other formations without regard to the grade of gasoline used, and to insure longer life for burner parts. Fuel is drawn from the vehicle's supply tank.

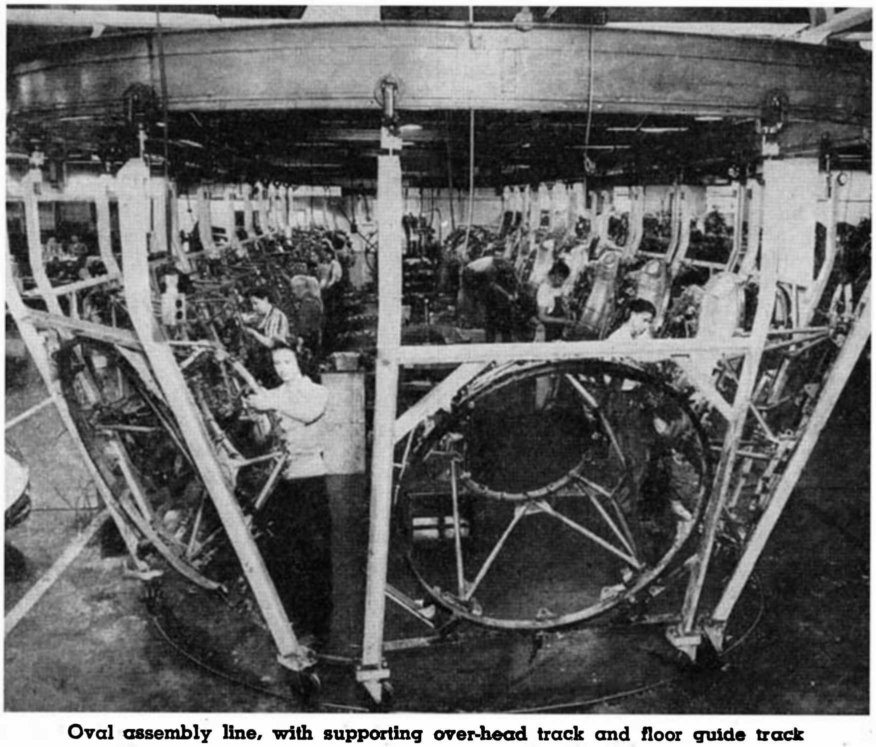
In designing Fluid Heat automotive type heaters, safety was a paramount consideration. Therefore the exchanger is constructed of stainless steel with gas-tight, continuous welded seams. There are only three moving parts—motor, fan, and a standard automotive type pump.

Applications for this heater are found in heavy trucks and trailers, Arctic rescue sleds, mobile laboratories, busses, and other vehicles. When mounted on wheels or skids it may be used for pre-heating engines of bulldozers, cranes, compressors, and for numerous other applications where heat is an aid to starting or operating.

PLANT MERRY-GO-ROUND

Simplifies Engine Mount Assembly

The strains of the calliope are missing and there are no horses to ride, but a moving oval jig, used for assembly of fixed cowlings and associated parts on engine mounts for Boeing B-17 Flying Fortresses, in many respects resembles a merry-go-round. The assembly line operates on a track suspended from the ceiling and guided by



Oval assembly line, with supporting over-head track and floor guide track another track on the floor. It holds 24 engine mounts at one time—enough for six Boeing bombers. The mount frame is placed in the jig at one end of the oval. When a worker completes one assembly operation, the mount moves to the next operator. After the mount has made a complete circuit, it is finished and ready for removal. Before this moving assembly line was designed and built by Boeing mechanics, it was necessary for an engine mount to be lifted and handled many times during the process of completion.

PERFECTED TELEVISION

Claimed by Radio

Industry Executive

APPROXIMATELY $25,000,000 has been invested in television research and development by the radio industry to get television ready for the public, according to James H. Carmine, vice president in charge of merchandising for Philco Corporation.

"Probably never before has the product of a great new industry been so completely planned and so highly developed before it was offered to the public as has television," Mr. Carmine says. "Through long years of research and development, the television art has been so perfected that the product itself and the service it renders will be ready for the public in a highly-developed state as soon as the war is over. The best evidence that the public thinks well of television is the universal response that comes from those who have a chance to see it. As soon as television receivers can be made and sold, the public will eagerly buy them in tremendous quantities."

FIBER BANDS

Now Protect Bombs,

Have Other Possibilities

AMONG the recent developments achieved by American industry to meet the "critical materials" situation created by war conditions, is a wheel-like, laminated paper bomb band, a co-operative development of the Alton Box Board Company and the Kenray Company. All bombs, up to 1000 pounds in weight, are equipped with two of these heavy fiber bands which facilitate transportation and handling of bombs and protect the metal lugs on the bomb casing against damage. Every bomb is protected by these bands from the time it leaves the factory until it is placed in the bomb bay of the plane as it prepares to embark on its mission of destruction over enemy targets. The "paper" bands, among other things, permit bombs to be rolled over rough ground with a minimum of effort and danger.

Previous to this development, bombs were equipped with steel bands to serve the same purpose. Each of these steel bands required 13 pounds of critical material—which was reduced to two pounds ten ounces per band through the substitution of paper-board bands. It has been estimated that this change-over has resulted in the saving of approximately 200,000,000 pounds of steel annually.

One of the surprising results of the change-over from steel to paper was that the band was greatly improved from the standpoints of ability to withstand shock and abuse, such as are encountered in combat area operations. In a drag test of 171 feet, a 1000-pound bomb equipped with steel bands showed worse damage than a bomb with fiber bands dragged 1275 feet over the same course. Similarly, in drop tests, steel bands showed failure after two drops, whereas the fiber bands were still in good condition after six drops.

In the development of these "paper" bands, certain rigid conditions had to be met. Specifications called for materials that would be absolutely waterproof—that would withstand rain, mud, and snow, as well as being light in weight and able to withstand extremely severe usage. Employing a synthetic resin base, The Kenray Company developed a moisture-proof adhesive which, when applied to fiber-board, could be immersed in water for a period of seven days and seven nights, at a temperature of 70 degrees, Fahrenheit, without absorbing more than 25 percent moisture.

Equipped with this moisture-resistant adhesive, The Alton Box Board Company went into production on Bomb Bands which are made by machine-winding and gluing paper-board stock convolutely into a solid rim.

This new "material," developed as a war project to meet an urgent need, would seem to have wide industrial applications for peace-time production. It is lighter and more shock-resistant than steel, it can be sawed, nailed, or screwed into like wood, is absolutely water-proof and weather-proof, and, finally, can be produced in large volume at relatively low cost.

SYNERGY

Is Acquiring Tremendous Importance in Industrial Chemistry

It is a commonplace of chemistry that a greenish yellow poison gas like chlorine and a bright, silvery, flammable metal like sodium will react to give common table salt or sodium chloride, which is neither sodium metal nor chlorine gas, nor their sum or average. Such behavior is well known in less extreme form to industrial chemists who deal with such things as plastics, fibers, emulsions, ceramics, and protective coatings.

Thus cellulose nitrate is insoluble in alcohol or ether but a mixture of alcohol and ether readily dissolves pyroxylin, yielding a solution known as collodion. Likewise, the effectiveness of pyrethrum, a common active agent of fly sprays, can be increased many fold by the addition of a small amount of sesame oil which in itself is harmless to houseflies. These mixtures possess properties not found in the separate ingredients used singly.

All such non-additive effects may be described by the term "synergy." This word has been used for a long time in pharmacology and has Greek roots meaning "working together." The basic idea of synergy may be expressed as "the whole is greater than the sum of the parts" or even as "two plus two makes five." To use the more cautious words of the dictionary, synergy is the "co-operative action of discrete agencies such that the total effect is greater than the sum of the two effects taken separately."

Can anything of value to the chemist be learned from so general a phenomenon as synergy? Do the many different systems displaying synergy possess any common factors in their mechanisms which can guide the industrial chemist in his work?

With these questions in mind, a large number of examples of synergy from diverse fields of industrial chemistry were examined as to type of mechanisms and general factors involved. Three main types of synergic mechanisms were recognized, based on (1) direct interaction, (2) complementary functioning, or (3) combined stepwise action of the components of a system or mixture.

The factors underlying all truly synergic phenomena were found to be self-association, packing effects, dissymmetry, and interaction of components. Thus, mixture of an inert diluent with a solvent whose molecules are combined or associated with other molecules of the same substance may cause these associated molecules to separate, thereby altering the solvent properties.

The reaction rate of a chemical may likewise be altered by changes in self-association upon dilution. By employing a mixture of particle sizes in the fillers used in materials such as putty and concrete, higher plasticity at a higher filler content may be obtained as against the use of a single particle size.

This results from the ability of mixed particle sizes to pack more closely. Plastics are made by combining certain compounds or chemical building blocks with themselves many times to form very large chains or networks. By employing a mixture of building blocks, differing in molecular size or polarity, dissymmetry is introduced into the structure of the plastic, thereby altering its solubility, strength, and elastic properties.

Synergy, which is so common in pure or theoretical chemistry as to hardly merit notice, acquires tremendous importance in applied chemistry. It triples the effectiveness of an insecticide or doubles the yield of a reaction. It represents a saving of time and money, conservation of materials, longer life and better use for the creations of the chemist.

Heretofore the application of synergy has been largely the result of long years of accumulated experience, or of some special theory about some particular process, or even the result of chance discovery. There has been a noticeable tendency among chemists to assume that mixtures of similar or related materials would give average properties.

This generalization of the nature of synergy and the factors underlying it which have now been made for the first time in the field of industrial chemistry do not represent any new discovery of principles. They do, however, offer the chemist a valuable new orientation or approach to his problems. Armed with an awareness of the nature of synergy and consciously seeking its utilization, chemists can speed the solution of their problems and better realize the hidden possibilities of the materials they work with. —*From a paper by Pat Macaluso, of Foster D. Snell, Inc., presented before the American Chemical Society.*

New Products

TOUGH FLOORS

ALL floors in industrial plants, especially loading platforms, receiving and shipping room floors, corridors and runways are subject to heavy traffic, shock, and abrasion. Consequently, floor troubles are frequent. Maintenance men have been demanding tough, durable floors which are not slippery, show no noticeable wear for long periods and involve practically no upkeep costs. It is claimed that such floors can now be constructed with Ferem, a concrete component developed by the laboratories of the A. C. Horn Company.

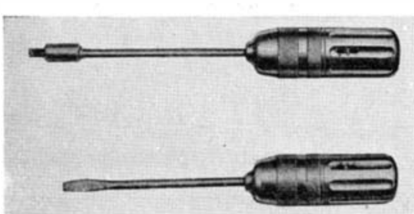
Ferem is a complete material containing all the desirable characteristics of concrete hardeners, admixtures, and processed components. Ferem contains no sand, stone, or silica and requires only the addition of cement and water. Ferem "Blue Temper" floors are reported to be unusually resistant to wear, water, and chemical disintegration. The principal component of Ferem has a rating of 9 in hardness on the Mohs scale, which is only one point less than the diamond.

Ferem is used exclusively as the "Blue Temper" component in place of sand and gravel or stone in floor toppings in dairy or creamery floors and in industrial plants where the floors are subject to heavy traffic or where resistance to water, oil, and dilute acid spillage is required.

TORQUE SCREW DRIVER

SAID to completely eliminate all danger of over- or under-tightening, thread stripping, or material-damaging, a new torque screw and bolt driver has been announced by Richmont, Inc. It is 7¾ inches long, with a 1.30 inch diameter handle.

This new driver, known as the Livermont Roto-Torq, may be adjusted to



Available in two models, this torque screw driver is easily adjustable

any torque desired between 1 inch-pound and 25 inch-pounds for setting screws, small nuts, bolts, and so on. Because it disengages itself at the proper torque, it is impossible for the operator to tighten beyond the prescribed fit or tightness.

The mechanism operates on a spring principle and is not to be confused, it is said, with a clutch, cam, or friction principle. Torque tolerances are very close and the torque is not influenced by excessive oil or other normal foreign material, nor by the way it is held or used by the operator.

ROTARY PUMP

A NEW low-pressure rotary pump, which is designed for industrial application and affords an efficient and economical method for pumping all types of liquids having lubricating qualities, has been announced by the John S. Barnes Corporation. The new Barnes pump is ideally adapted for use as a lubricating booster pump for oil lines, a gasoline dispensing pump, and for oil pressure systems on automotive, truck, or tractor equipment. It has also proved ideally suited for use on Torque Converters. Capacity of the Barnes pump ranges proportionately from one gallon per minute at 600 revolutions per minute to four gallons per minute at 2400 revolutions per minute. It has a high volumetric efficiency when pumping extremely low viscosity fluids.

An outstanding feature of the new pump is the Barnes patented spur gear tooth form. Tooth construction of the spur gear completely eliminates excessive sliding, and reduces slippage of the fluid to an absolute minimum; each tooth completely fills the mating space, as the gears mesh, and virtually perfect sealing action is effected. Thus positive displacement of the fluid is assured despite variations in fluid viscosity or other factors.

HYDRAULIC SPEEDPRESS

An entirely new air-hydraulic gap type speedpress, announced by Studebaker Machine Company, can exert a maximum pressure of 1¾ ton.

Inexperienced operators encounter no difficulty in working with this press.

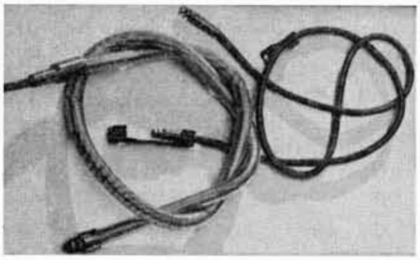
Maximum pressure 1¾ tons

The operator simply pushes down this hand (or foot) control and the ram quickly travels the set stroke from 1/32 to 2½ inches, and delivers pre-selected pressure. Operator releases control, and ram retracts automatically.

Air cylinder and hydraulic pump units are built into this press body and are easily accessible and removable. It is the fastest of all presses where speed is needed—or the ram can be slowed down to meet exact requirements.

FLEXIBLE HEATING UNITS

Flexible "serpentine" electric heat units have recently been perfected by the H. and A. Manufacturing Company, Inc. These new units can be coiled in close or in widely spaced turns around



Heat for any shape

pipes and cylinders, spiraled around molds, or fitted to odd contours.

Of metal-ceramic construction, the units can be made in varying lengths and diameters and in capacities up to 15 to 20 watts per lineal inch. Exact temperatures up to 1000 degrees, Fahrenheit, can be maintained without deterioration of the steel-ceramic structure.

Heat may be applied through direct contact of the unit or may be transferred through clips or fixtures of various designs. The unit may be left exposed or may be sealed or coated over with insulating cement.

Applications already have been designed for de-icing installations on airplane engine nacelles and on hangar doors; also on molds where critical temperatures must be maintained, and on melting pots of unusual shapes. Other applications include the heating of pipes and valves carrying viscous fluids. Experimental work is being done on various applications in the plastic field.

HYDRAULIC GUN

A PORTABLE 1½ ton capacity hydraulic press with off-set platen and ram, identified as Hy-Mac hydro-squeeze gun and built for pressures up to 1000 pounds per square inch, is announced by Hydraulic Machinery, Inc. Two ball-type switches are conveniently located on the unit to control a spring-returned four-way valve. As long as both switch buttons are pressed, the valve solenoid is energized and oil under pressure is valved into the gun, moving the ram through the working stroke of 1½ inch. When one or both buttons are released, the valve solenoid is de-energized and the ram starts the return stroke.

Working stroke is 1½ inches

The off-set platen and ram are constructed to accommodate special adaptors for various operations, such as pressing bushings and pins, riveting, dimpling, and so on.

This gun will reach many hard-to-get-at places, formerly inaccessible to power tools. A standard Hy-Mac hydraulic power unit, complete with pump, motor, tank, and valves, generates the hydraulic power for operation of the gun.

PLASTIC CEMENT

PLIASTIC Cement is the name of a synthetic resin adhesive recently announced by Paisley Products, Inc. It is a white fluid cement that may be used in its natural state or reduced with water. Application is by brush, gumming machine, spreader, dipping, flow, or spray gun. The manufacturer states that Pliastic is compounded of selected resin bases with complex non-resin materials to yield a tough, pliable, continuous film capable of joining many combinations of materials.

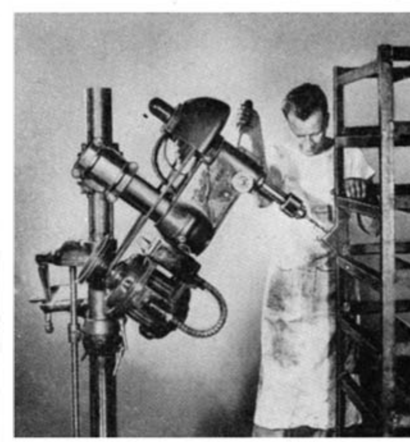
The Pliastic film, when dry, is a semi-transparent, glossy, flexible coating with excellent heat-sealing properties. When used in the liquid state for bonding materials it can be applied to one or both surfaces, the speed of setting being dependent upon the porosity of the materials used.

According to the manufacturers, Pliastic is being used in many industrial operations as a replacement for rubber latex on the following materials: paper; cardboard; wood; plywood; Presdwood; asbestos; cotton, wool, and hair felt; abrasive grains; tinsel and glass beads; plain or treated fabrics; cork; rock-wool and Fiberglas insulation; leather; plastics; porcelain; metals; stone; and many painted, lacquered, and coated surfaces.

DRILL-PRESS BRACKET

JUST announced by the Nobur Manufacturing Company is a new angle bracket that will convert any drill press into one of the handiest, most versatile machines in a shop.

This angle bracket changes a drill press into an all-purpose machine for angle drilling, polishing, buffing, sanding, rotary filing, wire brushing, tapping, reaming, burring, grinding, honing, and for many more specialized and varied uses.



Adaptable to any angle

According to the manufacturer, this angle bracket is a quick and inexpensive answer to the hundreds of tedious jobs that demand speed and efficiency. Spindle angles can be adjusted to any height, placed horizontally or vertically, at any angle, and can be set for greater convenience and operator comfort. It fits the machine to the work—and gets more work out of the machine.

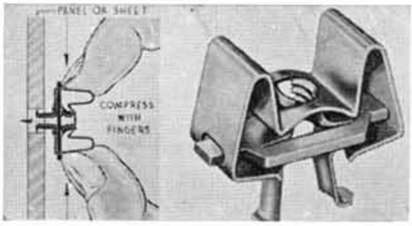
SLIDE RULE IMPROVEMENT

PLACING the decimal point is one of the biggest stumbling blocks in the use of the slide rule. Ever since the slide rule was invented, computers have felt the need for some positive, simple, mechanical method of placing the decimal point. Pointing off in powers of 10 presupposes a much better knowledge of mathematics than the average person possesses, or is able to retain and use with facility after leaving school.

Now there has been developed a new slide rule decimal-point locator—and a new slide rule—which does four things not accomplished by other rules: It determines the decimal-point mechanically in involved expressions with results up to 19 digits or 19 zeros; obtains 30-inch scale accuracy for cube root and 20-inch scale accuracy for square root on a rule with 10-inch scales; with one setting of the hairline reads square root, cube root, and logarithm or with one setting of the hair line determines the number of digits or zeros in the square root or cube root; simplifies slide rule calculations so that persons with a very limited mathematical background can evaluate and point off relatively complicated expressions.

CAGE TYPE SPEED NUT

NO RIVETING, welding, or spinning operations, nor any special tools, are necessary to install a new self-locking Speed Nut in screw-receiving position for blind attachments. It is necessary only to compress the cage as shown in the

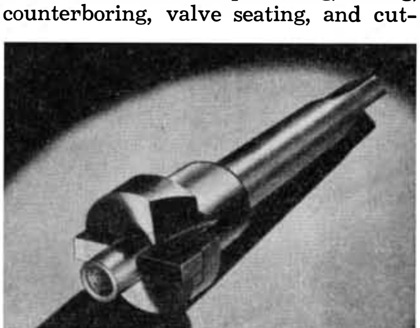


Speed Nut for blind attachments

sketch and to insert the legs. The legs spring apart when pressure is released, the turned-up ends just clearing the back of the panel. The nut will hold tight against the force of inserting the screw and the screw-tightening torque, and the floating Speed Nut within the cage allows for any misalinement of clearance holes.

FACING TOOL

THE Multifacer, applicable to drill presses, engine and turret lathes, and milling machines for spot facing, boring, counterboring, valve seating, and cut-



The bit is locked with set screws

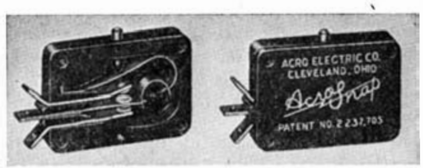
ting convex or concave annular rings, is a new tool introduced by The Rieger Manufacturing Company.

The head of the Multifacer is slotted for the insertion of a bit ground to the desired contour. The bit is locked in place with three set screws and can be adjusted to cut evenly even when the grinding is somewhat faulty. Clearance slots provide for the escape of shavings and chips.

The Multifacer is reported to be a production tool for long runs as well as handy for occasional jobs. It is built of tough alloy steel, heat treated and ground. It is said to have the ruggedness to last indefinitely under hard usage.

SNAP-SWITCH

REPORTED to be the smallest fully enclosed snap-action switch ever built, the new Miniac is only 17/64 inch thick, 13/16 inch high, and 1 3/16 inch long. Engineered on the well-known rolling

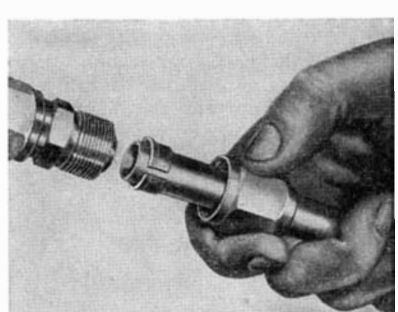


Contact points are of silver

spring principle, but with a new design and smaller size, it is fully enclosed in a Bakelite case with four mounting holes 3/32 inch in diameter. Actuation is with a stainless steel pin plunger. All parts are non-corrosive and all contacts are of fine silver. Main blade, contact blade, and rolling spring are made of beryllium copper. Rated at 15 amperes, 115 volts A.C. Furnished in single pole, normally open and normally closed, and double throw. Designed to permit leaf type or over-travel plunger type actuators to be attached to the case.

SELF-FLARING COUPLING

FOR USE with flexible plastic tubing, a self-flaring coupling has just been announced by Packless Metal Products Corporation. No flaring tools are required. The flare is formed as the members of the coupling are screwed together in one simple operation, as-



Re-usable coupling for plastic tubing automatically flares the end

suring uniform walled flare, with no thinning toward the end to weaken the tube. The plastic tubing is not preheated.

It is stressed by the manufacturers that the construction, by providing a union effect, eliminates twisting and distortion of the tubing in installation, as well as split ends. Only the simplest of shop tools are required and assembly may be made right at the job. Coupling may be re-used indefinitely.

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.)

GRINDING FACTS is a 136-page reference book on grinding which includes an explanation of new standard marking symbols, a schedule of grading recommendations, safety rules, and a table of useful speeds. *The Carborundum Company, Niagara Falls, New York.—Request this book on your business letterhead.*

SAFETY IN ELECTRIC AND GAS WELDING AND CUTTING OPERATIONS is a 32-page booklet compiled for the protection of operators from injury and illness, and for the protection of property from fire and other damage. It includes every phase of safety applicable to ordinary welding, cutting, brazing, lead burning, and flame-treating operation. *American Standards Association, 70 East 45th Street, New York 17, New York.—Single copies 40 cents.*

B. F. GOODRICH INDUSTRIAL RUBBER PRODUCTS is a 12-page, well illustrated booklet containing information and cross-sectional views of Vibro-Insulators, molded rubber goods, industrial cutless bearings, products made with Koroseal, and many other rubber products. *B. F. Goodrich Company, Akron, Ohio.—Gratis.*

THE OBSERVER'S HANDBOOK FOR 1945 contains data on the planets and other astronomical phenomena, month by month; also lists of double and multiple stars, variables, four star maps, an ephemeris of the Sun, and miscellaneous astronomical data to the extent of 80 very useful, practical pages. Most amateur astronomers obtain this booklet each year. *Royal Astronomical Society of Canada, 198 College Street, Toronto, Ontario, Canada.—25 cents.*

3-M ADHESIVE DATA is an eight-page booklet covering the viscosity, bonding range, and method of application of various coating materials, impregnators, spray-on insulators, and sound-deadening compounds. *Minnesota Mining and Manufacturing Company, Saint Paul 6, Minnesota.—Gratis.*

RELIANCE SPRING LOCK WASHERS—FOLDER NUMBER 142 contains engineering data on all types of spring lock washers including steel section sizes and I.D. and O.D. dimensions. *Eaton Manufacturing Company, Reliance Spring Washer Division, Massillon, Ohio.—Gratis.*

ENGINEERING INFORMATION ABOUT NO-SPAT WELDING FLUID is a four-page bulletin based on practical and scientific tests which were made to determine the effects of using an anti-spatter fluid in welding. This bulletin also suggests a method of keeping welding jigs free from spatter and contains tests for determining weld strength and weld soundness. *The Midland Paint and Varnish Company, 9115 Reno Avenue, Cleveland 5, Ohio.—Gratis.*

AVIATION PREDICTIONS is a 32-page brochure which presents in digest form the probable future of aviation, as seen by leaders in this industry. The post-war developments are conservative, but optimistic. *Simmonds Aerocessories, Inc., 30 Rockefeller Plaza, New York 20, New York.—Gratis. Request this brochure on your business letterhead.*

DUSTKOP is a 24-page catalog of individual type self-contained dust collectors for gathering dust from all sizes of surface, tool, pedestal, disk grinders, and sanders. This catalog is indexed according to grinder size for rapid selection of the correct equipment. *Aget-Detroit Company, 602 First National Building, Ann Arbor, Michigan.—Gratis.*

STOPS GUN RUST AND PITTING is a folder outlining the use of RIG as a cleaning and rust preventive measure for rifles, tools, battery terminals, locks, surgical instruments, bicycles, and so on. *Rust Inhibiting Products, 5830 Stony Island Avenue, Chicago 37, Illinois.—Gratis.*

SAE HANDBOOK, 1944 EDITION, contains 630 text pages of new and revised data on wartime industrial and technical progress in developing new methods and materials facilitating war production, with particular emphasis on standards, specifications, and classifications. *Society of Automotive Engineers, Inc., 29 West 39th Street, New York 18, New York.—$5.00.*

PRECISION LOFTING is a brochure giving management, engineering, tooling, and production executives an insight into a new industrial lofting method for producing, with accurate mechanically reproduced templates, a variety of products ranging from small parts to automobiles and aircraft. *Template Reproduction Company, 401 North Broad Street, Philadelphia 8, Pennsylvania.—Gratis.*

PRODUCTION REAMING TOOLS is a 32-page catalog on reaming operations and their effect on final cost, published for tool engineers, manufacturers, and production men. Many types of tools are described, with emphasis on simplicity of design and operation. Request catalog No. 21. *The Madison Manufacturing Company, Muskegon, Michigan.—Gratis.*

OPEN STEEL GRATING AND STAIR TREADS is a 24-page booklet showing the products in actual plant and building uses, with detailed construction particulars, drawings and tabular specifications, and full installation data for every requirement. *William F. Klemp Company, 6601 South Melvina Avenue, Chicago 38, Illinois.—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¢.

USES AND APPLICATIONS OF CHEMICALS AND RELATED MATERIALS

By Thomas C. Gregory

PROVED world-wide demand for information of the sort indicated by the title, presented in compact tabular form, has lead to the publication of this Volume 2, which complements and supplements Volume 1 published in 1939. The information is of specific interest to buyers, sellers, and users of chemicals and related materials. (459 pages, 6½ by 9 inches, unillustrated.) —$9.10 postpaid.—*A.P.P.*

THE UNIVERSE AROUND US

By Sir James Jeans

REWRITTEN by the author and reset in a new edition, the fourth, this famous 15-year-old classic, which has passed the 75,000 mark in sale (for a scientific book this is phenomenal) but which had been becoming dated in recent years, is now back and closely up to date. It is not a beginner's book in astronomy but a semi-popular, semi-scientific but most readable account of the science of astrophysics. Its content: Exploring the Sky; Exploring the Atom: Exploring in Time: Stars; Carving out the Universe; The Solar System; Beginnings and Endings. (297 pages, 5½ by 8¼ inches, 56 illustrations.)—$3.85 postpaid.—*A.G.I.*

MORE ACIDS AND BASES

A Collection of Papers

THIS compilation of articles from the *Journal of Chemical Education* will interest many teachers and students of chemistry who found much of value in the original publication of "Acids and Bases" in 1941. (79 pages, 5 by 8 inches, a few illustrations.)—$1.00 postpaid.—*A.P.P.*

AVIATION DICTIONARY

By Charles A. Zweng

A GREAT many well-selected terms are here defined clearly and amply, often to an extent where the definitions constitute a small but scholarly treatise on the particular word being defined. Hence the descriptive term Encyclopedic Dictionary is fully justified and points up the difference between a mere dictionary and an encyclopedic dictionary. The subject matter of aviation is well covered, with topics ranging from Aerodynamics and Theory of Flight to Aircraft Engine Instruments and Civil Air Regulations. Short biographies of men who have contributed to the advancement of aviation are included. (356 pages, illustrated.)—$6.10 postpaid.—*A.K.*

THE TECHNIQUE OF THE TERRAIN

By H. A. Musham

CONTENTS: map geometry; map construction; units of measurement; drafting; conventional signs; scales; direction; distance; relief; slopes; coördinates; aerial photography; tactical topography; maps and logistics; military geography. Despite these chapters this is not a book on making but rather on the thorough understanding of maps. (228 pages, 6 by 9 inches, 105 illustrations.)—$3.95 postpaid.—*A.G.I.*

LAKE MICHIGAN

By Milo M. Quaife

THE AUTHOR'S secretaryship of the Burton Historical Collection, Detroit Public Library, and his several previous works, undoubtedly have enabled him to serve with special distinction as editor of The American Lakes Series. With scholarly thoroughness, yet entertainingly, the earliest economic trends and developments of Lake Michigan are told. The importance of that waterway in commerce and industry of the mid-west, and its bearing on the inception and growth of great cities on its shores, are delineated in the light of their world importance today. (384 pages, 5½ by 8½ inches, 32 illustrations, index, bibliography.)—$3.60 postpaid—*A.D.R., IV.*

PLASTICS STOCK MOLDS

IN addition to listing of current stock injection and compression molds for plastics, this edition of a comprehensive catalog includes extruded cross sections and laminated sheets, rods, and tubes. Illustrations show molded items for which molds are in existence, together with brief descriptions and dimensions. Added to this are listings of functional shapes, standard shapes, and special shapes. Sources of supply are given. (168 pages, 8½ by 10 inches.) —$5.10 postpaid.—*A.P.P.*

A TREATISE ON THE THEORY OF BESSELL FUNCTIONS

By G. N. Watson

AGAIN this widely known work is available, in a second edition. Minor errors and misprints have been eliminated but discoveries made since the first edition in 1922 have not been embodied. (804 pages, 7½ by 10 inches. 33 figures.)—$15.25 postpaid.—*A.G.I.*

COUNTERFEITING

By Laurence Dwight Smith

ROUNDED exposition of the general subject of counterfeiting: how genuine United States currency is made and how counterfeiting is done; how to detect counterfeits; a few stories of counterfeit crime; work of the Secret Service; examples of genuine and counterfeit engraving showing all the different kinds of work that go into a bill. The author had the co-operation of the Secret Service, the Mint, and the Bureau of Engraving and Printing in preparing this practical all-around treatise. (254 pages, 4¾ by 8¼ inches, nine illustrations.)—$3.60 postpaid.—*A.G.I.*

AN EDUCATIONAL GUIDE IN AIR TRANSPORTATION

By Ralph E. Hinkel and Leo Baron

THE main objective of the text of this little volume is to describe jobs in the aviation industry and to present vocational descriptions for the guidance of those who look to the future of air transportation for possible careers. Included is a brief survey of aviation and an orientation course in air transportation. (140 pages, 6 by 9 inches, illustrated.)—$.85 postpaid.—*A.P.P.*

THE ASHLEY BOOK OF KNOTS

By Clifford W. Ashley

SO COMPREHENSIVE was a large knot book reviewed here last year that it seemed the *ne plus ultra,* yet it now has been surpassed by a wide margin, not merely in number of knots, bends, hitches, splices, and sinnets (3853 as against 3257) but mainly in other ways. The author is a facile sketch artist and shows, by means of 7000 drawings, *how the knots are tied.* He is a writer, (author of "The Yankee Whaler") and makes his subject fascinating and humorous, tells yarns, explains the physics of knots, and so on. He was once a whaler. To collect his knots he spent 40 years, and to write his big book he spent 11 years. One chapter reveals a repertoire of trick knots to keep informal gatherings and friends mystified—a little showmanship. (620 pages, 8½ by 11 inches, 7100 illustrations.)—$7.75 postpaid.—*A.G.I.*

Telescoptics

A Monthly Department for the Amateur Telescope Maker

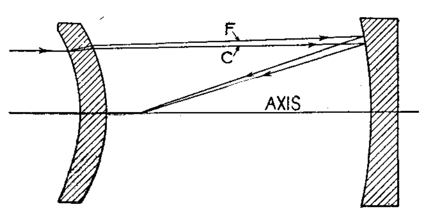
Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

Two months ago, in this department in the October number, Norbert J. Schell, 1019 Third Avenue, Beaver Falls, Pa., presented the fundamentals of the new type of telescope invented by D. D. Maksutov of the State Optical Institute, Moscow. In the following article, he concludes that discussion for the immediate present. In the meantime 13 advanced amateurs, whom we have dubbed "The Mak Club," though there really is no formal organization other than a common interest and consciousness of a common parallel aim, have ordered 8.2″ disks (slightly larger and more finished—molded roughly to curve—than was mentioned two months ago) of optical glass of suitable specifications from Corning Glass Works, with which to make the thick meniscus lens which, with a spherical primary mirror, is the basic part of the Maksutov telescope. "The Mak Club" is open to all martyrs to science who wish to be pioneers, and more glass is said to be available, the disks alone at $32.50 or with a grinding tool of similar deep-curved shape and non-optical glass, at $40. Schell's discussion follows:

In the first article on the new Maksutov type of telescope, in the October number, which was necessarily of a general nature, it was possible to mention only certain of this telescope's features. Since Maksutov has offered his design as a solution of the problem of producing a telescope having a wide field of good definition, free from chromatic aberration and at the same time possessing the important advantages of simplicity and ease of construction—features not found in any previous type—it is felt that a further and more detailed analysis of its operating principles should be made in this second article. It is hoped that, by this means, and as a supplement to the first article, the working principles will be covered, and that the two articles will serve as a foundation for later discussions.

CORRECTING ACTION—As stated in the first article, in the Maksutov telescope the negative spherical aberration of the spherical mirror is compensated by the positive spherical aberration of the meniscus lens. This is accomplished as a part of the overall diverging action of the lens. In the example given, of an 8″ aperture, $f/4$ system, the radius of the mirror was stated to be 65.856″. If this mirror were reflecting incident parallel light, the rays from a very small area at its center would come to a focus at a distance of half its radius, or 32.928″, while the rays from a zone of 8″ diameter would have a focus of .122″ shorter, or 32.806″. (This is in accordance with our familiar formula of $r^2/2R$, where r is radius of zone and R radius of mirror.) In the Maksutov, however, the distance S from mirror to focal plane comes out as 33.6″. From this it can be seen that the meniscus acts as a negative lens, diverging the rays and lengthening the distance from mirror to focal plane for all zones including the center. The action gradually increases from the center toward the periphery, so that the rays from all zones are brought to (practically) the same focal plane. In this case, within tolerances mentioned below, we can consider the minimum



amount of lengthening to be .672″ at center, and the maximum .794″, at outer zone, indicating the effect of the longest and shortest negative focal lengths, respectively, of the lens; in other words, its spherical aberration. (I am indebted to J. H. King for the information that designers usually refer to a weak lens of this kind as a lens of "zero power"—a point well taken and worth remembering.)

RESIDUAL ABERRATIONS—In the Maksutov system, with spherical surfaces on both the meniscus lens and mirror, an overall correction is attained in the above manner, but it is not possible to secure an exact theoretical correction for all zones, nor for all wavelengths of light, and thus residual aberrations, both spherical and chromatic, remain. The extent of these residual aberrations determines the upper limits of aperture-focal ratios and aperture dimensions possible without deterioration of image quality.

In determining the effect of theoretical (or actual) aberrations on image quality, we must take into consideration the maximum resolving power of any given aperture as associated with the wavelength of light. Briefly, it has been shown by mathematical methods that, in a theoretically "perfect" optical system, the image of a point source does not conform strictly to geometric proportions, but consists of an interference pattern having a central concentration, or disk, of finite size, surrounded by so-called diffraction rings, with most of the light in the disk; and that the diameter of the disk is inversely proportional to aperture diameter with a given wavelength of light. This disk is also known as the "Airy" disk. It has also been shown that if any aberrations in an optical system do not result in optical path differences between source and image greater than plus or minus ¼ wavelength of light, they will cause neither a noticeable change in the size of this disk nor in its relative intensity. In aiming for unimpaired image quality, aberrations within the above limits may therefore be considered as allowable tolerances.

SPHERICAL ABERRATION—The control of residual aberrations consists of such adjustment of the design factors as to bring about a balanced correction with respect to a plane of "best focus," which may be referred to as the "focal plane," having as nearly as possible a minimum variation for different wavelengths of light and a minimum tendency to produce coma. It is obvious that, where there are differences, the "focal plane" will fall somewhere between the shortest and longest focal lengths. The differences may be termed displacements, either plus or minus, relative to the "focal plane." While spherical aberration concerns theoretical focal lengths of different wavelengths for the various zones of the aperture, a satisfactory balance can be found by adjustment for a single intermediate wavelength; provided chromatic dispersion is also balanced as will be described. By calculating the theoretical longitudinal displacements of focus for different zones in terms of angular dimensions, the "focal plane" is established as the plane in which equality of angular aberration is found for the extremes of such aberrations both plus and minus. The aim of the adjustment is to reduce the angular aberration at the "focal plane" to a minimum.

In the design data given in the October article for the $f/4$ system, the minus extreme (corresponding to shortest focal length) is identified with the 85 percent zone of aperture, and two identical plus extremes with the 35 percent and 100 percent zones. The "focal plane" lies between the focus for the 85 percent zone and that for the 100 percent zone. (The focal lengths of the 35 percent and 100 percent zones are not identical, as angular aberration decreases with aperture.) This adjustment is the best possible for spherical surfaces, as given by Maksutov, and is perfectly logical, but a fuller treatment will have to be postponed until such time as a mathematical discussion can be prepared.

CHROMATIC ABERRATION—As the meniscus lens is a single lens, it is natural that the question of its chromatic dispersion should arise, even though it is understood that this lens has a very long focus and therefore causes little dispersion. It is obvious that considerable variation in chromatic aberration could be expected, in a system of this kind, among lenses having different design characteristics. Maksutov found that, if the lens was made of sufficient thickness and suitable radii, chromatic aberration could be eliminated at the focus of a certain chosen zone of the aperture and held to a negligible amount for other zones.

The action for this zone is shown in schematic form in the drawing. The usual spectral lines *C* (in the red) and *F* (in the blue) are shown, since the brightest part of the visual spectrum falls between these lines. The *F* line is refracted more than the *C* line and consequently diverges more after passing through the lens, so that it reaches the mirror at a point where it is reflected at a greater angle than the *C* line and thus meets the *C* line on the axis. For zones outside of the zone indicated, the *C* and *F* lines cross before they arrive at the axis, and for the inner zones they do not meet before crossing the axis. In the design data given, this zone is near the zone of extreme minus spherical aberration for mid-wavelength, previously mentioned. Stated differently, the dispersion, relative to this zone, is over-corrected for outer zones and under-corrected for inner zones.

This (corrected) zone is chosen so that the dispersion on either side of it, at maximum, is approximately the same with respect to theoretical angular dimensions at the focal plane. Actually, the dispersion (within the above limits) represents the difference between the residual spherical aberrations for the *C* and *F* lines and, when distributed as indicated, consists of only a fraction of the total aberration.

DESIGN LIMITS—If the aberrations are controlled and minimized in the above manner, the allowable tolerances first mentioned fix the upper limits for design with maximum resolving power. These limits are those given in the table with the first article, and it is felt pardonable to repeat that they apply to spherical surfaces only. It is well, however, to consider that these limits are theoretical and, as such, can be expected to be attained with unimpaired image quality only if the glass specifications as well as radii and thickness dimensions are exactly realized. It is obvious that a departure in any of these factors will have the effect of widening the aberrations to some extent. On the other hand, as may be inferred from the table, the aberrations quite rapidly become smaller than the tolerances for resolving power as the aperture-focal ratio is reduced below the indicated upper limit for a given aperture. By taking a somewhat smaller aperture-focal ratio than the upper limit, in an actual design, we secure the advantage of a certain amount of tolerance for glass characteristics as well as for radii and thickness, which is highly desirable from a practical standpoint.

It is hoped that the amount of freedom in this respect can be determined and made available as a guide within a reasonable time. The very attractive prospect of producing a telescope capable of superlative performance, requiring nothing more difficult than spherical surfaces of a reasonably accurate radius, would seem to dictate the logical choice of design.

COMA AND FIELD CURVATURE—It is not feasible to outline coma without a more or less complete mathematical treatment, which present space does not permit; however, it can be understood in the Maksutov by comparison with the action in the Schmidt camera. It will be recalled that the correcting plate in the Schmidt is located at the center of curvature of the mirror, and for that reason light from any part of the field is reflected symmetrically; consequently coma is not produced. In the Maksutov, while the lens is not located as far from the mirror, the action is similar, and coma is reduced to a negligible quantity over a wide field. In the data previously given, for the $f/4$ system, a field diameter of upward of two degrees is indicated without noticeable coma.

This brings up the question of field curvature, which was not previously mentioned. In this respect the Maksutov is again similar to the Schmidt camera; while its field is curved, the curvature is convex toward the mirror. This is the opposite to that in ordinary telescopes and should be of advantage in visual instruments, especially for short focal lengths, as the field curvature, concave toward the eyepiece, will be in the same direction as that of usual eyepieces, providing a closer "match" between their fields.

APPLICATION—Pending further descriptions of more complex designs available with this system, a final word is added regarding the possible applications of the fundamental system so far mentioned. As it is a corrected system, it can be considered and used the same as a corrected mirror, in any of the following applications:

1: For direct photography, with convex sprung films.

2: As a Newtonian, with diagonal, and so on, in any of its forms, and should be an exceptionally good "Richest Field" instrument; of course, with suitable eyepieces for this purpose.

3: As a primary for a Cassegrain—in which case the secondary would have to be corrected to hyperbolic form in the regular manner.

4: As a primary for a Gregorian—also with corrected secondary of usual elliptical form.

5: Off-axis forms. Since what is true of the whole is true of a part, a section of diameter representing somewhat less than half of the full aperture in the fundamental design, wholly on one side of the axis, will function without any obstruction in the light path. This achievement, with spherical surfaces, requires special constructional considerations, also reserved for future articles.

In both the Cass and Greg, as mentioned above, the secondary focal planes would not be free of coma over as wide a field as at the primary focus, but this should not be noticeable in the smaller fields usually available in such instruments.

INDEX TO VOLUME 171, JULY—DECEMBER, 1944

 Printed in the U. S. A. Press of the Wilson H. Lee Company, Orange, Connecticut

"Raking Leaves" painted by Rudolf Wetterau

Home

In your mind's eye, this may be the spot that's yours, the place you return to, sanctuary and birth-place of dreams, where all is as you want it, be it ever so humble.

Perhaps among the things that make it distinctively yours, is the memory of the pleasant flavor, the welcome fragrance, of a Kaywoodie Pipe.

Many men have found the Kaywoodie flavor so satisfactory that they've made this their permanent choice among pipes.

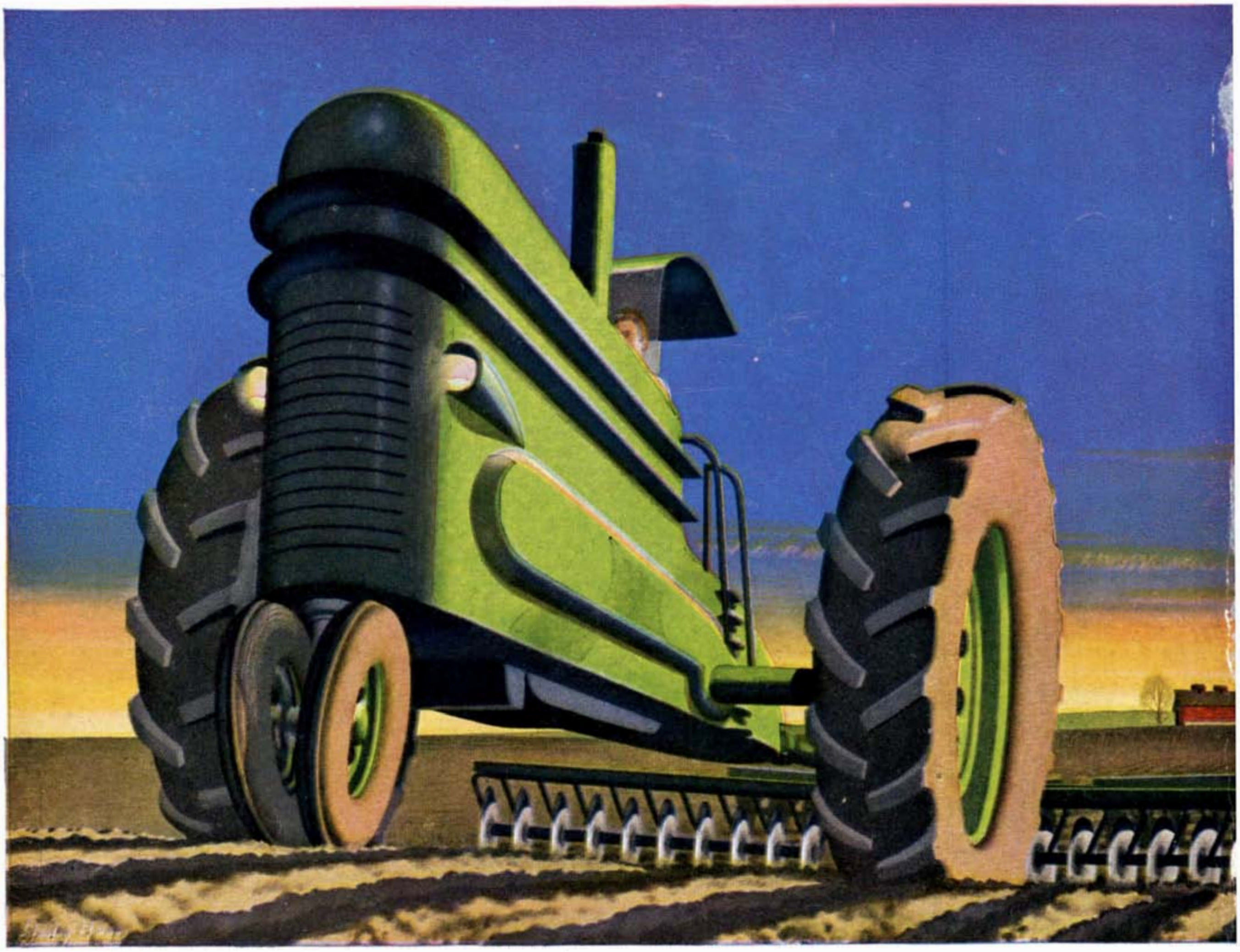
Kaywoodie Pipes are tempered with fine curing-agents, so that they deliver the mildest, coolest, most delicious smoke you ever enjoyed. They are cut from the real pre-war briar brought from the Mediterranean, from which the finest pipes have been made for 100 years.

It is a natural product. Like home, it grows slowly. You can't speed it up. We will keep right on making Kaywoodies of it, cutting them deftly and seasoning them well, so your Kaywoodie will always be your good companion and steadfast friend.

Many Kaywoodies go direct to our fighting men — please be patient if your dealer temporarily can't supply you. Illustrated here is Flame Grain Kaywoodie "Dublin" Shape, No. 13 — $10.

War Bonds come first

Kaywoodie Company, New York and London
In New York, 630 Fifth Avenue



Finger-tip Control — FROM FURROW TO HARVEST

The numbered days between frosts are crowded with labors that make the crop. Power, successfully applied on the farm, is designed to out-race the seasons . . . to tend broader acres in fewer man-hours against the uncertainties of weather.

On more efficient tractors, and on the implements they pull in series, HYCON hydraulic systems can give ease—lessen fatigue through *Finger-Tip Control*—to the heavier jobs of farming *more* acres *faster*.

In diversified applications of power on the mechanized farm, HYCON units can take over many back-breaking, everyday chores. On many types of new equipment they can actuate lifting, steering, braking, and other operating devices . . . can provide the reins to control horsepower harnessed to lighten the work of man.

When industry turns to the building of new implements for modern agriculture, compact power units, engineered and patented by the makers of HYCON, will help to do many hydraulic jobs *better*.

LET'S ALL BACK THE ATTACK—BUY MORE WAR BONDS

HYCON *Triumphs in Air Force Test*

In a grueling hydraulic test in the 3000-pound pressure range at Wright Field, the HYCON "Stratopower" pump stood up under the blistering heat of 160 degrees and the bitter cold of 65 degrees below zero for 550 continuous hours of operation. When no longer restricted by wartime needs, this revolutionary pump will do a great many hydraulic jobs *better*.

Out of the incredible demands of the war have come miracles of technological improvement to help rebuild a shattered world. More goods must be produced faster and cheaper. New machines will be created and old machines modernized.

Though our facilities are primarily devoted to production for the armed forces, there are still available for industry HYCON pumps and valves in the 3000-pound range. If you have a problem of actuation in your postwar plan, or the modernization of your present equipment, HYCON will help to solve it. Write for full information.

★ ★ ★ **HYCON** ★ ★ ★

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