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WISCONSIN ENGINEER

MEMBER ENGINEERING COLLEGE MAGAZINES ASSOCIATED

KEEPING UP WITH

Electricity

BROADCASTING TIN. "Flowing" tin plate by induction heating is now accepted practice in the industry. Frequency used in the first installation was 200,000 cycles per second—and the equipment was salvaged from a discarded broadcasting unit! Incidentally, this first installation is still in daily use.

IT'S A MATTER OF SPEED. Radium gives out 1,200,000 times as much energy as the same weight of coal burned with oxygen. Even if we had plenty, however, it would probably be a poor substitute for coal, since it releases energy only one-eightieth as rapidly. Nothing that scientists have been able to do has had the slightest effect in speeding up the process.

THE SUN IS STILL SLOWER, releasing energy by a process which involves the transmutation of elements and takes between six and seven million years.

WOMAN'S WEAPON. One reason that electric irons aren't being made is that the thermostats used to control their temperature are busy on land, sea and air. They're guarding against motor trouble in tanks, fire danger in planes, overheating in gun equipment on battleships.

PEAK FLATTENERS. Resistance welders have speeded up production in thousands of war plants, but they have imposed enormous on and off single-phase loads on power circuits, often building up impossible peak demands. Capacitors are proving to be the answer, correcting the power factor to approximate unity.

THE HIGHER, THE FEWER no longer applies in radio vibrators. At high altitudes, vibrator contacts literally "boiled away" in ten hours, hence this type of radio was seldom used in airplanes. New-type vibrator, using Westinghouse-developed materials and techniques, has a life expectancy equal to that of the plane.

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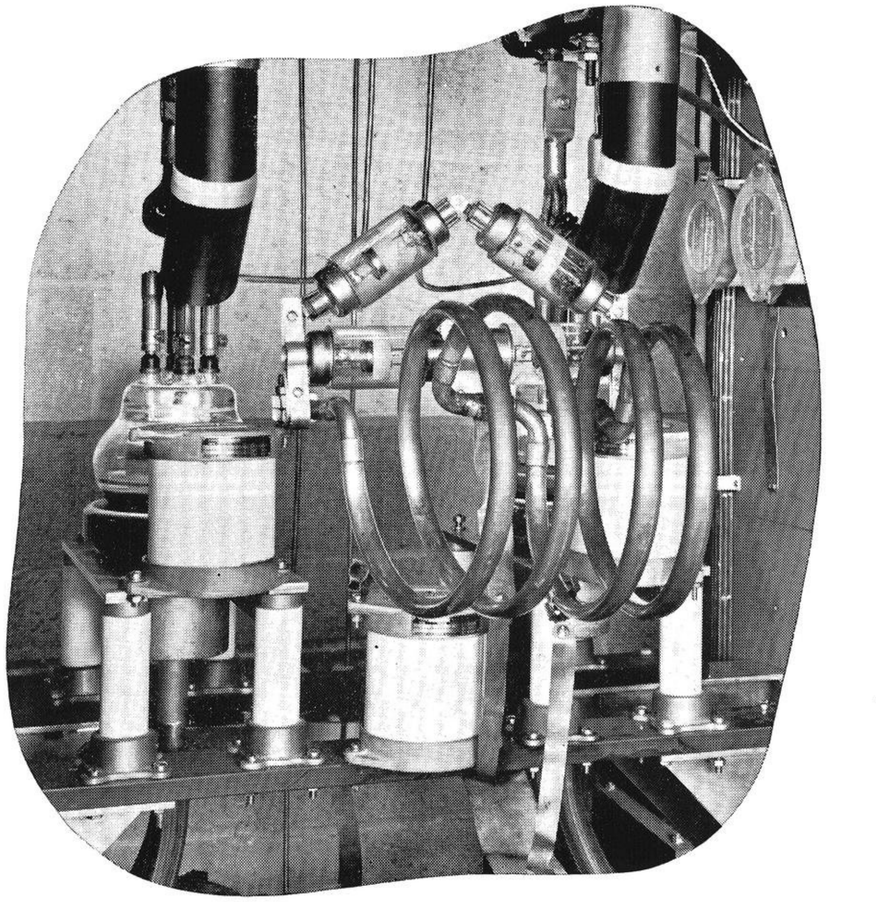
The above items are condensed excerpts from articles in the WESTINGHOUSE ENGINEER, a bi-monthly engineering review. Regular subscription price—$2.00 a year. *Special price to students—50¢.*



Plastics, plywood and electronics

This is a Westinghouse laboratory set-up for research in dielectric heating—internal heating by high-frequency radio waves. Together with induction heating—surface heating of metals by high-frequency radio waves—this process is daily finding new applications in industry.

One outstanding use of the principle of high-frequency heating is the Westinghouse development of flowing of tin on steel strip. Other important applications are in the bonding of plywood and the curing of plastics.

Dielectric and induction heating effect important savings in time and materials with attendant benefits of better control and more uniform results.

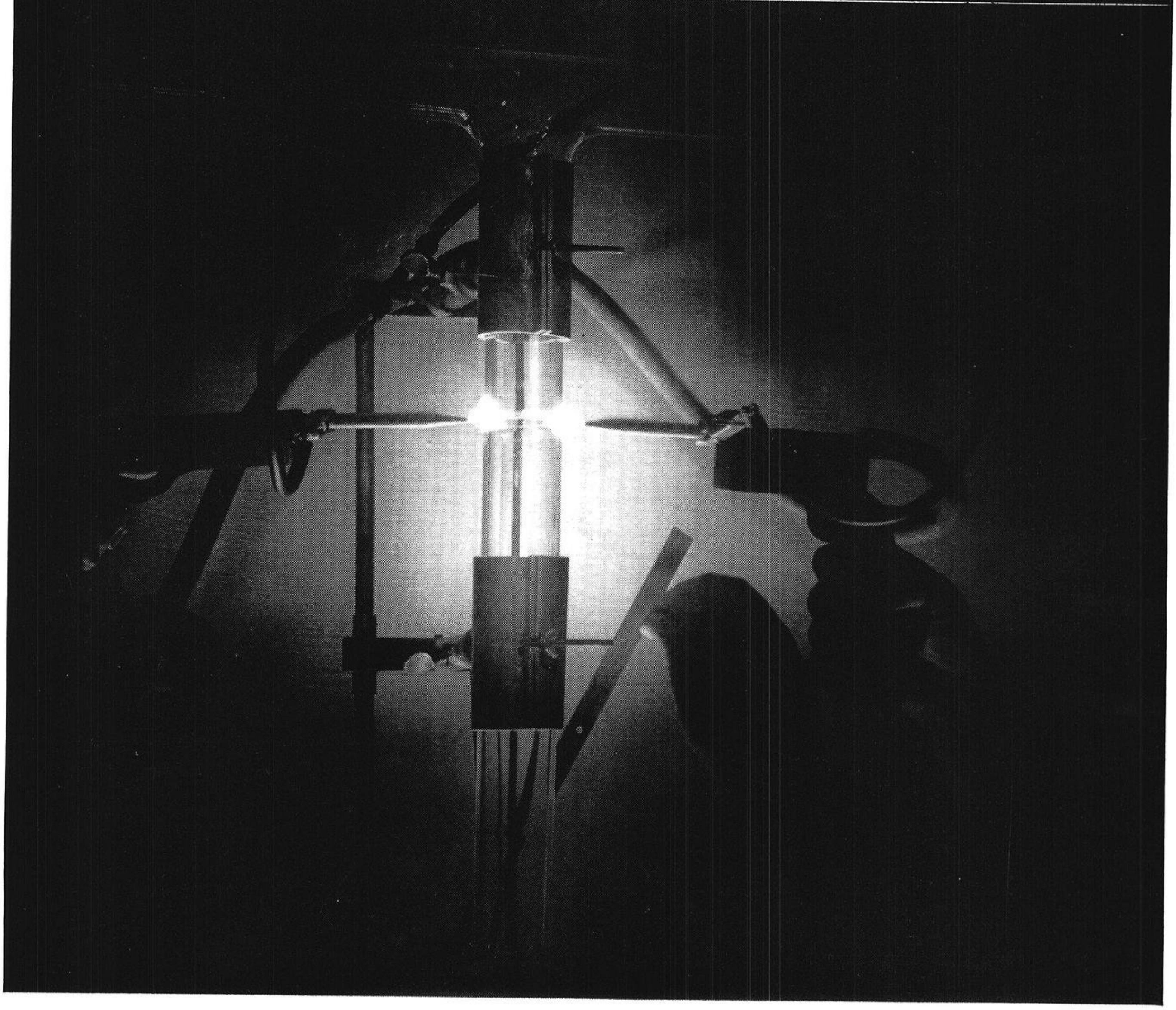
High-frequency heating is an example of electronics at work, another phase of Westinghouse leadership in electricity. Westinghouse Electric & Manufacturing Co., Pittsburgh 30, Pa.

WESTINGHOUSE PRESENTS: *John Charles Thomas, Sunday, 2:30 p.m., E.W.T., NBC. "Top of the Evening," Mon. Wed. Fri. 10:15 p.m., E.W.T., Blue Network.*

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

Sewing glass with a thread of fire...



FOR a long time industry has wanted a method by which two or a thousand pieces of glass pipe could be joined into a continuous piece. Corning has worked out a high-frequency electrical welding process that literally sews glass with fire.

It has these advantages: 1) It's faster than old methods. 2) It makes a smooth, transparent joint, just as strong as the pipe itself. 3) With the new portable welding equipment it may soon be possible to go into a food or chemical plant and install continuous glass piping right on the job.

Welded glass pipe isn't available now except to certain war plants. But it's another interesting development that points to a greater use of glass when some of the present restrictions on production are behind us. Others are a new type of glass so resistant to thermal shock that it can be heated cherry red and then sprayed with ice water without breaking; "ribbon glass" in sheets almost as thin as cellophane; and a new method by which accurate shapes of almost any size or description never before possible in glass can be quickly formed. Glass is going to play a major role in post-war. And Corning will be there with what it has learned during the war plus a background of nearly a century of glassmaking experience. You can count on it. Glass, the material with a sparkling future, will keep full pace with your own sparkling future as an engineer. Corning Glass Works, Corning, N. Y.

CORNING
means
Research in Glass

WISCONSIN ENGINEER

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MEMBER OF ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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In This Issue . . .

ON THE COVER . . .

Unique suspension bridge constructed by the Seabees on Guadalcanal . . . Courtesy Military Engineer.

DISTRICT HEATING

by Don Caldwell, ch'44

THE district heating plant for a group of institutional or industrial buildings is obviously superior to separate heating plants in the individual buildings. District heating utilizing steam is especially advantageous when low pressure steam, bled from electrical generating units, can be used. Water, sometimes used as the heating medium, is at a disadvantage when used to heat tall buildings because it must be kept under high pressure in order to force it to the uppermost parts of the structure. This difficulty is not encountered when steam is used. Steam heat is superior to water heat also in the fact that steam is easier to meter than water. Steam condenses to form a small amount of liquid condensate, but to convey the same amount of heat a much larger volume of water must be used. Both are metered after they have passed through the heating system and just before entering the sewer.

From an efficiency standpoint the district heating plan is clearly superior. The thermal efficiency of a district plant will be much higher than that of an individual boiler plant but there are other losses that must be considered, such as heat loss from the distribution system, steam leakage, and heat loss in the radiator condensate. The overall efficiency of a district plant will average at least 5% over that for a large individual plant and up to 25% over that for small installations. This difference, in the case of the large individual plant, is due to the fact that even with the great increase in size of the district plant the fixed losses of the two are approximately the same. For the small home plant the large discrepancy in efficiencies is due to a combination of the above mentioned reason and the fact that the firing in a large plant is done by experts who know how to obtain the best performance from the equipment while home firing is done by amateurs who are apt to waste almost as much fuel as they put to good use.

It is most convenient when the steam can be conveyed through a tunnel system. These tunnels are usually made of concrete or brick. The size and shape of the tunnel used will depend upon the number of pipes, the character of the soil, and the depth of the tunnel in the ground. The tunnels in a commercial district are usually buried at depths varying from 25 to 60 feet. It should be stated here that the use of such tunnels is warranted only when there are two or more services to be installed in the same tunnel, as when the tunnel has been constructed to house electric cables, gas mains, or any of a number of other public services. The use of tunnels is convenient because it makes possible the easy entrance for inspection and repair of any point in the system.

Not only is district heating more efficient and less expensive than individual heating, but it also presents many other outstanding advantages to consumers, home and industrial alike. For the industrial consumer there is a considerable saving of space and equipment. This enables the owners to utilize this additional space for plant expansion or to have any new buildings constructed on a smaller scale originally. Likewise, for the home-owner there is a large saving on the cost of equipment. In addition to this another story is effectively added to the dwelling since most basements are fairly well filled up with the heating plant and fuel bins. The convenience and cleanliness of district steam heat are outstanding talking points also. It's a few and far between husband who enjoys leaving the early morning comfort of his bed to stoke the furnace. With district heating, however, all that is necessary is that he turn a valve, set the thermostat, and go back to bed for his extra "40 winks," so accurate is the control of the heat flow made possible through this method. Much of the public smoke nuisance, especially bad in some cities, is eliminated due to the consolidation of the heating equipment in one building and the smoke controls that are now economically feasible to install on large chimneys. This means lower cleaning and laundry bills, and fewer colds. Since there are no fires in individual buildings on the district steam, the fire hazard, no mean item, is greatly reduced. This results in the lowest of insurance rates.

There is nothing especially new about central heating. It is general among colleges and state institutions. All Washington's government buildings are heated from a central plant. It is being adopted in Russian industrial cities. According to heating engineers, a home-heating revolution is overdue in the United States. Many U. S. cities have it, but Virginia, Minnesota, as a city which has gone all out for central district heating, is an example of the savings and convenience it can bring to the average American community — under either public or private operation.

(**Author's note:** The author wishes to express his appreciation to Collier's magazine and David O. Woodbury, parts of whose article, "Don't Keep the Home Fire Burning" [Collier's, Feb. 19, '44], have been quoted.

ENGINEERING METHODS APPLIED TO PHYSIOLOGY

by George Luecker, e'44

REFERENCES to the "machinery" of the human body and analogies relating body processes to mechanical devices are a common memory of anyone who was exposed to grade school science courses. However, a little study of more mature treatments of physiology will surprise people trained in the physical sciences by the remarkably profound level to which the similarity extends. It is only in the very last stages of many detailed analyses of body structure and function that physiologists must admit the inadequacy of the same laws of mechanics, hydraulics, electricity dynamics, and heat which are applied to the inanimate world and offer explanations unique to living matter. Even the division between living and non-living matter is obscure; the distinction, as in many studies, being sharp only when considering examples well removed from the transition area. Thus, a virus responsible for a tobacco leaf disease acts in every way like a living bacteria—grows, reproduces, and infects—but study under the electron microscope reveals no cell structure but molecules identifiable as protein. By reducing the virus to crystals in a test tube all animate properties of the virus can be suppressed—yet such a crystal placed on a tobacco leaf again multiplies and produces the characteristic disease.

Not only is the usual engineers technical background applicable to explaining physiological phenomena but ingenious adaptations of his investigating methods and equipment are vital in obtaining data in the physiological laboratory—the electrocardiograph for amplifying and recording heart potentials or the measurements of blood velocity with thermocouples are examples. The necessity of working on live animals without inflicting pain and, in the case of humans, without causing death, often demands extremely clever modifications of the engineers' instruments.

Suppose we consider the explanation of some of the common bodily phenomenon which would interest engineers and then take up a few of the instruments applied to the laboratory.

The properties of nerves and muscles have been studied intensively both in the living animal and in dissections extracted from them. In muscle-nerve extractions a contraction of the muscle may be induced by stimulating the nerve with an irritating chemical, a sharp pinch or blow, or by shocking with an electric potential. Pure muscle tissue, on the other hand, which is often studied to avoid the mediating influence of nerve action, is appreciably sensitive only to electrical and chemical stimulation. Because of the precise control of stimulus intensity and the choice of either single or multiple-volley impulses, an induction coil with movable secondary is almost invariably used to provide stimulation of either muscle or muscle-nerve extractions. One hundred fifty years ago the twitching of frog legs suggested to Volta the existence of an undetected elementary electric cell and his resulting development the physiologist calmly appropriated for studying the nerve and muscle properties of the same frog legs.

Conduction of nervous impulses in the body itself is largely electrical. The strands of nervous tissue are covered with an insulating membrane impervious to the electrical charges of opposite sign which collect on its inner and outer surfaces in the resting condition. Stimulation of the sensitive end of a nerve where it terminates in a specialized receptor irritable to touch, heat, cold, light, pain, or taste, for example, causes the membrane to lose its electrical insulating properties at that end. The result is a prompt (though not instantaneous) neutralization of the charge at that point. Now, it is a peculiar property of the membrane that not only does the separation of charge depend upon the impermeability of the membrane but that the impermeability of the membrane depends upon the continued separation of charge. That is, once the charge is dissipated the membrane becomes a poor insulator for a short period of time and allows charge from the next section to discharge across it in a sort of a sneak current. This action leaves the membrane of that section permeable and so on down the length of the nerve till the far end receives the impulse in the form of a discharge across its membrane.

After a brief "refractory" period—in most cases before transmission has been completed—the first sections of the nerve are restored to their original impermeability in some way, and charge again appears, making the nerve ready for another impulse. The electrical nature of the nervous impulse is easily proved by the deflection of a galvanometer connected to two points along a nerve with nonpolarizing electrodes. But the transmission velocity—about 100 meters per second—is much slower than the transmission of electricity down a metallic conductor. The

(continued on page 20)

SERVICE ENGINEERING THE AIRPLANE

by Drake P. Dale, ce'17

The Structural Repair Manual gives data and instructions for repairing the structural parts of the plane.

Standardization and weight conservation are the keynotes. Efficiency in weight saving makes flying physically and economically possible, and determines range, safety, and accomplishment. Standardization does for the labor process what interchangeability does for the replaceable parts. Once a repairman diagnoses a damage, and ascertains that for its class standard repair No. 5 is indicated, the rest of the job is routine, although it may call for care and skill. The serviceman may splice or repair a section without realizing that its design is the best that modern science can devise to maintain the original section at as near 100% of the strength of the original part as practicable, at the least possible cost in weight and effort.

The plane's longerons, stringers, frames, spars, and other structural parts are built largely of standard sections. If a structural section is completely severed, the situation might call for cutout of the torn part, and replacement with a nesting section one gage heavier, lapping a specified distance at each end. Or the situation might require a filler of the same section with one cover plate plus a fishplate at each end. Details of all the standard repairs ever to be made on that standard section are worked out once for all, are described by illustration showing rivet pattern and installation, and are indexed by being given class numbers. Likewise for all the other standard sections used in the plane.

A tapering wing spar with variable section may require a special repair if severed. A ragged hole, if entirely in the web, may still be mendable with a standard repair. In the chapter on **wing,** views are shown illustrating every expectable type of damage, and reference is made to the standard or special repair applicable. Likewise the body group, the landing gear, the nacelle, the tail group, are treated. The skin, being a stressed member susceptible to injury, is included.

Other chapters discuss the structural materials used in the plane, and their heat treatments; sealing procedures for pressurized cabins; raintighting; cleaning; anti-corrosive finishes; fabric repair; self-sealing fuel tank repair; cable splicing; testing; repair records. Tables include properties of all the standard sections (formed sections, tubing, extrusions, sheet) used in the plane; preference list of specifications for the various materials (acetone, alcohol, aluminum bar, etc.) used in the pane; British material replacements for AN standards; conversion tables of gages, and others.

The Weight and Balance Book. Control of weight and balance in the plane is so important that a service manual is devoted to it. A plane nose heavy or tail heavy can easily result in inefficient or dangerous performance, materially restrict the range, or even result in failure of the ship's mission.

Design of the plane is expected to result in normal flying conditions for the plane empty, fully fuel-loaded, or fuel-plus-cargo loaded. One of the serviceman's duties is to load the ship so that the center of gravity or dead-and live load can be kept within proper limits at all times. One of the illustrations in the manual is a phantom view of the ship showing the various compartments, accompanied by a table giving the cubical contents of each, the x-y-z dimensions of each, the x-y-z coordinates of each, weight restrictions on each. Typical problems discussed are determination of gross weight and center of gravity for specific loading condition; center of gravity adjustment by relocating cargo or crew; gross weight and center of gravity change due to expenditure of variable load items.

Special instructions in the Armament Handbook are relied on to control order of releasing bombs so as not to unbalance the ship unduly at any stage of unloading; the pilot is schooled in fuel and oil control (by means of selector valves) to the same end; there remain for manipulation other cargo, stowed furnishings, the crew.

Integrating graphical methods are commonly used for solving loading problems. An ingenious device for this use is in circular slide rule form with three discs. To get the result of an assumed given loading, one begins with the moment at the ship's centroid for the empty ship; then adds algebraically the moment effect of the fuel load as calculated by the rule, of the oil load, of the crew load, the cargo load, etc., until all the partial loads are considered. If the resultant moment is excessive, the effect of shifting is calculated, until satisfactory loading is found. During flight, the moment effect of the changed

(continued on page 22)

GAS WARFARE

by Fabian Brusoc, ch'45

DURING the trying years of Hitler's regime, the most talked subject was the use of war gas. The gases which held the spotlight were ones which were lethal in small concentrations. They are also the most interesting, but by no means the most important. It's simple to see that they would be the most talked about and people do the most worrying about because of their toxic effect. So, poisonous gases, being the type of gas people are most familiar with should be the first topic of discussion.

The title "Father of all War Gases" we can bestow upon chlorine. It was first used in World War I on April 22, 1915. The Germans used it on the French Colonial and British troops in Belgium, and this climaxed a rush between the allies and the Germans to outdo each other with new poisonous gases. There were, roughly, 300 gases developed during the World War I, but of all of these, only 25 or 30 were actually used and only about six survived to see the end of the war. They are as follows:

Troops advancing under gas attack.

Mustard gas, phosgene, chloropicrin, ethyldichloroarsine, diphenylcyanarsine, and bromobenzyl. We might add here three others, the lacrimator, chloroacetophenone; the irritant smoke diphenylaminechloroarsine; and the vesicant, chlorovinyldichloroarsine (lewisite), which were developed in this country during the war, but were not used on the battlefield.

There are many other gases that are used for warfare. Some of which are used as much during peace time as on the battlefield. In this class we put our smoke screens and lacrimators. Where are they used during peace time? Have you ever seen skywriting? Here they have used most commonly the H-C mixture or Titanium tetrachloride. Titanium tetrachloride is the most effective where the air is rather humid. Then the lacrimators are used very widely during group clashes by law-enforcement officers. Here we should be well acquainted with this type during our annual Homecoming celebrating. A lacrimator is commonly known as tear gas.

There are three types of gas we have not mentioned. There are the lung irritants which cause irritation of lungs, vomiting, tears, coughing, and leaves the victim with a doped feeling. Another one is the sternatator—nose and throat irritants. They have the odor of coal smoke or shoe polish, some of which just cause vomiting and give the victim an uncomfortable feeling, while one of the gases of this type if the concentration of it is greater than 130 milligrams per cubic meter. The last type of gas comes under the title of systemic. This type causes internal poisoning. Of all the gases listed in this group, only one has any important significance. That one is HCN —Hydrocyanic Acid. It has the odor of bitter almonds and is extremely toxic. Two-tenths of one ounce in one-thousand cubic feet is extremely deadly. The only trouble with it is its very short life of deadly effect. It is dispersed very readily in the slightest breeze.

It may seem strange, that with all this preparation both costly and elaborate, we have not yet heard of any report of the use of the gas in the present war. Chemical warfare has been confined to smoke screens, incendiaries, and flame throwers. Why haven't poisonous gases been used? Alton L. Kibler, chief, Information Division of Edgewood Arsenal sums up the reasons as follows:

1. They have not needed them. Until the attack on England nations were conquered by a few weeks of blitz.
2. Advances have been so rapid, gases could not have been used without endangering their own troops.
3. Fear of retaliation.
4. Fear of world opinion.
5. Gas is being held in reserve for surprise attack when it might mean final victory.

Hydrogen Cooled Generators

by William Ille, me'44

WITHIN the last 6 to 8 years, orders are being filled for hydrogen-cooled generators. Sizes built range from 25,000 KW to 60,000 KW at 3600 rpm, and from 65,000 KW to 150,000 KW at 1800 rpm.

Hydrogen cooling for electric rotating machinery was first suggested in this country by Dr. Whitney of the General Electric Research Laboratory about 1921. Laboratory tests on actual machines operating in hydrogen and other gases showed hydrogen superior to all other known gases. The turbine generator was early recognized as a particularly desirable application for hydrogen cooling, due to its high windage losses and adverse coolings factors. The chief problem is sealing rotating shaft extensions, and much money and time has been expended developing a suitable shaft seal.

First the hydrogen-cooled synchronous condenser and hydrogen-cooled frequency converter were introduced. With these machines, the problem of sealing the rotor shaft was not present; the entire unit can be completely enclosed in a gas-tight housing. There are now quite a number of these two types in service, and their performance has been highly satisfactory.

The first generator to go into commercial service with hydrogen cooling was a 25,000 KW unit in 1937. Following about one month later, a unit of 150,000 KW capacity was put into service in the Chicago area.

Present acceptance of hydrogen-cooled turbine generators by the power industry has been brought about chiefly through the demand for increasingly larger units at 3600 rpm. Although improvements in materials and ventilation methods have been important factors, hydrogen cooling, offering approximately 20% more output from a given amount of material, has had a dominant part of this development.

There are certain advantages of hydrogen cooling:

1. Due to low density of hydrogen, windage losses of a machine operating in hydrogen (above 95% purity) are one-tenth of their value in air.

2. As a result of the superior cooling properties of hydrogen, about 20% greater output can be obtained with the same amount of active material, for the same temperature rise of the windings. (Hydrogen has a thermal conductivity 7 times that of air, which greatly reduces the thermal resistance of all heat flow paths that include gas spaces, such as the insulation and laminations. Also, the rate of surface heat transfer in hydrogen is about 35% greater than in air, which permits increased surface intensity of loss for the same surface temperature rise.)

3. The effect of corona on insulation is negligible in hydrogen, and the insulation retains its flexibility longer.

4. As hydrogen will not support combustion, fire hazard is eliminated.

Since windage losses may represent from 40 to 50 per cent of the full load losses, in an air-cooled turbine generator, the use of hydrogen cooling results in a considerable gain in efficiency. At partial loads, this gain is considerably greater than at full load.

The size of gas coolers of hydrogen-cooled machines is only a fraction of that of air coolers. Losses to be removed are much less and rate of heat transfer to the cooler tubes is much greater.

The chief disadvantage usually associated with the idea of hydrogen cooling is the possibility of an explosion. However, if the amount of hydrogen by volume in a hydrogen-air mixture is kept above 75% or below 5%, the mixture cannot ignite. The purity of the hydrogen mixture is automatically maintained at 95% to 97%, well above the upper limit of inflammability.

In filling the casing with hydrogen initially, the possibility of having an explosive mixture is avoided by first displacing the air with an inert gas, such as carbon dioxide. A mixture of about 70% carbon dioxide in air is obtained before the hydrogen is admitted. Also when removing the hydrogen from the machine, carbon dioxide is first introduced until a mixture of about 90% carbon dioxide in hydrogen is obtained. This mixture is then removed by admitting air to the casing.

To provide against failure to follow defined procedure, or any failure of the equipment which could result in an explosive mixture, the frame of the machine is designed to withstand the force of a hydrogen explosion. By actual test with most explosive mixtures of hydrogen and air, this pressure has not exceeded 50 lbs., while frames and end shields of hydrogen-cooled machines are designed to withstand 250 lbs. without permanent deformation. These casings are usually welded in cylindrical shape to give maximum resistance effect to explosion.

In all cases anticipated benefits from hydrogen cooling have been realized, and are felt to justify the large amount of development work that preceded the introduction of this new-type machine. The future of the hydrogen-cooled turbine generator will depend largely upon the trend in turbine construction. In general, hydrogen cooling for turbine generators may be considered economical for machines in the larger capacities for which power saving is usually sufficient to justify the additional cost.

POISONING AND CHEMISTRY

by Douglas Johnson, ch'45

IN DEALING with the scientific, it is well to recall the statement of Scheele, one of the greatest chemists of all times, who discovered oxygen, chlorine, manganese, and baryta. Scheele said, "It is the truth alone we desire to know, and what joy there is in discovering it." Knowledge is the common property of all who have sufficient initiative to use and understand it. It is available if they wish to turn it to their advantage. Thus one's discoveries which appear to be only of restricted theoretical interest, may ultimately prove to be a powerful tool to the medical worker in saving millions of lives or to the criminologist in countering the efforts of "clever" criminals.

Now let us pick chemical analysis out from the list of many different sciences and, to be more specific, apply it to the uses of the criminologist. Indeed there are few problems with which the modern criminologist is concerned in which his services are required. Very often these services have only a small bearing on the problem on hand; but all together they make up the teeth that makes the cogwheel go around.

To find out how the chemical science is used in modern crime detection, let us delve into the problem of murder by poison. The poisons that can injure or kill a human are very numerous and varied. A short list would include many coal tar products, hydrocyanic acid, mineral and organic drugs, alkalis, lead, mercury, and arsenic compounds, and many organic drugs. Partly because of the varied nature of the substances involved, and partly because, as a rule, they occur only in very small quantities and in association with a large proportion of material from which they are not easily separated in the pure state, the question of identification and determination of the quantity of poison is often very difficult. However, with greater applications of new scientific methods of identification of substances, the problem is being solved.

In continuing our consideration of poison detection by the chemist, it is perhaps best fitting to refer to arsenical poisoning for an actual case, since for a long time arsenic has been a favorite among poisoners. Arsenic was probably used most frequently because of its lack of taste, ease of obtaining, and its symptoms are often similar to those of natural diseases.

Now in an arsenic case, the goal of the analyst is not only to identify the poison and prove its presence, but also to show that the amount present would have produced fatal results. This is a very high standard indeed. In carrying out the test, all those internal organs of the victim likely to contain the poison must be removed and have the poison removed from them or at least concentrated. This is usually done by boiling the organic in acid until the whole bulk is concentrated. Then, if testing for arsenic, the material thought to contain arsenic is added to a solution in which hydrogen is being liberated. This so-called "nascent" hydrogen reduces the arsenic compound forming arsine, AsH^3, a substance that is a gas at ordinary temperatures. The gas goes out through a small glass tube from the reactor. This outlet tube is strongly heated at one spot, and, as the arsine passes by, it is converted back into arsenic and hydrogen. The arsenic is deposited on the tube as a black deposit and the hydrogen escapes. By measuring the size and blackness of the arsenic deposited, the quantity of arsenic present in the victim can be determined. Then by weighing the body and comparing the amount of arsenic present with the body weight, it is possible to determine whether or not a fatal dose was present in the body.

This is only one instance of the many hundreds of cases where chemistry is playing a definite role in the detection of fatal poisoning cases. Other methods have been developed to test for all the many other known poisons. However, the success of the procedure depends on the skill of the analyst, because the quantities of poison are very small and the use of unfamiliar poisons, the chemistry of which is not known, often crops up, particularly in the East.

Through the actual practice of chemistry in the prosecution of criminals, scientific methods, if properly applied, have never been known to fail in the long run. We may then close this paper with the note of confidence that in the struggle of science against crime the former will win out over the evil.

POLYGON

ROLAND WETZEL

The V-12 member of Polygon, Rolly Wetzel, came to Madison from the Milwaukee Extension Division. He attended Shorewood High and was a member of the varsity track team for two years. His leisure hours were taken up in gardening and fishing, but he has not allowed the latter to interfere with his college work as his sophomore high honor standing indicates.

Rolly, being a true engineer at heart, spent the summers of '41 and '42 obtaining practical experience at Allis Chalmers and Ansco Drafting.

His activities since attending the University at Madison have consisted of being a member of the track team, Navy Chorus, A. I. Ch. E., Theta Chi, Tau Beta Pi and Phi Gamma Upsilon.

After completing his Chemical Engineering course here he hopes to be sent to Midshipman's School after which he will receive his commission.

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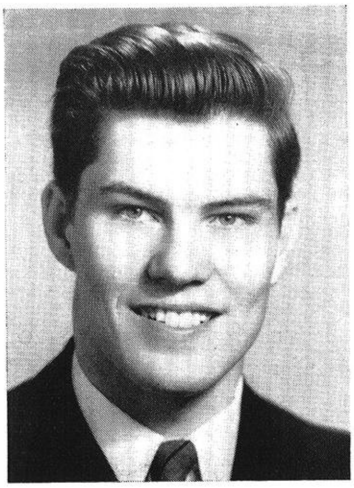
GORDON ROBECK

Born at Denver, Colorado in 1923, his parents later moved to Madison where Gordy attended Madison Central in preparing to become a Civil Engineer. While at high school, tennis, basketball and the school chorus took up his spare time. His interest in forestry led him to become a member of 4H club.

During the summer months Gordy kept up on his Civil Engineering by attending the U of W surveying camp for two years. Recently he has kept on the straight and narrow by working as surveyor on the Highway 30 improvement project. His love of the outdoors combined with an interest in mathematics led him to take up Civil Engineering work.



Gordy is now vice president of A. S. C. E., vice president of Chi Epsilon and a member of Tau Beta Pi. The remainder of his leisure time is taken up by participation in intramural sports.

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JOHN SHAW

John hails from Cleveland, Ohio where he blessed his parents in 1923. Later the Shaw family made Verona, N. J. their home and it was here that their son attended the Henry B. Whitehorn High School. His literary ability was brought out while in high school where he became Co-Editor of the "Bookworm", a literary magazine, Co-Editor of the "Verona Gazette" and finally editor of the latter publication. It was while on the "Verona Gazette" that he was gently accosted by members of the faculty for expounding his own ideas too freely. All ended in young Mr. Shaw's favor however.

Other leisure activities consisted of radio, music, photography, and in conjunction with his paper work, printing. He spent his summers working at the Std. Tool and Mfg. Co. in Arlington, N. J. on such things as high frequency furnaces.

John claims to be a born Electrical Engineer. His father is in the same profession and as early as 1933 radio experimentation took up an important part of John's leisure activities.

Since coming to Wisconsin he has become vice president of Eta Kappa Nu, secretary of Kappa Eta Kappa, and is a member of Pi Mu Epsilon, Tau Beta Pi and A. I. E. E. Another

BOARD

important phase of his work at Wisconsin is in the physics department where he is now analyzing Nitrogen with the aid of the mass spectograph.

Marine communications is his present plan upon entering the armed forces after graduation.

WAYNE MARCOULLIER

Born in Oconto, Wisconsin on April 19, 1922 AD he later moved to DePere, Wisconsin to make his mark in the world of sports on the DePere High School basketball and football team. Speech, photography, baton twirling, and music are among his other activities while in DePere. His work in music and baton twirling won him a national championship for trombone playing and one for twirling.

An interest in airplanes and mathematics were the factors which decided his professional career in Mechanical Engineering.

While at Wisconsin he has been active as a member of A. S. M. E., S. A. E., Pi Mu Epsilon, and Triangle, senior class treasurer, prom chairman, freshman orientation chairman and drum major in the University of Wisconsin band.

•

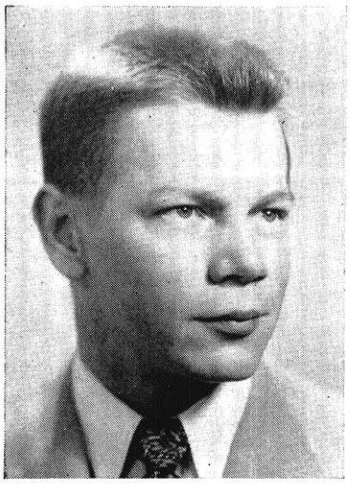
BOB JIRUCHA

Bob was born in Racine in October of 1922. He attended Washington Park High School, where he was on the student council and in the school chorus. Football and track were the athletics that he participated in.

He is the second of his family to enroll in Mechanical Engineering at the University. It was partially through the influence of his brother that he came to Madison.

During his summers, Bob worked at the Massey-Harris tank plant in Racine. M-5's and M-15's were his specialty.

Besides Polygon, Bob has participated in many extracurricular activities at Wisconsin. He is a member of SAE and MESW, finance chairman for the prom, and a mem-



ber of the varsity boxing team.

Bob plans to leave soon for service in the Navy Air Corps.

•

BILL WENDT

Bill, who claims Wauwatosa as

his home town, is a graduate of Washington High in Milwaukee. During his stay there, he served a two-year term as sports editor of the high school paper. He was a member of the Washington players, and vice president of the literary society.

When he came to Madison, Bill went out for freshman baseball, and won a minor letter in that sport. He also played ball in the Industrial league. However, a heart ailment has prohibited him from continuing in that sport.

Bill is an honor student, being a member of Phi Eta Sigma and achieving Sophomore Honors. He is Residence Halls housefellow, was a member of Pershing Rifles, and chairman of the St. Pat's Dance. He also played intramural basketball and football.

During his stay at the University, he has served as an instructor in Physics and Drawing. Two summers were spent as a draftsman at Nordbergs. After graduation, Bill intends to get into the field of Diesel Engineering.

LOOKIN' BACK

by Don Niles, m'44

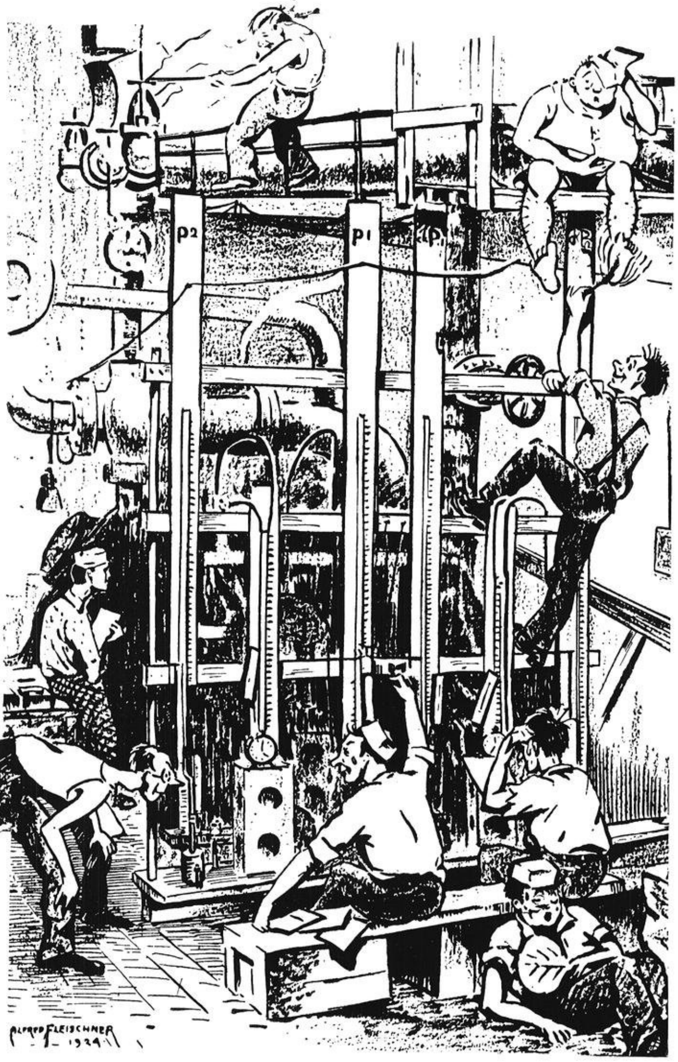
English!! As if we needed any training in our writing. Do they think we will be dumb?

When we were frosh the seniors said, "It ain't what she used to be." But we did okay for ourselves.

Only the seniors can remember the exposition. Oh what fun—and work.

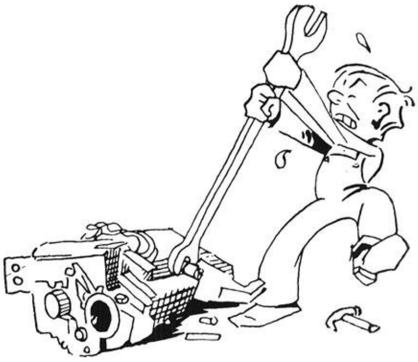
Madison is beautiful in spring, such lovely flowers, green grass, and those limbs—ahh!

What would the poor m.e.'s have done in chemistry without those cookbooks?



The heating plant experiment in M.E. 73 caused many a headache . . . at 5 a.m. at that.

Take the word of one who knows—M.E. 124. Ouch!



No story would be complete without those St. Pat dances.

Cigars have a new meaning to us now.

S-T-A-T-I-C

by Fabian Brusoc, ch'45

Some girls are not afraid of mice—others have pretty legs.

•

Stranger: "How about a ride, sister?"

Girl: "Going north?"

Stranger: "Sure thing."

Girl: "Good. Give my regards to the Eskimos."

•

Then there was the lawyer who asked for the definition of a "privy council." The sewage disposal commission. of course.

Election year again.

George, whose only means of support was his rich father, was being married. Everything went well until the bridegroom had to repeat the words: "With all my wordly goods I thee endow."

The congregation was then startled to hear a moan from his father: "Gracious!" he muttered. "There goes his radio set."

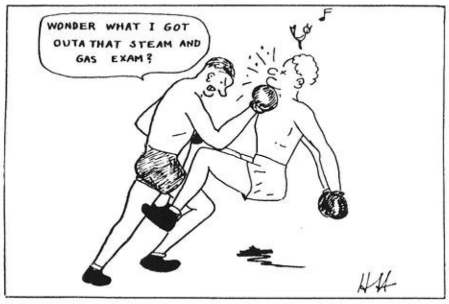
•

Friend: "Hey, you look sick! What happened to you?"

Man: "Last nite I dreamed I was eating shredded wheat, and when I got up this morning, most of my mattress was gone."

•

There are two things some fellows miss most—gas and whiskey.



First V-12: "Do you think love is blind?"

Second V-12: "I don't know about it being blind, but I've seen some examples that convinced me it is half-witted."

•

He had been working at the shipyards for several weeks when he arrived at his boarding house one evening with his pet skunk. His room-mate when he convinced himself that the animal was no ordinary pussy, asked him what he was going to do with it.

Shipyard worker: "I'm going to tie him under the bed."

Roommate: "But, what about the smell?"

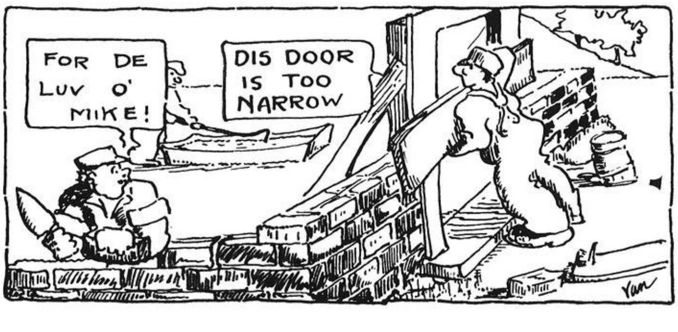
Worker: "Well, he'll have to get used to it like I did."

•

A man gives a party to entertain his friends; a woman gives a party to snub her enemies.

•

A judge was sentencing a criminal: "I'm giving you the maximum punishment—I'm letting you go free to worry about taxes, rationing, shortages, and everything else like the rest of us."



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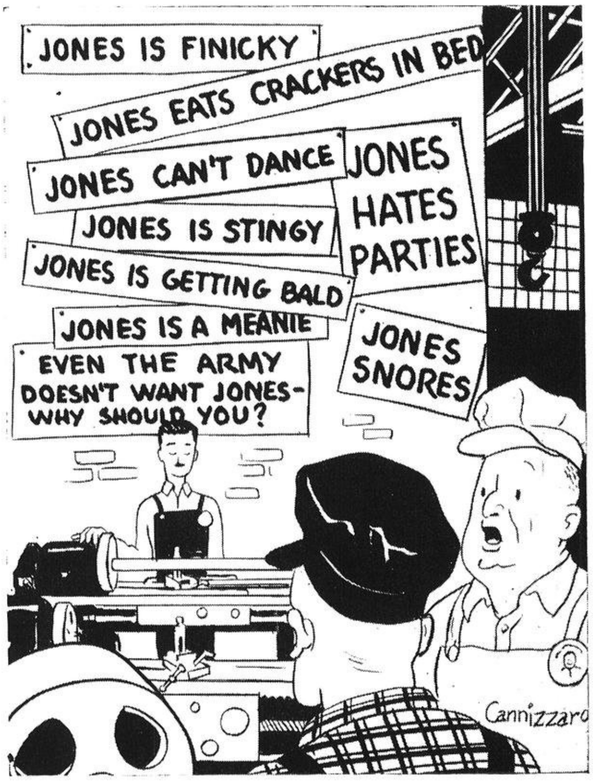


Jones figures this will be his hardest year to stay single.

STATIC . . .

(continued from page 16)

The class was doing arithmetic:

Teacher (to one student): "How much would your father give you if he wanted to send you to the store to buy 4 pounds of coffee?"

Student (objecting): "He'd never buy that much at once."

Teacher: "Never mind that. How much would he give you?"

Student: "But teacher, he doesn't like coffee. He'd not give me anything."

Teacher (sternly): "Now, no evasion. What would he give you to buy that coffee?"

Student (protesting): "Nothing, I tell you, if he did like coffee, which he doesn't, and if he would buy that much, which he wouldn't, and if he would send me to the store, which he wouldn't—he'd use the telephone—he'd have the store charge it."

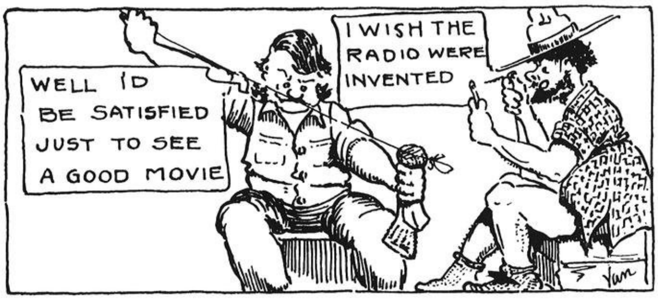
Teacher: "But supposing he did do it anyhow?"

Student: "O, teacher, you wouldn't ask such questions if you knew my father."

•

Junior: "Dad, what are untouchables?"

Dad: "Well, a good example of an untouchable is the guest towel in the bathroom."



Bullock advises us that he once attended a party where the girls dressed in the colors of their boy friends' hair.

"And one girl had to decline the invitation to attend," Bullock says "Her boy friend was bald, so she didn't want to come to the party."

•

Rastus: "Boss, Ah gotta get off tomorrow to go to a lodge meeting."

Boss: "I'm afraid I can't spare you tomorrow."

Rastus: "But, Ah gotta go, 'cause Ah's de sublime king."

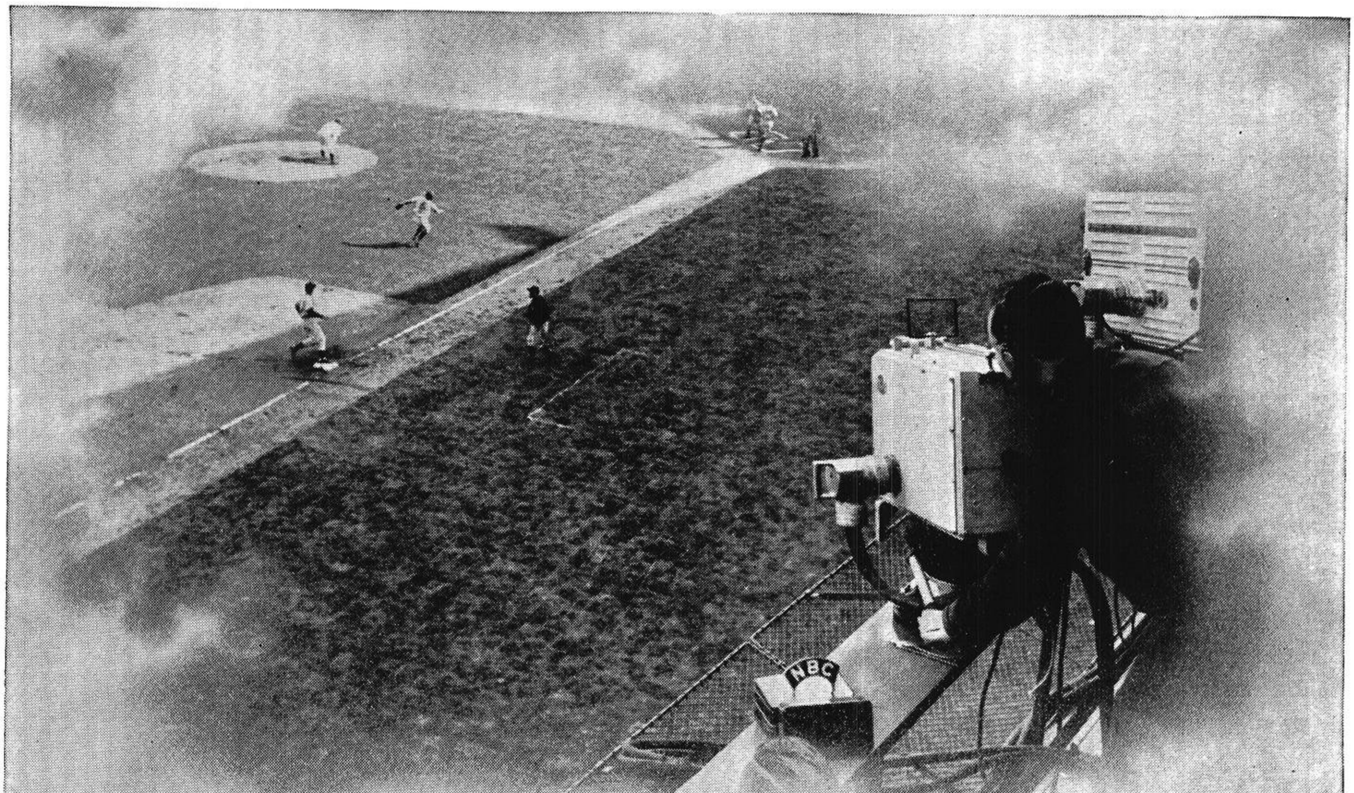
Boss: "What! And you just joined two weeks ago?"

Rastus: "Well, you see, suh, in our lodge, de sublime king am de lowest office what dey is."

•

Young Man (eloping): "How much is the fare?"

Driver: "That's all right. The young lady's father has settled all that."



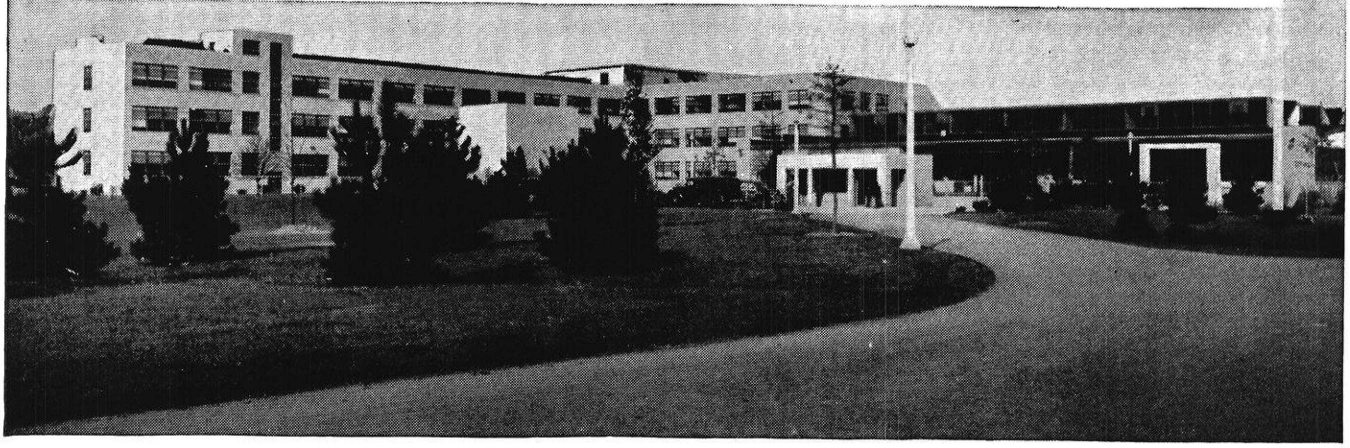
NEW VISIONS for Tomorrow's World

● IT DOESN'T MATTER NOW whether clouds hide the sun, or whether evening shadows fall on the baseball diamond. If the fans in the grandstand see the game so can the modern television camera.

That was not always so; the pre-war television "eye" needed as much sunshine as it could get to illuminate the scene. The same was true of football—final quarters were occasionally "washed out" on the television screen.

But thanks to research, conducted at the RCA Laboratories, a new super-sensitive television camera, rivaling the human eye in its ability to see under conditions of poor light is in prospect for the post-war world. Then, by television you will see every last-minute play of the ball game as clearly as if you were in the stands. Entertainment, sports, news events will pass before your eyes with every detail, every shadow faithfully reproduced.

Today, RCA's research facilities are devoted to providing the fighting forces of the United Nations with the best radio and electronic equipment available. Tomorrow, these same skills will continue to serve America in developing and creating new and finer peacetime products.



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TUNE IN! RCA's great new show, 7:30-8:00 P.M. EWT, over the Blue Network, every Saturday ★ BUY WAR BONDS EVERY PAY DAY ★

PHYSIOLOGY . . .

(continued from page 7)

explanation is that nerve transmission is not ordinary longitudinal conduction but the discharge of a series of minute condensers, progressing longitudinally (but with the actual current flowing transversely), the discharge of one being necessarily accomplished before the succeeding one may discharge. Actually applying a DC potential across a length of nerve fibre confirms this fundamental difference by showing the usual high velocity of transmission associated with metallic conductors.

The blood system is particularly rich in engineering material. The two sides of the heart are, in effect, two separate pumps—one for pushing blood through the resistance of the systemic circulation for nutritive purposes and the other for forcing the returned blood through the resistance of the lung capillaries for aeriation. The volumetric output of the heart is maintained constantly under normal conditions by several "governing" nervous controls but unusual demands for oxygen supply or muscle cooling, as during exercise, are met by stimulation of other nerves which increase both the "stroke volume" and heart rate.

Consider the three following applications of hydraulic theory:

To prevent the "water hammer" effect on the arterial system at each contracting stroke of the heart, the arterial walls are constructed of extremely elastic tissue which serves to buff out pulsations. By the time the blood arrives at the capillaries this is so complete that no pressure fluctuation is discernable and flow is uniform.

To route the blood to the most needy parts of the body under various conditions of activity, the bore of the smaller arteries are under muscular control. The high viscosity of the blood makes this particularly effective because the internal fluid friction goes up rapidly with decrease in cross section with such a liquid.

The progressive reduction in cross-sectional area of the vessels as the blood goes from heart to capillaries might be expected to cause a corresponding increase in velocity. However, it has been estimated that the total cross-sectional area of the capillary bed is about 100 times that of the first artery at the heart so that the velocity is actually much reduced, thus facilitating the transfer of material through the capillary wall between blood and tissue.

In the blood clotting mechanism of the blood a long series of chemical reactions ending in formation of a sealing clot are set off by the contact of the blood with bruised tissue of a wound but their action is delicately restrained by the action of other chemicals during normal conditions so as to prevent dangerous internal clots from forming.

Now, there are several interesting engineering instruments that should be mentioned.

In early studies of blood circulation the volume discharge per unit time was basic in the arguments of Harvey against the old conception of a daily tide of blood which flowed out from the heart in the morning to return at night. A crude determination was made by tapping the wall of an artery and timing the discharge into a volumetric bulb. Such procedure is applicable to dogs but is repugnant to human subjects, so a clever solution based on the same heat transfer theory used on the condensers and heaters in the steam and gas labs was developed. A small heating element is placed over the skin at an artery and a differential thermocouple reads the difference in temperature of the blood in the vessel—before and after the element—in the same way. From the specific heat of blood, the thermal conductivity of the skin and arterial tissue, the energy to the element, its length, and the room temperature, the discharge of blood through any superficial vessel of the body may be determined with great accuracy.

In studying the variation of blood pressure during the heart cycle a mercury manometer was tapped into a blood vessel. This again was rough on humans and had the additional disadvantage of possessing so much inertia that the peaks and minimums of the pressure wave were never recorded. A solution, which Dr. Gilson of the University of Wisconsin has developed into a unit the size of a piece of art gum, is to use a photo-electric recorder. A hypodermic needle, which may be inserted into human subjects with relatively little discomfort, is attached to a short length of flexible tubing ending in a chamber topped with a sheet rubber diaphragm so that the variation in blood pressure causes a compression of the air in the chamber and a displacement of the diaphragm. This is a very low-mass system and its motion is transmitted without disturbing that advantage by the interference of a strip of paper (glued perpendicularly to the diaphragm) with a light beam falling on a photo-electric cell. The cell output is amplified and recorded on sensitized paper by a string galvanometer.

One of the most refined instruments of research and diagnosis is the electrocardiograph for analyzing heart action. When any muscle contracts it sets up minute voltages over its length and heart muscle is no exception. With electrodes placed directly on an exposed heart, an amplifier may be used to detect these varying voltages during the heart cycle.

A research version of the instrument has also been developed in which the three potentials are applied to three radial sets of deflecting coils arranged about the axis of a cathode ray tube with angular spacings corresponding to those of the three conducting planes in the body. These voltages cause deflection of the electron beam from a circular sweep pattern.

It has been my purpose to direct the engineers attention to the striking similarity with which he and at least one branch of the biological scientists attack their problems and perhaps add weight to the view that an engineer's training need not find the limit of its application within the strict boundaries of the profession.

SOPHOMORE HONORS

Ranking at the top of their class are the following sophomores:

SOPHOMORE HIGH HONORS

Chemical Engineering

Stewart, Warren E.	3.00
Johnson, Douglas L.	2.97
Harris, Elwin A.	2.94
Daub, Edward E.	2.91
Blumenfeld, John F.	2.90
Zamzow, William H.	2.65

Mechanical Engineering

Brusberg, Jack L.	2.86
DeLong, William R.	2.82
Derks, Richard J.	2.64
Koetting, John L.	2.60

SOPHOMORE HONORS

Chemical Engineering

Strohm, Jack A.	2.42
Kluberton, Thomas R.	2.41
Hlinak, James C.	2.40
Kulakow, Sheldon E.	2.34
Manny, Benjamin L.	2.15

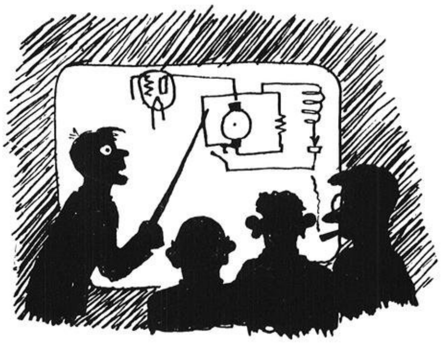
Getting hooked.

Electrical Engineering

Garber, Richard L.	2.31
White, Viola J.	2.25
Vasilion, James L.	2.18

Mechanical Engineering

Rose, Paul J.	2.60
Holmes, Vet V.	2.51
Tiedemann, James B.	2.51
Hollinger, Robert L.	2.26
May, Harold L.	2.21
Smart, Edwin A.	2.18



It's all in the dark.

SERVICE ENGINEERING . . .

(continued from page 8)

fuel loading, the oil loading, etc., can be calculated and summed up for the existing partial loads.

The General Manual for Structural Repairs is issued by joint action of the Army Air Forces, the Navy Bureau of Aeronautics, and the British Air Commission. It represents the effort to standardize repair practice in the three services. It deals with repair item so general as to apply to all airplanes, whether repair is to be made under base or combat conditions.

By recording data basic to all planes, this manual eliminates the necessity of duplicating such data in many manuals. It covers nomenclature; properties, heat treatment, and identification of materials; tables of rivets, bolts, and standard parts; standard processes such as cable splicing, welding, and anticorrosive precautions.

This manual is one of hundreds on aeronautical subjects issued by the federal government. It fits conveniently into the series.

The other books of the series relating to the principal systems deal in standard fashion each with its appropriate installation. Typically, Chapter I of the **Radio Manual** is entitled **Theory of Radio,** and has the following intriguing headings: Chemical and Physical Basis of Matter; Transverse and Longitudinal Waves; Basic Condenser Phenomena; Energy Radiation; Vacuum Tube Operation; Elementary A-C Phenomena; Conditions of Resonance; Filter Circuits; Radio Equipment of the X-N Airplane.

Writing a Manual (The Parts Catalog)

The announced purpose of this project is to list all replaceable parts of the plane—obviously an important element in any servicing program. More specifically the aim is to enable a customer to order by number any desired part or assembly.

The particular Parts Catalog examined is divided into five sections. Section I describes the plan of the book, and gives directions for the user in identifying and ordering parts and assemblies. Section II is the Group Assembly Parts List, an outline breakdown of the major assemblies into their sub-assemblies; these into their sub-assemblies, and so on, by name. It enables users to call the various assembly units by their right names, a material aid in getting dependable part descriptions. Keyed illustrations help visually in describing such parts from a single bolt to major component installations of the airplane. A plane may have hundreds of thousands of parts: systematic identification is important. Here the truth of the proverb, "A picture is worth a thousand words", becomes real.

Section II may be called the parts list proper, since reference is there made to the figure where the part is picturd and its part number is given. The index to a textbook is ordinarily alphabetical; this arrangement is based

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SERVICE ENGINEERING . . .

(continued from page 22)

on the relationship of parts. Typographically the indention shows subordination of parts and groups of parts.

Section III is the Numerical Parts List. All parts entering into the construction of the plane are here listed in numerical sequence. At this point we need consider the system used for identifying the various parts and assemblies.

Each part in the plane has its part number stamped upon it: each part also bears the same number as the drawing describing it. The drawing number identifies a part similarly to the way in which the section, township, range, meridian numbers identify any square mile in the United States. In the designation K67WO742-8, 67 might refer to model 67, W to wing, 07 to the beltframe series, 42 to the serial number of the assembly, and -8 to the particular stiffener or sheet in that assembly. K refers to the size of drawing. Thus a designation (number) positively and completely identifies a part.

Incidentally we may here note the vast advantage to the manufacturer of **interchangeability,** and the important role it plays in speeding production. Model 67 might be a cargo plane. Suppose it is desired to get up a passenger plane, to be called the 72, by converting the 67. Such change might by accomplished by eliminating freight bins and doors, and installing windows, seats, heating and ventilating, oxygen systems. The wing might not be changed at all. In that case duplicates of all the 67 wing drawings would be released for wing 72. Plane 72 would then bear parts stamped 67: but no harm is done thereby, since the only purpose of the imprint is to identify the part. The manufacturer would save the time and cost of redrawing or revising the many wing drawings; or new tooling; of a new set of dies, jigs and fixtures.

Every plane is an aggregation of parts brought together from hither and yon. If every part had to be designed and built from scratch, the plane would be obsolete long before it could be put into production. No one would think of getting up a new series of bolt and nut standards, with the ample heritage we now have; for the same reason we select engines **here,** hydraulic assemblies, turrets, thermostats, ailerons **there** or from whatever plant can best serve the purpose.

In Section III, on the same line with the listing for each part, are listed also the page where the part is called out, and the quantity (number of times it occurs in the airplane.) The quantity is useful to know for estimating the stocks required for servicing at the various echelons of service. A depot may require a certain percentage of the ship quantity, a subdepot a lesser percentage. The quantity is useful also for calculating **weight,** the ever-present bogey.

Section IV is the Standard Parts List. It is similar to Section III except that only standard parts are listed therein. Certain designs series of bolts, nuts, bushings, turnbuckles, etc., occurring in standard sizes, materials, finishes, are detailed and catalogued in available reference books. These parts can be cited by using the appropriate reference number. They may be shown on company drawings by conventional representation only. "AN" refers to Army-Navy Aeronautical Standards; "NAS" to National Aircraft Standards; "R" (or some selected letter or letters) to standards set up by a particular manufacturer. Since these parts (e.g. bolts) occur in vast numbers throughout the ship, reference is not given to every assembly in which they occur. Their total number however is shown, and the total number required for attachments. Rivets are called out AR (as required) but are not indexed nor their amount stated.

Section V treats of the special tools and equipment required for servicing a plane. The utility of this section is demonstrated by the example showing the necessity for complete and adequate servicing, cited early in this article. This information is just one more item which experience has shown is necessary for the education of a serviceman, especially for the present-day average man, whose background experience may have been in fields remote from mechanical matters.

How does one use the parts list? If the part numbers could always be read from the damaged parts, and if one could be sure of including in his order all such parts needed after every accident, such numbers might merely be listed in the requisition for new parts. But gunfire, or a belly landing, or a fire, may cause some parts to be mangled or lost. In such cases, the diagrams, the illustrations, the Group Assembly Parts List of Section II, may be used in arriving at fairly accurate verbal descriptions of the wanted parts. From the **breakdown** the keyed illustration is found; nearby, and referenced therefrom, the part numbers are given.

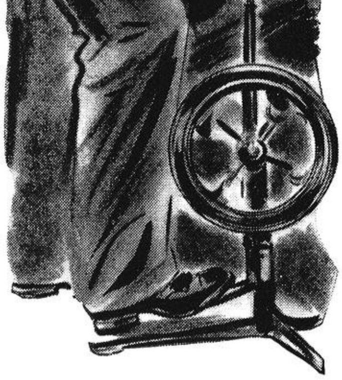
How does one proceed to get up the parts list?

For obvious reasons such list cannot be compiled until all the drawings are released. A drawing may undergo many and fundamental changes before release. It sometimes becomes the subject of animated discussion and extended investigation before all essential matters of design are settled. Generally, however, when a drawing is released, the main features of design have been adjudicated and the consequent details have been elaborated. Stringent effort is made to reduce subsequent changes to a minimum because they introduce confusion and hamper production routine seriously.

Starting with the released drawings, the parts lister requisitions the production drawings. Sooner or later he must have every one of them. Section II, the outline breakdown into subassemblies (the breakdown, as it is called) is the first object of attack. Two clues are found on every shop drawing: (1) the "next assembly" (the part number of the next larger assembly of which the part shown on the given drawing is a component); and (2) all the subassemblies and standard parts component to the

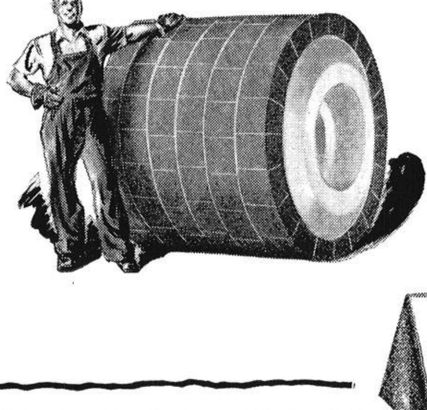
(continued on page 26)

An African Victory that might have hung by a tooth!



1. At one of the critical engagements of the North African campaign the American officer in command of a vital sector developed a wow of a toothache. Now he certainly would have won that victory, toothache or no toothache. But he didn't have to go into battle distracted by that pain-thumping molar because there was a dental unit right at hand to take care of him. Whether they are working close to the battle front or on your pet incisor here at home, dentists generally use tiny abrasive points such as are made by Carborundum.

2. The Carborundum Company manufactures abrasive wheels for every grinding job, from little dental points to mammoth five-foot stones that grind logs to pulp for paper making. And in between are wheels by Carborundum for all the production grinding operations that are doing so much to speed the war effort.



3 The complete abrasive and refractory service that Carborundum offers industry will be of help to you in your work in the field. When you are in industry feel free to call on us for assistance.
The Carborundum Company,
Niagara Falls, New York.

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SERVICE ENGINEERING . . .

(continued from page 24)

part or assembly shown on the drawing. The parts lister and his crew patiently rearrange every individual part in its proper sequence in relation to its next assembly. The result is attained by dividing the eight main component parts (groups) of the airplane (Armament, Fuselage, Wing, Empennage, Landing Gear, Power Controls, Surface Controls, Furnishings) into their major assemblies, these into their main installations, these into minor installations, and so on. Six degrees of subordination, indicated by indentions, are recognized. The following column headings show the appearance of a typical page in Section II.

SECTION II		GROUP:	Landing Gear	MAJOR ASSEMBLY	Main Landing Gear
Fig. No.	Index No.	Part No.	Nomenclature Indention 1 2 3 4 5 6	Units per Assy.	Prop'ty Class. Ar'y N'y Brit.
176		67L1934	Link Assembly	1	
	3	AN4-27	Bolt	2	
	6	AN365-1032	Nut	2	
	7	AN960-10	Washer	2	
176		67L1470	Rod Ass'y	2	
176	8	67L4567	Sleeve	1	
	9	67L3265	Coupling	2	

In the nomenclature column is given the name of each part. The names begin in a column indicating relationship of assemblies. Thus a sleeve (indention 6) may be one of a dozen parts of the rod assembly (indention 5) which in turn is one of several assemblies comprising the link assembly (indention 4), one of several units composing the drag strut assembly. The property classification is left blank to be filled in with designations determined by others.

Concurrently the parts lister and his group work with the illustrations group. The **breakdown,** in segments, is given to the illustrators. They make tracings, schematics, or perspectives of each assembly and subassembly, sufficient in number to allow every part of the airplane to be identified on an illustration. Many of the perspectives are made from the orthographic projection shop drawings, a process requiring uncommon skill; sometimes they are made directly from the part. These drawings are done in colored pencil.

The overlay. The drawings now go to the parts lister for "indexing." This process is simply hooking up the individual parts shown on the drawing with the part number therefor. The lister clips or tapes a piece of tracing paper (the overlay) over the illustration; he lists the parts in order of installation. On a separate sheet with lines numbered from 1 on, by aid of the shop drawing, he lists the part numbers corresponding to the assigned index numbers; exactly as on a convention photograph the convenient plan is to place a number on the portrait of each individual, and then below, his name opposite the same index number. Skipping around over a drawing with index numbers, requiring search in finding desired ones, is an inherent disadvantage, but is done because the list is used more than the illustrations. In some cases the disadvantage is avoidable by starting at one corner of the drawing, going clockwise around it, numbering successive parts with consecutive numbers.

Back to the illustrators the pictures go, with the overlay, to enable the index numbers to be lettered on, with lines and arrows identifying the parts. Shading, to emphasize the essential parts, and titles, and other items of the finishing process, are done; then to the lister again they go for verification of the index numbers, and for assignment of figure numbers. These must agree with references thereto in the parts list. The illustrators take them again for reproduction in ink (except for the index numbers and figure numbers) on craftint paper. This drawing is called the original. It is now photographed; the index numbers, with lines and arrows as shown on the colored pencil drawing, are added on the photographic glossy print. The figure number being part of the printed text is not shown thereon, but is marked on the containing envelope. The layout problem is almost nil, since practically all the drawings are full-page. All that remains to finish Part II is to arrange the sheets in order and to page them.

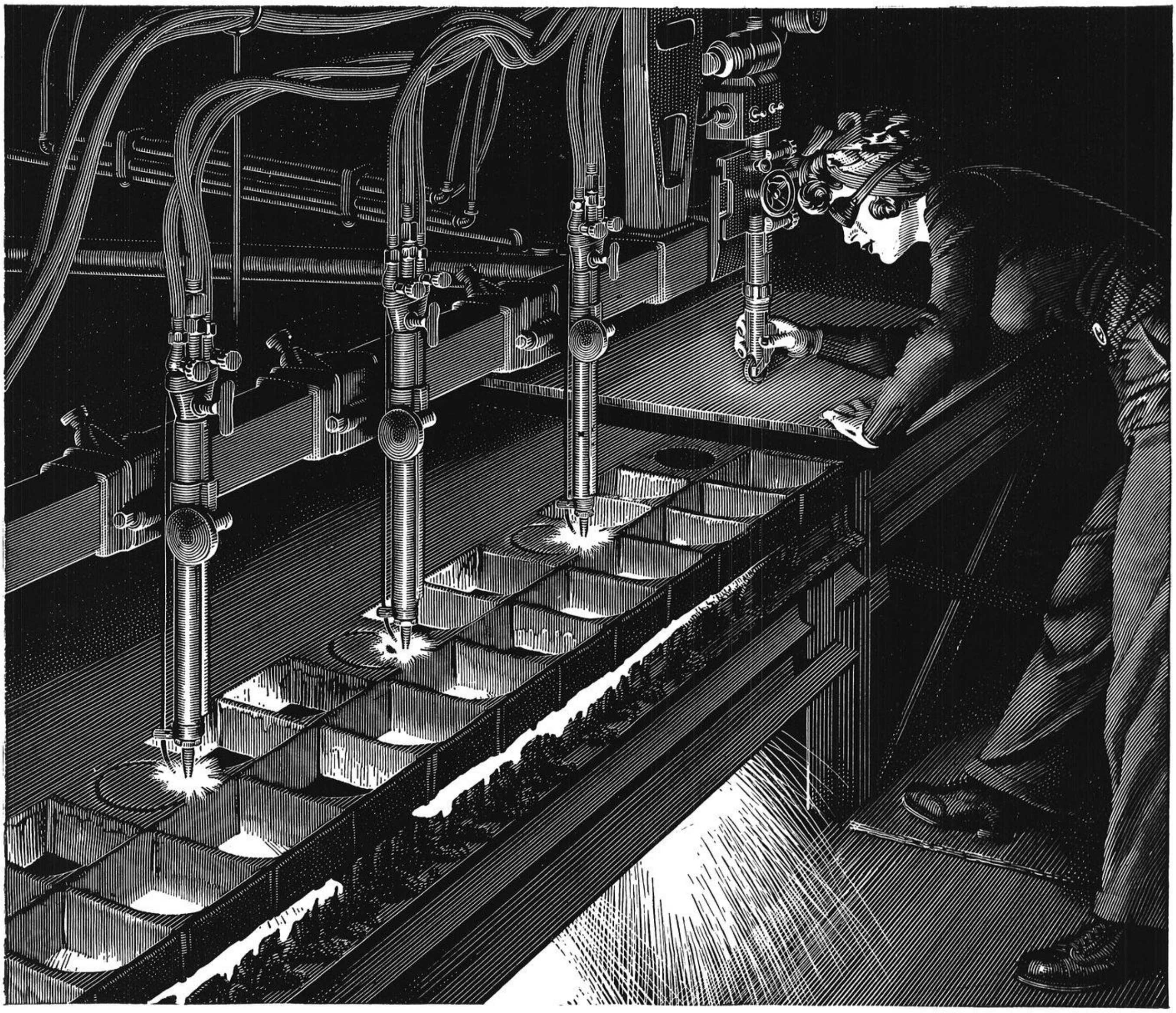
Part II is the laborious part of the job. It is something like compiling a peculiar kind of directory, say of the city of Chicago. It is as if one were given the listings in the order of telephone installation, and were asked to arrange a directory enabling anyone to answer readily this type of question: "Who lives at 6810 Michigan Avenue, Apartment 47, and what is his telephone number?" Part III is an easier assignment. It is analagous to making a directory enabling one to answer this type of question: "Who has telephone Edison 101214, and where does he live?"

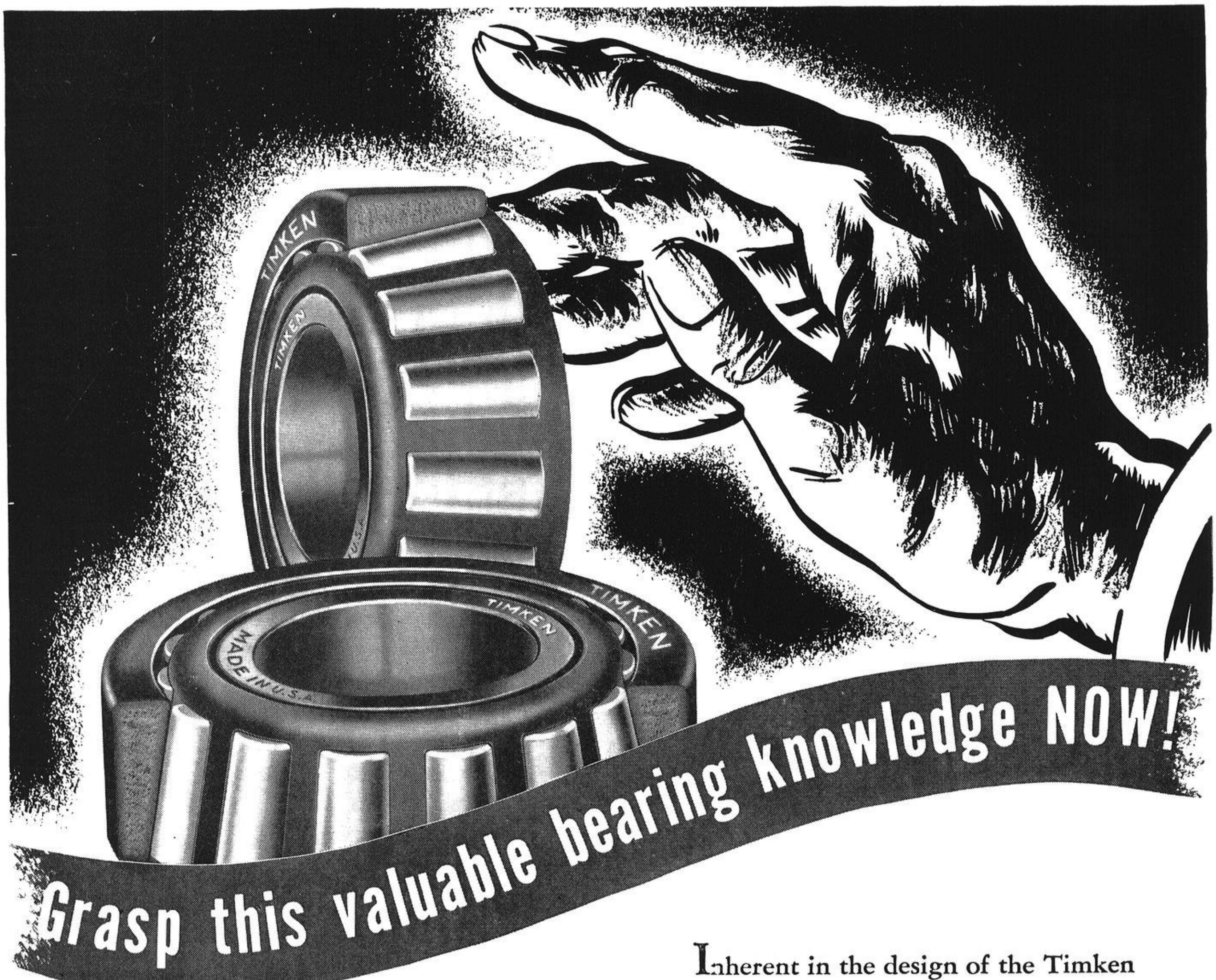
Government-furnished equipment, typically radio and armament, is identified by the symbol GFE, and is not here broken down. Purchased parts are analyzed like any other parts; getting the breakdown, names and part numbers from the vendors is a part of the research necessary in constructing a book of this kind. Structural parts such as spars, longerons, skin, are not considered to be replaceable. Their disassembly, repair, and reinstallation are left to the Structural Repair Manual.

Many parts of the plane occur in R and L patterns. The illustrations should be made for the right hand part uniformly, or for the left. The directions for use of the List should state clearly which practice is followed.

An illustration will cost from twenty to a thousand dollars. Although in these war times little attention is paid to costs, as compared to normal practice, the service engineer might well remember that costs are involved and must all be paid.

For the present purpose only one copy of the book is prepared. Reproduction, perhaps by the lithographic process, and distribution, will be taken care of by the customer.





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