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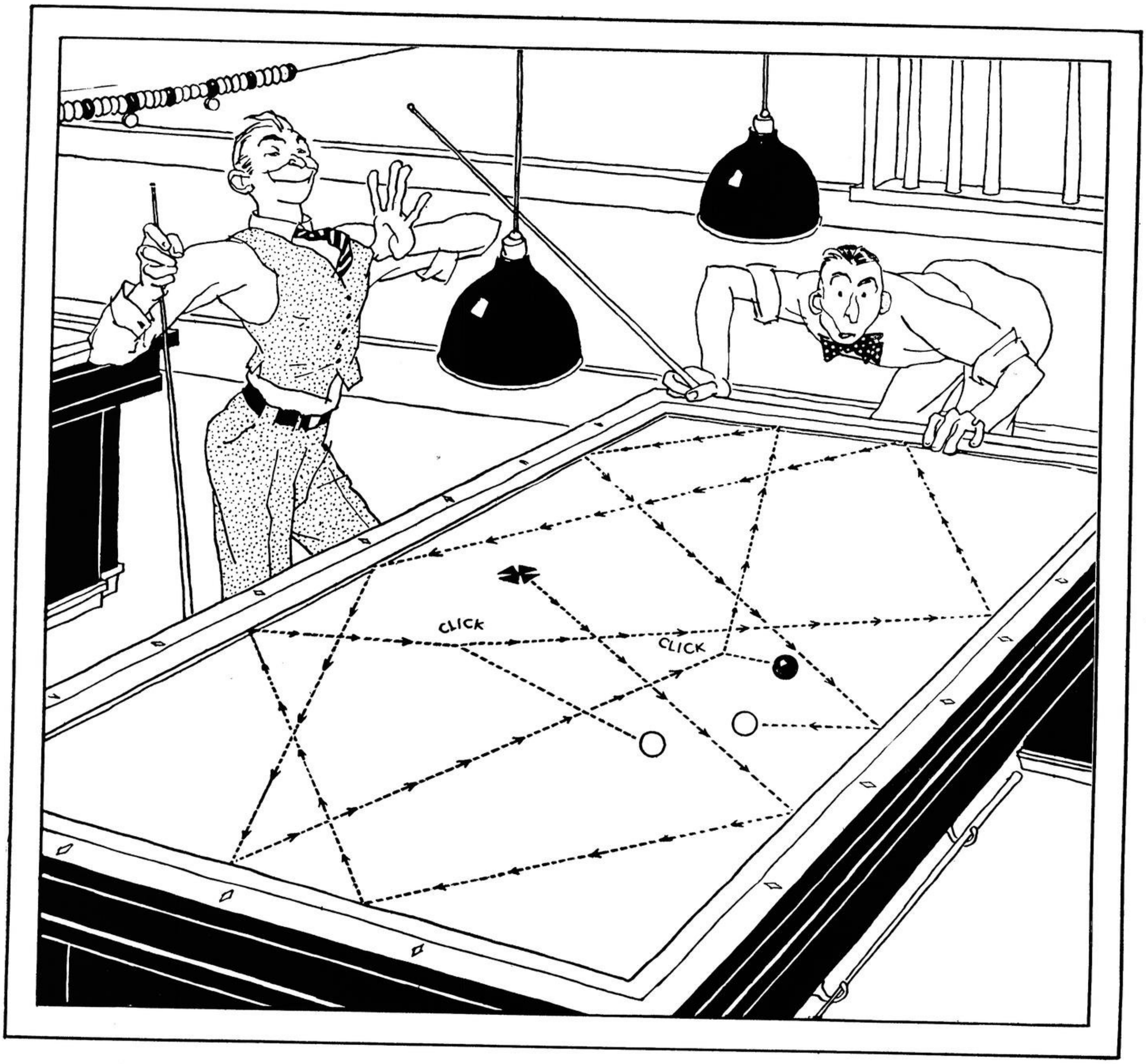
WISCONSIN ENGINEER

August, 1945

MEMBER ENGINEERING COLLEGE MAGAZINES ASSOCIATED



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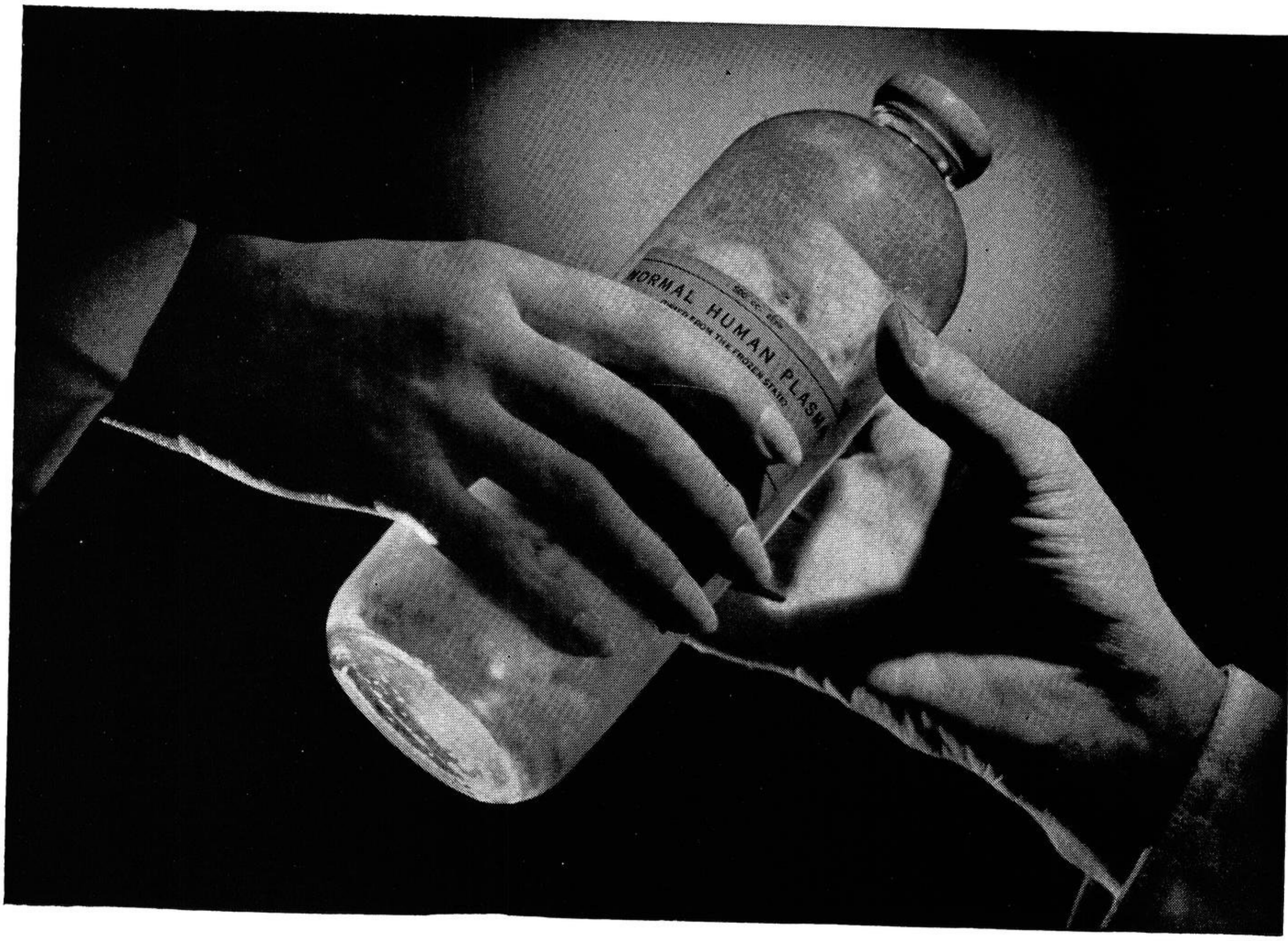
NORMAL HUMAN PLASMA

An Introduction To This Issue

ONCE AGAIN, as the copy goes to the printers, and there was that last minute rush to meet the deadline, this issue marks the beginning of a new volume of the WISCONSIN ENGINEER. And it is our hope that this new volume will be bigger and better than before.

Our editorial staff has some new additions. Also, some of the old gang are gone. Fran Tennis, assistant editor, is relaxing for the summer. It might be he's just trying to think up some new jokes for the humor column. Fran and Ralph Williams, also an ex-staff member, packed up at the end of the semester and tried their luck at hitch-hiking to California. They must have made it; we got a card postmarked Los Angeles. Bob Clayton is also gone this semester, and taking over Bob's and Fran's "humor" column is Gene Daniels, e'46, who, by the way, wrote the Static column for the ENGINEER back in '43-'44. Gene will finish in February, and I think his greatest ambition is to put in a joke that will get the editor kicked out of school.

Ralph Watson, Alumni Notes, is also gone for the summer, but will be back in November again. Taking over the Alumni Notes is Joe Teskoski. Joe hails from Wausau, and if you've ever met Joe, you've heard of Wausau. If you haven't (and I had never heard of it either), it's a small pinpoint on the map, 160 miles "due north of here." Joe is, he claims (and who are we to doubt his word?), just a home town boy who is "tall, light, and lonesome." He is also president of Theta Chi fraternity.

Two other new staff members are Ken Burmeister and Ed Dassow. They are both from Wisconsin Rapids, Ken in chem engineering and Ed an electrical. Besides his interest in engineering, Ken spends much of his spare time with his clarinet. Having played in band and orchestra five years before coming to the University, he is now a member of the Concert Band here. His ambition is to "be an engineer, naturally." Ed has one ambition, one hobby, and one main interest. That is radio. He finished high school four years ago and since that time has been in the Army. He's back at school again now and naturally taking up electrical engineering. (Which, without a doubt, is the best course to be in.)

And to keep interest here, for those of you who haven't met our Campus Notes writers, we have Jane Strosina and Millie Smith, both from Milwaukee. I'm sure, though, that most of you already know them. Jane is in civil engineering and Millie in mechanical. Recent polls seem to indicate that the staff will now double since their joining.

Back at school again in V-12s, after having previously completed four semesters here, is Ed Fischer, a chemical. Ed comes from the more civilized part of the state—Milwaukee. We're glad to have him back in school and glad to have him work on the staff.

Of course, some of the old staff is here again. For one, Don Hyzer, me'46, is here. He and a couple of the other staff members are going to have a "super-duper" of an article for you in the November issue about our University. And we have Gerald Brown still with us, a V-12, physics engineer who keeps us posted around the navy barracks.

The business end of the staff is headed now by Keith Brown, V-12 and an aeronautical. He takes Eddie Daub's place who was graduated at the end of last semester.

Now you've had a brief look at the staff for this semester. We still have some vacancies on the staff and if any of you are interested in joining the staff, drop up to see us in 356 and we'll talk it over.

But it's the magazine you want to read, so let's see what we have—

—June Hartnell

WISCONSIN ENGINEER

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MEMBER OF ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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In This Issue . . .

COVER:

"Keeps 'em Rolling While Shooting"—American tanks can now fire accurately while racing at full speed over proving grounds or battlefields due to a robot aiming device known as a gyro-stabilizer which keeps gun barrels at a fixed elevation and the target within focus of the gunner's telescopic sight. Developed by Westinghouse and now produced in quantities matching the nation's output of tanks, this stabilizer increases by as much as 500 per cent the shooting accuracy of Army tanks in motion Photo by Office of War Information.

FRONTISPIECE:

"Science Shoulders Arms"—Science's role in the American war effort is dramatically portrayed in this photograph of Newton Foster, chemist at the Westinghouse Research Laboratories, where metallurgists, chemists, physicists, and electrical and mechanical engineers are busy working on war projects. Hundreds of new developments have come out of these laboratories since Pearl Harbor to give the nation's armed forces and war industries better weapons and production equipment.
—Courtesy Westinghouse

Engineering Aspects Of Mass Spectroscopy

—Joseph F. Hull

ON THE ground floor of Sterling Hall among some of the denser jungles of wires, atom busters, atom twisters, and what not, there has appeared a new atomic instrument of great engineering significance: a mass spectrometer, otherwise known as the "atom sorter." Until the last few years the mass spectrometer had been the tool of the physicist only, having been used in studying nuclear packing effect, element transmutation, and even the age of the earth. But now the fate of the atom sorter is rapidly becoming the fate of the electronic vacuum tube; engineers are commercializing it, allowing the physicist to look for something new. Chemistry and biochemistry are using it in the study of complicated chemical and biological relations and reactions as well as in trace work by the use of separated isotopes. It has also found its way into a number of industrial laboratories, especially in the oil industry.

This instrument, patterned after one developed by A. O. Nier of the University of Minnesota, was built by Fred Eppling, a graduate physics student, under the direction of Dr. H. B. Wahlin of the Physics Department. It is being used with the cooperation of P. W. Wilson and R. H. Burris of the Department of Agricultural Bacteriology in their study of nitrogen fixing bacteria. The construction of the instrument required great care. Successful operation requires expert servicing, the lack of which in the past has caused the failure of many similar mass spectrometer projects. The instrument at Wisconsin, however, has been operating successfully and, according to Dr. Wilson and Dr. Burris, it has yielded many good results.

Principle of Operation

The purpose of the mass spectrometer is to sort the particles of a substance according to their molecular weights and to find their relative concentrations. It is most frequently used to find the relative abundance of the various isotopes of an element in a substance. The sorting action of the spectrometer operates on the principle that the paths of electrically charged particles, moving with different momenta in a magnetic field, are bent into circles of different radii as given by the following equation:

$$r = mV/He$$

where r = radius of the curvature of the path
m = mass of particles
H = magnetic field strength
e = the charge of the particles

Figure one illustrates the sorting principle. Molecules of the sample to be tested are pumped into the low pressure ionizing chamber at W. At the source, S, they are electrically charged and are accelerated to a high velocity. The ionized particles then move in a straight line along the relatively field free path, SF, and enter the mass analyzer, which is nothing more than a deflecting magnetic field and a receiving electrode. Due to the fringing flux the boundary of the magnetic field is larger than the pole face. The integrated effect of the flux on the particles has been shown to be equivalent to having a uniform magnetic field with a boundary extending approximately a pole gap width beyond the physical boundary of the poles. This equivalent field is shown by the dotted lines, ABCD. From F to G the ionic path is an arc of a circle of radius given by $r = mV/He$. If the radius happens to be equal to d, the particles emerge from the magnetic field at G, move along the horizontal line, GJ, and strike the collecting cup J. The rate at which the ions strike the cup is indicated by the potential measuring device, E, and

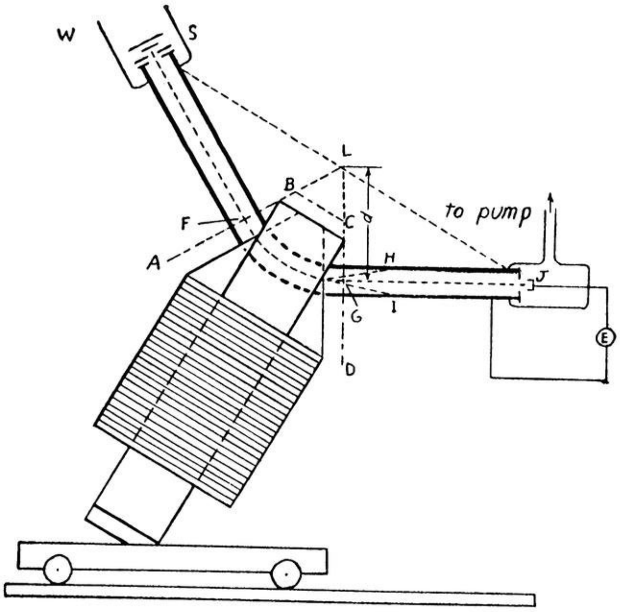


Figure One

is proportional to the amount of the focused isotope in the sample. Particles having less momentum travel in the arc of a smaller circle and strike the side of the tube at H, while particles with more momentum strike the side of the tube at I.

Figure two is an enlarged view of the ion source and accelerator. Electrons are emitted from filament, F, and are accelerated to the adjacent plate by the potential of an ordinary radio B battery. About 10 per cent of these electrons pass through the slit, S, and move along the line, ST, ionizing the molecules of the gas sample. A small potential difference between the plates A and B slowly accelerates the newly formed ions toward the plate B, and a fraction of them pass through the slit, S_2. Between the plates B and C there exists a large potential difference which accelerates the ions to a high velocity. A fraction of these high velocity ions then pass through the slit, S_3, to the mass analyzer. By this arrangement all equally charged ions possess very nearly equal kinetic energies as they leave S_3, making the mass selectivity of the spectrometer very high.

Equating the potential energy lost by an ion as it moves along the path S_2, S_3 to the kinetic energy gained:

$$Ee = 1/2\ mV^2; \quad (2Eem)^{1/2} = mV$$

Thus at a given voltage E, if the charge of each ion is the same, the momentum of the particles, mV, is proportional to the square root of the masses. But since for a given field the mass analyzer focuses only the ions having

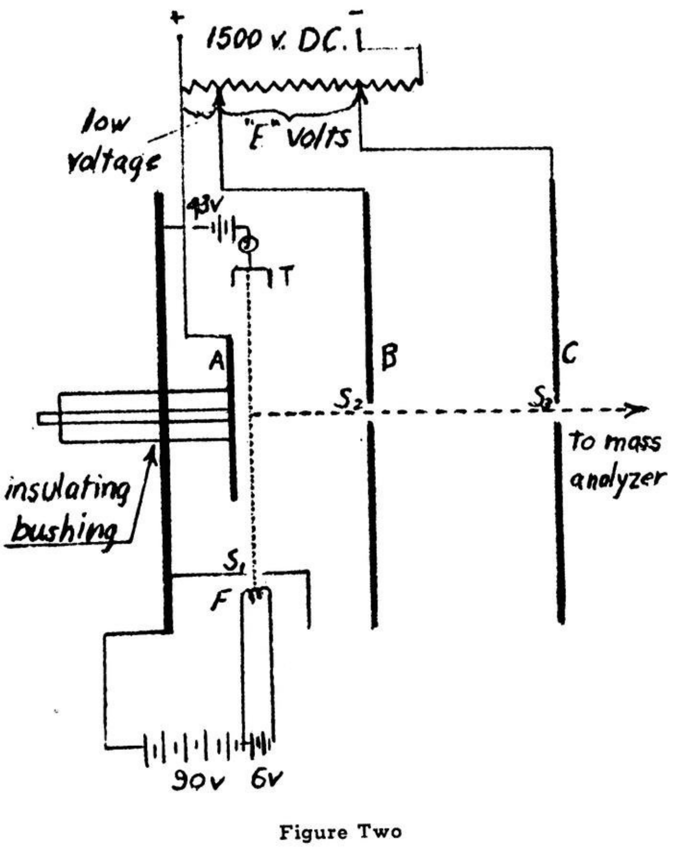


Figure Two

a certain momentum, the mass of the focused particle depends only on the accelerating voltage, E.

$$m = (mV)^2/2\,Ee \quad = K/E$$

The value of the proportionality constant, K, may be easily found by focusing a known ion. Hence when the voltage, E, is varied, and the potential measuring device

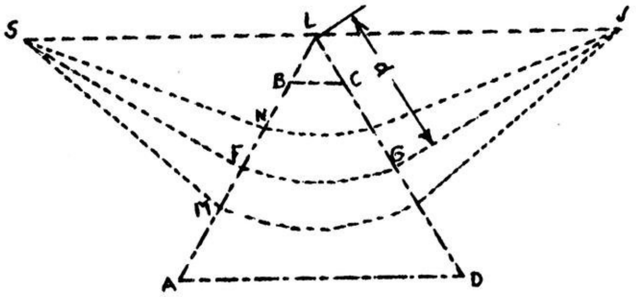


Figure Three

registers a "peak," the magnitude of this peak is a measure of the relative concentration of focused ion, and the voltage, E, indicates the ionic mass.

An interesting feature of this type of mass selector is its automatic focusing principle. Ordinarily an ionic stream diverges because of the mutual repulsion of the particles. This would cause flattened peaks in a mass spectrometer and consequent errors in mass measurements. But if, as in Figure one, the points S, L, and J lie in a straight line, the particle stream will be automatically focused on the collecting cut, as may be seen from Figure three. Particles entering the field at N travel through less field and are deflected less, while particles entering at M are deflected more, causing the ion stream to converge at J.

The potential measuring device, E, consists of a DC electronic vacuum tube amplifier which must have a very high current amplification because of the low ionic currents to be measured (about 10^{-15} amperes). For this purpose a special electrometer type of tube, D96475, is used, which is made by the Western Electric Company for such special applications. The sensitivity of the combined amplifier and galvanometer is about 100,000,000 mm. deflection per micro-ampere of ionic current.

Applications

Tracer work in biochemistry is one of the most interesting applications of the mass spectrometer. One problem is to find where a certain substance goes in the body of a rat after feeding. The substance, an amino acid, $C_2H_5O_2N$, is synthesized, using an isotope of one of the elements. Carbon of atomic weight 13 is frequently used because it

(please turn to page 21)

Chemical Engineering In The Post-War World

—Dorothy Miller

FOR the past five years the United States has been on wartime production and research. During these years new discoveries and improvements have been pushed ahead. More new processes and developments have been put into operation than one would normally expect in a generation's time. How do these things affect the world and the chemical engineer?

Reconstruction in Europe has barely started and Asia must wait until Japan is conquered to begin rebuilding. At any event as much time and energy to get production running will be required of engineers as was expended during the war. Then too, many of the heretofore untouched resources of several countries will be developed.

Many products have been discovered in this country during the war; such as penicillin for the sick, new types of clothing for all kinds of weather, improved methods of housing and insulation, plastics with varied uses, new things from glass and a host of other products; many of these will be of use to a civilian peace-time world. The building and maintenance of the plants to produce them will require the skill of engineers. The sulfuric acid plants, the paper mills, the oil refineries and the other industries which have long been in production will continue to need the services of the chemical engineer. Many of these companies have vacant places which would have normally been filled by young graduates who have instead gone to fight.

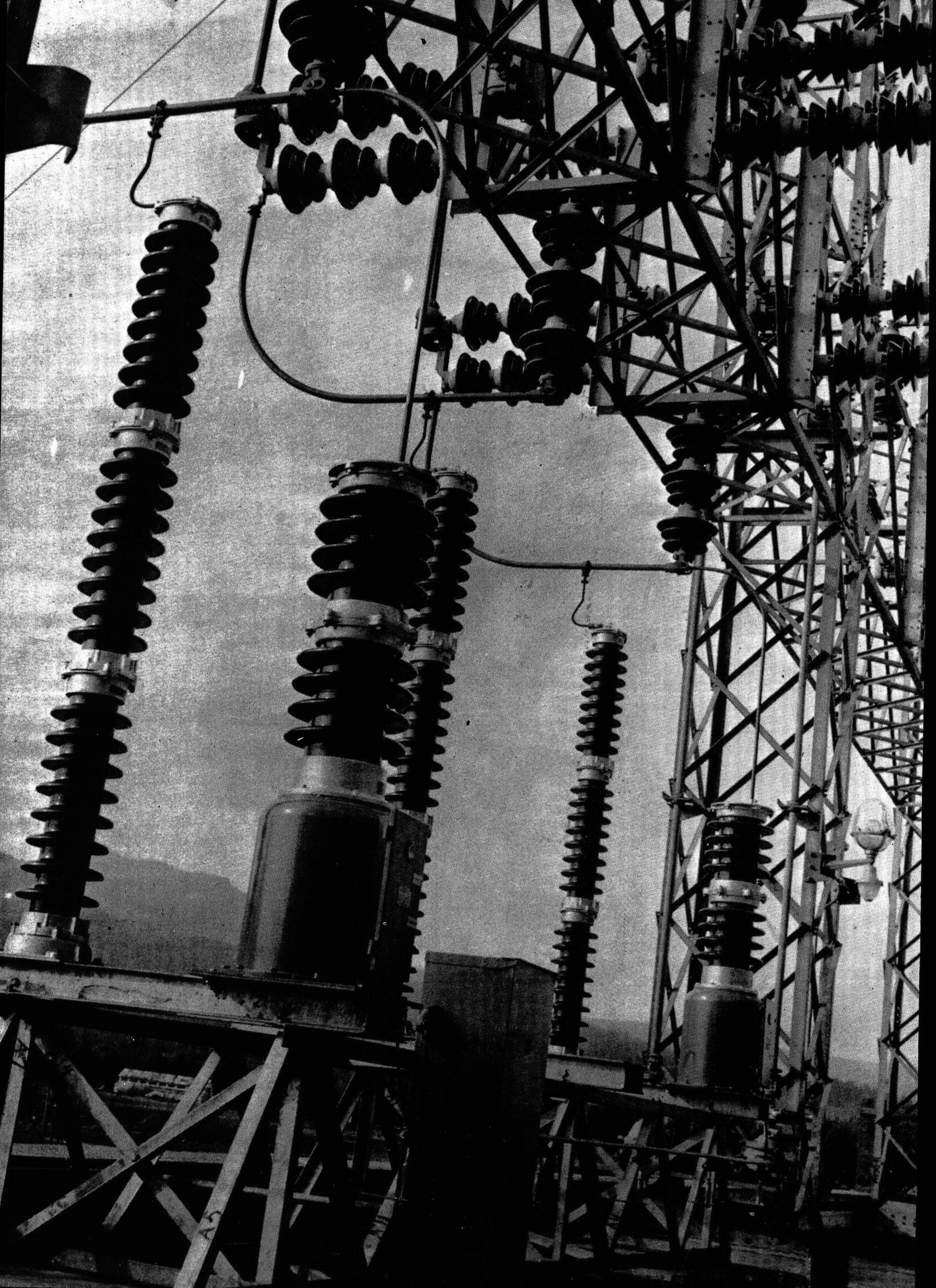
Today the graduate in chemical engineering has opportunities never before equaled. He is to be called upon to help build plants all over the world. It is also a great responsibility in that each man who goes to another country will be an ambassador from the United States. The actions of these men will play a part in building a sounder foundation for world peace. After the last war, many mining and metallurgical engineers went abroad with their business and set up a profitable enterprise. It is expected that chemical engineers will follow suit when peace comes after this war. There are already several highly successful firms so doing; though there have been a number who started too soon with too little knowledge and foresight that failed.

Many young engineers discard the idea of working in another country because of stories of bad living conditions, poor transportation and backward development. However there are many advantages to working abroad especially for one just beginning in the field. The living conditions, while slightly below those of some parts of the United States, are still average compared to those of most citizens in this country. The pay is above that received here by an engineer of equal ability and that excludes living expenses which are usually paid by the company. Therefore it affords an opportunity for those who are anxious to save money. The opportunities for advancement are much greater since there are fewer men working abroad. One has an unequaled chance for studying a society different from our own and contacts people of wider personality and importance than one would possibly meet at home.

In the United States there will still be many opportunities for employment for engineers. Some of these positions will be with old, well-established firms, others in view of new discoveries of scientists, will be with small companies just beginning to place their products on the market. Many young men do not consider attaching themselves to the employment of these little-known firms because they lack confidence in them. It is well to consider them, however, for many times these companies grow and expand. An engineer who has confidence in himself and who has investigated the worthwhileness of the products of this small company would do well to affiliate himself with it. There is a greater opportunity for broader experience also with the expansion of a small company; the promotions are more rapid. If a man wishes greater chance for advancement and is not afraid to associate himself with something new, a company like this is where he belongs.

Large companies offer positions in which one may become a specialist. An engineer's chance of broad experience is sacrificed to the intensified knowledge of one phase of production. The prestige of association with reliably established firms is, of course, to be considered. Opportunities for research are greater, for a large, well-established firm can afford to pay more attention to developing and improving their products. The security of jobs with large concerns is of importance to an engineer who wishes to settle and establish a home. Security, prestige, and opportunity for research and specialization are offered by the large company.

Engineers will still be needed when the war is over. One should keep in mind that the same qualities and characteristics which got and held jobs before the war still apply. There is always a place for an honest, hardworking young man no matter what firm he wishes to work for. One will advance if he is thorough and conscientious, shows an interest in the welfare of his company and makes every effort to improve his value as an employee.



A Future In Electrical Engineering

—June Hartnell

THERE is always the speculation and comment about the new products and developments that will appear on the market at the end of any war. That speculation has again reached a high point with the war at an end.

The public has heard much about electrical developments; yet they know only a very few of the smallest details concerning them; radar, new electronic applications that can be applied to household conveniences, television improvements and numerous others. And it is true, that although there have been many developments in the electrical fields, the majority of them have been to further the war effort. Only a few of them will be immediately useful to the general public. Many of them will find no place in a world of peace, but others, perhaps the majority of them, will be improved upon, revised, and made to fit into the living standards of Mr. and Mrs. John Doe.

Just as the electrical engineer found and filled his place in the wartime world with its accelerated programs, he will find and fill his place in the post-war world. The pace will be much slower, perhaps, as there will no longer be the driving necessity that a war brings forth, but the opportunity and the need will still be there. It will be his job and the future electrical engineer's job to "keep up with times."

The war has opened anew the field of electronics. Although some wartime applications will not be able to be converted into useful appliances, new secrets and discoveries in that field have widened the knowledge of men about electronics and this knowledge can be applied to practical inventions and discoveries. The applications of electronic research in industry can be found everywhere and these will not be thrown away with the close of the war.

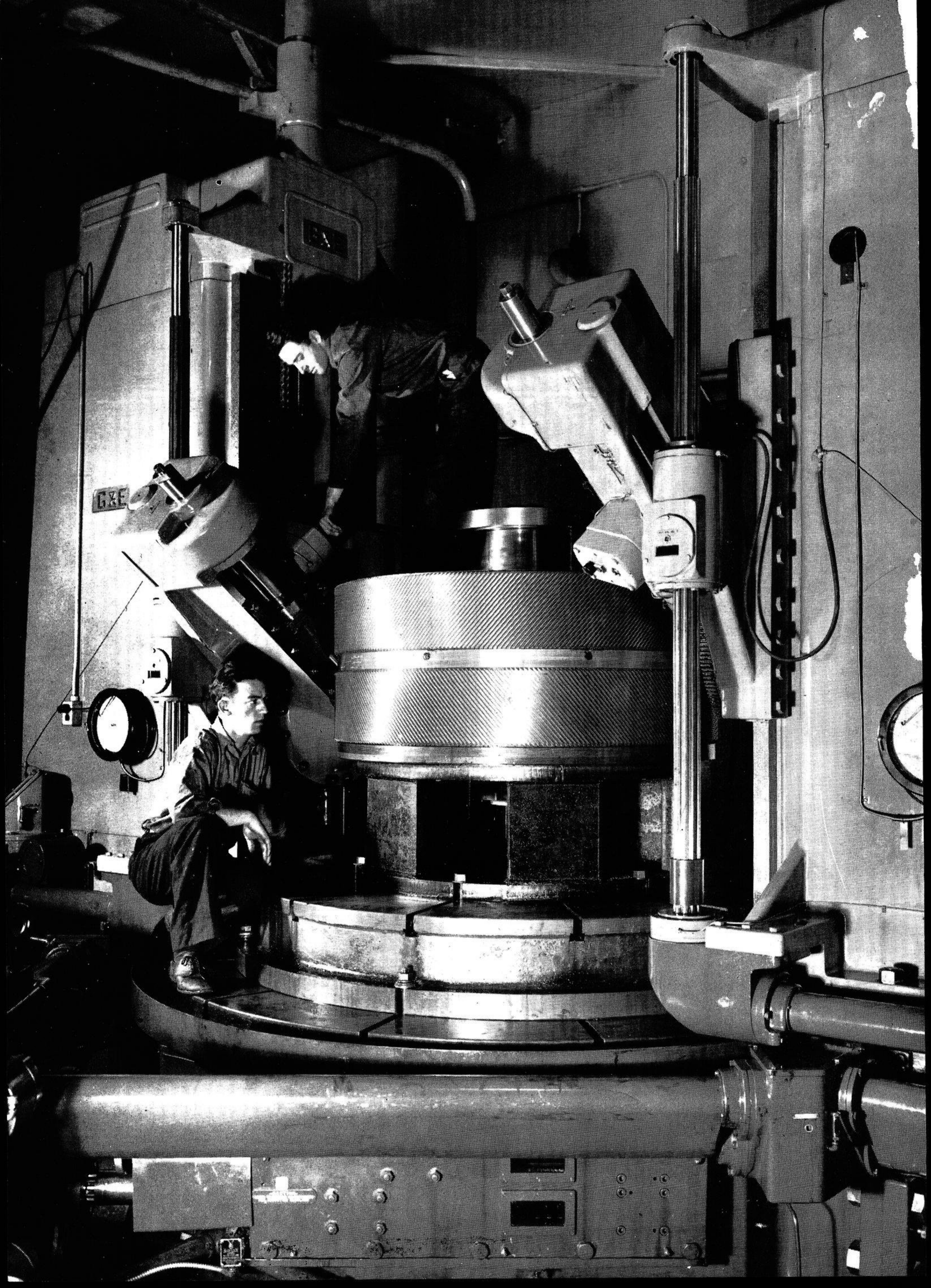
The field of communications has also been "busted wide open." New types of radios, television equipment will be available to the public. But to bring this to the home will still require the work of engineers. We have all heard of the "walkie-talkies", yet they could not find their place in our life as they are. They would be much too hard to carry with us as we walked down the street if for instance we were going shopping and would have other packages to carry, despite the advantage they might offer in letting us carry on a conversation with someone two or three blocks ahead of us.

For the power engineer, interested in distribution work and heavier electrical equipment, there is a widening field as the factories and plants must convert from wartime production to the production once again of automobiles, refrigerators, washing machines. And the public will want, not the same refrigerator that was sold on the market before the war, but something new, better. The power engineer will be looking for better means of transmission with smaller losses and the means to harness more electrical energy to do his work.

It makes no difference which branch of electrical engineering the man may be in. He is dependent on the other man. And the electrical is dependent upon other engineers —mechanicals, civils, chemicals, mining and mets. Each must keep pace with the other. If one falls behind, the work of all will lag. This has always been true. Today it is more important and perhaps more difficult to keep up with developments. The engineer entering the post-war world must not only have in hand all of the work prior to his entering the field of work, but he must keep tab of the new developments along the same line. He has, perhaps, two hundred-fold more facts and theories and principles to become acquainted with than did the engineer of ten years ago. Radio, in comparison with such inventions as the simple hammer, is very new, yet it is much more complicated and covers a much wider field. Even in a lifetime, a man could not learn all the facts about radio and its different aspects and potentialities.

The work of the electrical engineering student in college offers a background that is needed for any future research or work the engineer may be interested in. The laboratories provide him with practical experience, the classroom with the facts and theories underlying all other work. No university could give the student a thorough understanding of the field he is to enter upon graduation. But he does have the basic understanding of principles and applications that will enable him to give the public what they want. He will also be familiar with much of the work of the mechanical, chemical, civil engineer with whom he may some day be working.

Without a doubt engineering in the post-war will be of great importance and significance. Electrical engineering will be up in there giving the public new conveniences, and things that are now unheard of, unthought of, but perhaps they are being dreamed of by their future inventors. The electrical engineer sees the future and this future he must give to the world.


G&E

Mechanical Engineering Tomorrow

—Don Hyzer

JUST what is the post-war possibility of a future for the mechanical engineer? That is the question of every student and he just hopes there will be an answer when he graduates. Your author is in the same boat but with a little investigation and thought some conclusions have been made. Probably the best way to get a picture of the future is to pick up some engineering publication such as A. S. M. E.'s MECHANICAL ENGINEERING and study the advertisements. All the companies are showing products which will be developed and produced after the war.

Emphasis is now being placed on such projects as air-conditioning of homes, greater economy and beauty of automobiles, family airplanes, automatic machinery, and the mechanization of the farm. These and many other projects show immense possibilities for development by the mechanical engineer.

For the adventurous M.E. there is always the rebuilding of European industrial centers and the development of new industries in South America, India, and China. If one has the ability to organize and direct, the new countries have great possibilities.

Research is a definite field for the studious engineer. In it is such work as the gas turbine, where only a small scratch has been made on the surface of a project which may change the entire field of prime movers. The research field is wide open with projects supported by every major company.

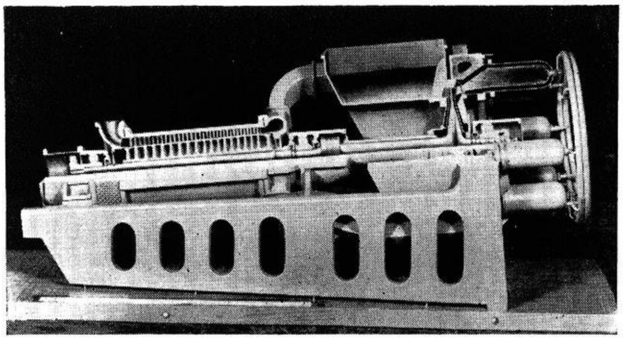
In a world with mass production there must be innumerable accurate measuring devices. Since each part must fit exactly, it has to be made and inspected accurately and quickly. This is done by many ingenious devices which must be developed for greater use as the tempo of production increases.

With the high speeds, high pressures, and massive structures, the field of materials testing has been broadened. For the mechanical engineer it opens many opportunities in the design of accurate testing machines, and such instruments as one just developed to measure point strains. It has gage points one sixteenth of an inch apart and the change is multiplied by 50,000 before taking the reading. This happens in a very small instrument which weighs one tenth of an ounce.

For the good mechanical engineer who thinks and has foresight the field presents great post-war possibilities. Every company wants good men and has plenty of work for a mechanical engineer.

These three articles are first of a series of five on engineering tomorrow and today with the war at an end.

The Gas Turbine



Its Many Potentialities, Limitations, and Probable Future Applications

Courtesy "Electrical World"

—G. B. Warren, m'24

SO MUCH has recently been written regarding the gas turbine and by so many able engineers, that it would seem unnecessary to add another paper to those already available. On the other hand, there seems to be a demand, particularly from those engineers in public utility, industrial power, and transportation work, to know more about the characteristics and probable field of application of this old yet new form of prime mover. They seem to desire to know where it will fit in with existing types of prime movers. It is to this need that the present paper will be addressed.

Much of the already available material on this subject contains elaborate curves dealing with the potential efficiencies, effect of operating pressures, temperatures, etc., and no effort will be made to furnish this information here except in general terms.

The writer has been interested in and engaged in research work at various times on the gas turbine since 1914. It was his firm conviction then, and it is now, that the gas turbine has a brilliant future ahead of it, but this future will be alongside of, as a competitor, and as a supplement to many existing types of prime movers. It is possible but improbable that it will completely displace any of the existing types of prime movers for many years.

What a Gas Turbine Is

A gas turbine may be any one of a large variety of machines, and may probably have a greater basic diversity of design than any other form of prime mover. Generally, however, what is meant is a relatively simple internal combustion machine as shown in Figure I operating at relatively constant pressures. In this simple form a compressor takes in atmospheric air, compresses it to about six atmospheres upon which it is heated by having a combustible, generally liquid fuel, burned in it until the temperature of the resulting mixture of air and products of combustion is some 1200° F. to 1600° F. This mixture then passes at this relatively high pressure and temperature into the turbine where it does work and is discharged to the atmosphere. Part of the power of the turbine drives the compressor, and the remainder is useful work. The turbine does more work theoretically than that required to drive the compressor because of the greater volume of the heated gases passing through the turbine than of the relatively cool air passing through the compressor.

The principle of the gas turbine in its modern form is at least 60 years old, having been described quite completely in a patent issued to Charles Parsons in 1884. It has really been quite actively worked on by many men and groups in the intervening years, including in addition to Parsons in the early days, Armengaud and Lemale in France, Holzwarth and Brown Boveri in Germany and Switzerland, Dr. Moss and the General Electric Company in this country.

It was apparent to all of the early workers that neither the efficiency of the turbines nor of the compressors available at the time were sufficient to get any net power with the temperatures which available materials would permit. After spending great sums of money active work on the problem direct largely ceased by about 1912, and all of the gas turbine enthusiasts settled down to the longer job of securing their objective by indirection. This work followed three obvious lines of effort: (1) to get more efficient turbines, (2) to get more efficient compressors, and (3) to get better materials.

The rapid development of the steam turbine was aiding the first, and Dr. Moss and the General Electric Company in the United States and the Brown Boveri Company in Switzerland set out to develop and sell the centrifugal compressor to an already available market for blowing blast furnaces in the United States and furnishing compressed air to mines abroad. The metallurgists fortunately needed some of the same properties in a high speed cutting tool as were needed for gas turbine materials, namely high strength at high temperature, and so they carried along many developments that have been most helpful.

Then, with the emergence of the airplane two new developments in connection with it have been of great help. During World War I Dr. Moss and the General Electric Company, because of their early work on the gas turbine, were commissioned by the National Advisory Committee for Aeronautics to develop the exhaust gas turbine driven airplane engine supercharger. This is simply a small, high speed gas turbine driven by the hot exhaust gases which drives a centrifugal air compressor for forcing the rarified air at high altitudes into the engine intake so that the engine does not lose power at altitude. Although money for this work dribbled to a mere trickle through the Twenties and early Thirties both the Army's vision and Dr. Moss's persistency kept it going. The result was that by the beginning of this war materials and the technique of wheel, bucket, and nozzle construction had been so developed that it was possible to operate small, high speed turbine wheels on gases of 1700° F. temperature for appreciable periods of time.

The second development, stemming also from the airplane, was carried out by Brown Boveri in Switzerland and also to some extent by Escher Wyss aided by Dr. Ackeret of the Technical High School at Zurich. This was the development of Parson's original axial flow compressor into an efficient machine accomplished by applying the new knowledge of air flow around wing and propeller sections which had been developed in the aerodynamic laboratories of the world to the design of the blading for this machine. The result of this was that at one stroke the compressor efficiency was raised from some 75% of the centrifugal to the 85% of the axial flow machine.

These things proved to be just the stimulus that the gas turbine needed. Brown Boveri, followed by the Allis Chalmers Company here, applied the new compressor and a moderate temperature gas turbine to the industrial process of blowing the catalytic chambers of the Houdry cracking process at high pressure during the part of the cycle when they are being regenerated and obtained much valuable experience. They also built a few straight fuel oil burning gas turbines.

Design Considerations

In connection with all gas turbine designs there are four very important considerations:

1. The compressor and turbine efficiencies must be high.
2. The initial temperature ahead of the turbine must be high.
3. The parasitic pressure drops must be low.
4. The ambient temperature entering the compressor must be low.

When one considers Figure 1 and realizes that the new power is the difference between the turbine output and the compressor input, the reason for the above four principles becomes immediately apparent. Generally, the compressor requires from 1/2 to 4/5 of the total power developed from the turbine, depending upon the values of the above quantities. In the early machines the compressor actually took more than the turbine power to operate it.

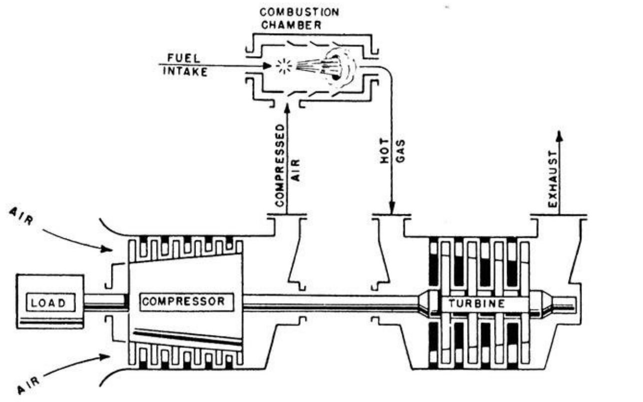


FIG. 1
SIMPLE GAS TURBINE CYCLE

GENERAL ELECTRIC CO.
SCHENECTADY, N.Y.
DRAWN BY
H-8220394

From the standpoint of the efficiency of the cycle, the compressor work is not lost, and with high enough compressor and turbine efficiencies, is nearly all regained in the turbine.

The importance of, the difficulty of, and the cost of procuring low parasitic pressure drops is not so generally appreciated. The volumes of gas flow are tremendous, in the general order of 9,000 to 12,000 cu. ft. per minute per 1,000 hp of net output of the set. The total available pressure drop is not great compared to a steam turbine for instance. As a result, the obtaining of sufficiently low entrance and exit losses to and from the machines, of low pipe drops, and of low combustion chamber pressure drops is most important; and on more efficient regenerator units the pressure drops must be reduced on both sides through the heat exchanger surface to the minimum possible value, otherwise excessive power losses will result.

The great effect of the ambient or incoming air temperature is not generally appreciated. The work of the compressor is directly proportional to the absolute temperature of the entering air; and if the power absorbed by it at 80° F. or 540° F. abs. is twice the net power, then at 0° F. the compressor will absorb but 82% as much, and the net power will be increased in the ratio of 50% to 68% or 36%. On the other hand, the air will come out of the compressor about 120° F. colder depending upon

(next page, please)

(from preceding page)

the pressure ratio, and in the absence of a regenerator will have to be heated up this much further by the fuel. This will, however, only take at most 10% more fuel; so we have a machine that produces 36% more power on 10% more fuel when running at the colder temperature, i. e., its efficiency will be about 25% greater. Similarly, a still greater gain would result if even colder air could be taken in; and, conversely, a loss of sizable magnitude would take place if the plant were to have to run in the desert.

The power of a gas turbine is also directly affected by the barometric pressure of the inlet and exhaust if the ambient temperatures are constant. Both gross and net output are directly proportional to the barometric pressure, but the efficiency is not thereby affected. Thus, at a high altitude where the barometer reads half of sea level pressure, a gas turbine would have to be proportioned to handle double the volume of air.

The Gas Turbine As It Is Being Considered Today

Basically, two variations in the gas turbine cycle are being considered today. The first is the simple cycle shown in Figure 1. This has no heat exchanger surface whatever, and is probably one of the simplest prime movers known. It should be capable of obtaining overall thermal efficiencies in the neighborhood of 16% to 18%. Possibly 20% with higher initial or lower ambient temperatures can be obtained.

Figure 2 shows the two principal modifications being considered. These are a heat exchanger or regenerator in

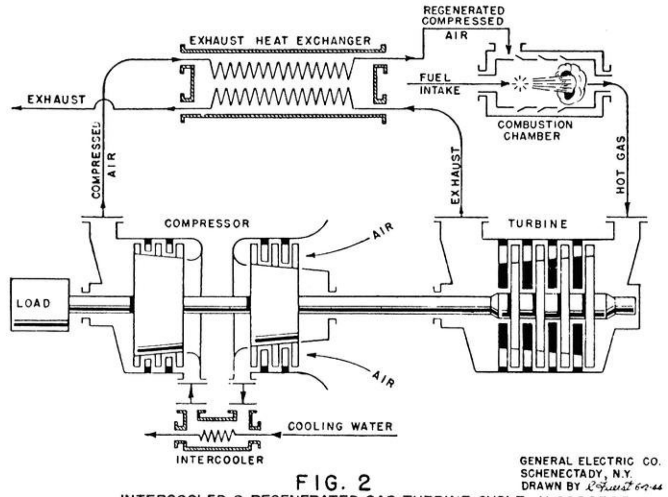


FIG. 2
INTERCOOLED & REGENERATED GAS TURBINE CYCLE H-8220395

the exhaust and an inter-cooler in the compressor. If a heat exchanger that would give complete recovery of the exhaust heat down to the temperature of the air leaving the compressor were to be used, the gain in economy would be about 30% to 40%, but such a heat exchanger would be impossible. To get 50% or 75% of this recovery is possible; and would require about 3/4 sq. ft. per horsepower or 2½ sq. ft. per horsepower, respectively; and would give about 1/2 or 3/4 of the above gain in economy, respectively, reduced somewhat by pressure drops. This is to be compared to the modern steam plant which has a total of about 2 sq. ft. per horsepower in boiler, superheater, economizer, air preheater, and condenser. In some gas turbine designs, however, from 10 to 12 sq. ft. per horsepower are actually being considered in the heat exchangers. This seems excessive.

An intercooler in the compressor will give a gain in output depending upon the cooling temperature available, and will give a gain in efficiency if used in connection with an exhaust heat regenerator. This gain in net output is roughly 15%, and the gain in economy due to the intercooler is about 10% if a regenerator is used. Thus the cycle shown in Figure 2 should, with turbine and compressor efficiencies and initial temperatures that seem obtainable, and somewhat greater than a 50% heat exchanger, have an overall efficiency of 25% to 27%, or a fuel consumption of about 0.53 lbs. of oil per horsepower hour. This will probably be a good commercial machine for many purposes.

Water Injection (Combined Steam and Gas Turbine)

Normally the temperature leaving the combustion chamber is kept low enough for the turbine by adding excess air. This requires compressor power. This could also be done by injecting water.

If the consumption of water is not a disadvantage, if the pressure ratio is in the higher ranges, and if the set is designed for it, water can be injected ahead of the heat exchanger with a very considerable increase in net power and without too great a detrimental effect on the efficiency. It is theoretically possible to inject the water into the entrance of the compressor, and so secure still greater advantages, since some cooling of the air during compression results, including a gain in overall efficiency, but the practical difficulties are great. For instance, there will be difficulties in maintaining proper mixing, in mechanical losses and erosion of compressor blades, or else deposits on the blades with resulting decreases in compressor efficiency and increased maintenance. The same may be true on the heat exchanger surface. All of these practical difficulties can be eliminated if this scheme is carried to the ultimate and the gas turbine combined with a steam boiler and condensing results. It is quite possible, however, that for many applications the gas turbine may be advantageously combined in some manner with a steam cycle.

Control and Light Load Economy

Generally, the control of a gas turbine will be simple, since the net output can be varied simply by varying the amount of fuel fed into the combustion chamber.

If a turbine as in Figure 2 is run at a constant speed and lighter loads, the economy is rather poor, the no load

(please turn to page 24)

Alumni Notes

—*Joe M. Teskoski, me'45*

Mechanicals

DETTMAN, CAPT. CHARLES E., m'40, and Sgt. William F. Tinsman, Philadelphia, Pennsylvania, Ordnance men with Uncle Sam's Air Forces, examine casts for bomb fins. Captain Dettman is with the Ordnance depot of the 15th Air Force Service Command. After completing his university work, Captain Dettman was employed by the Kearney and Trecker Corporation.

GRIFFITH, LT. ROBERT L., m'43, B-17 Fortress pilot with the 15th Air Force in Italy, is home on furlough. Lt. Griffith is a veteran of forty missions and is known for his hospital entertainment fame.

PETERSON, GARFIELD E., m'43, was not killed in action as reported in the May issue. He at present is recuperating from wounds in a United States hospital.

McNALL, ENS. PRESTON E. (SANDY), m'44, son of Professor P. L. McNall, is with the Seabees in the Pacific. He was recently commissioned at Camp Endicott, Rhode Island.

SCHINASI, SEYMOUR B., sophomore here in 1942-43, was reported in action in Germany on March the 2nd.

DONAHOE, ROBERT J., who was called to service at the end of his freshman year, has been missing in action in Germany since March 14.

BICKELHAUPT, IVAN A., '14, Capt. U. S. Army, who has been in charge of construction at the Marine Air Station at Cherry Point, N. C., has been transferred to the Fifth Naval District with headquarters at Norfolk, Va.

FRICK, RICHARD, '43, accepted a position with the Goodyear Aircraft Corp., Akron, Ohio.

•

Capt. Charles Dettman and Sgt. William Tinsman

Civils

PURDY, CORYDON T., c '85, died on Dec. 25 at his home in Melbourne, Fla., at the age of 85. He was chairman of the board of directors and the former president of the firm of Purdy & Henderson Co., consulting engineers of New York. In 1889, he began private practice in Chicago as a designer of bridges. He soon turned to the design of steel-frame buildings. One of his first jobs was the famous Tacoma building in Chicago, generally considered the first of the steel "skyscrapers." He opened a New York office in 1894. His company designed many important buildings both at home and abroad.

WHITNEY, A. BRADFORD, c '08, a citrus grower of Upland, Cal., died at his home on Jan. 5. His father, Prof. N. O. Whitney, occupied the chair of railway engineering at the University of Wisconsin from 1891 until his death in 1901.

SHOREY, CAPT. EDWIN ROBERT, c '35, has been awarded the silver star for gallantry in action near Sassetta, Italy, last June 16.

DIETZ, JESSE C., c '40, former instructor in sanitary engineering at this college, has been promoted to the rank of Lt. Col. He is with an engineer aviation battalion on the western front in Europe.

PLATE, J. KENNETH, c '40, died on Sept. 2 of lymphatic leukemia at a Cedar Rapids hospital. He had been working for the Milwaukee Road out of Marion, Iowa.

RALL, LLOYD L., c '40, Lt. Col. AAF, visited the college on Jan. 19 on a 30-day leave. He was wearing three battle stars.

WESLEY, JOHN, c '40, died in St. Louis on Feb. 4 of a heart attack. He was a service engineer with the International Filter Co. of Chicago.

MEYER, KARL, c '41, is serving with the navy in the Philippines as carpenter's mate, 2nd class.

SANDNER, FRANK X., c '42, announces the advent of son Frank X. III on Jan. 13, at Portsmouth, Va. Frank is a Lt. USNR, Bureau of Ships, and is building carriers at the Norfolk Navy Yard.

THOMPSON, ENSIGN MYRON O., c '42, was married on Feb. 19 at Washington, D. C., to Margaret McConnell of Nazareth, Pa., a student at the American University. Ens. Thompson is stationed at the Bomb Disposal School at the same university.

MUELLER, OTTO H., c '43, is a corporal in the 7th Engr. Bn., somewhere in Europe, according to a Christmas card.

Chemicals

CRETNEY, ROBERT W., '21, is superintendent of the Thermatomic Carbon Co.'s Sterling, La. plant which produces furnace carbon for natural gas or mixtures of natural gas and hydrogen.

DAMON, GLENN H., '26, Ph.D. '32, has left a position as research scientist with the Division of War Research, Columbia University, to become section manager of a lab for Carbide and Carbon Chems. Corp. of New York.

McCARTER, ROBERT J., '40, took leave of absence from Universal Oil Products Co. to accept a commission as Ensign in the Navy. He took indoctrination training at Tucson, Ariz. Previously he spent considerable time in Arkansas and Oklahoma putting new petroleum plants in operation.

HARE, JAMES H., '41, was captured by the Japs at the surrender of Corregidor and has since been reported to have died in a prison camp.

LAVRICH, MILTON E., '42, after six months with the Lockheed Aircraft Co. in Burbank, Cal., doing analytical work, has accepted a position with the Schenley Laboratories in Penicillin research.

HADDOCK, GORDON W., '43, is doing research on high speed combustion for the N.A.C.A. at Cleveland, Ohio.

TIMM, GEORGE J., '43, visited his Alma Mater last November. As Asst. Dept. Head for the Carbide and Carbon Chems. Corp. of Louisville, Ky., he is responsible for the management and administration of the production of butadiene from alcohol.

(please turn to page 22)

MASS SPECTROSCOPY . . .

(from page 9)

occurs naturally in a low concentration (1.09%). The synthesized amino acid is then fed to the rat; since the isotopic carbon possesses the same chemical properties as ordinary carbon, the synthesized amino acid is normally digested. After a period of time different parts of the rat's body are examined by means of the spectrometer for the isotope. Its abundance indicates to what extent that part of the body is utilizing the acid.

In the nitrogen fixation studies of Drs. Wilson and Burris of the Agriculture Bacteriology Department, nitrogen-fixing bacteria are placed in flasks in which favorable living conditions are maintained. An atmosphere containing nitrogen of atomic weight 15 is confined over the bacteria, and a nitrogenous compound containing ordinary nitrogen is placed in the flasks. After a time the bacteria cells are examined for the abundance of the isotopic nitrogen, and from the ratio of this to ordinary nitrogen the amount of fixed nitrogen can be computed.

In many complicated chemical reactions intermediate processes are undergone and intermediate products are formed which cannot easily be analyzed by ordinary chemical means, but may be studied by means of the mass spectrometer. The reacting compounds are enclosed in a vessel with an opening through which gaseous reaction products may be periodically drawn off and examined in the atom sorter. Knowing the weights of the different particles and their relative concentrations, the nature and composition of the various intermediate products may be deduced.

Probably the most important commercial use of the atom sorter at the present time is in the analysis of complex mixtures by the isotopic dilution method. For example, to find the amount of toluene in crude oil, synthetic toluene is first made using a "tagged" element, usually C^{13}. A known amount of this toluene is thoroughly mixed with a definite amount of crude oil. A small sample of toluene is then isolated from the oil, and from the ratio of isotopic to ordinary carbon the original amount of toluene in the crude oil may be determined.

A. O. Nier has made an interesting mass spectroscopic study of the age of radioactive bearing minerals. His investigations were based on the fact that the ultimate disintegration product of radioactive substances is lead. Knowing the amount of lead present in the mineral, the ratio of the disintegrated lead isotopes (uranium lead RaG and Thorium lead ThD), the amounts of uranium and thorium, and their decay constants, the approximate age of the mineral can be computed, provided the amount of common lead impurity is known. Since the atomic weight of the common lead impurity is 207.2, while the mass of uranium lead is 206 and that of thorium lead is 208, the amount of contamination may be determined from a mass spectroscopic analysis of the mineral. Nier's results are in good agreement with those previously calculated from the Pb/U ratio. In the earlier work the contamination was computed from the atomic weight of the lead, and some empirical relationships were used.

Up to the present time the greatest hindrance to the commercialization of the mass spectrometer has been the prohibitive first cost (about $6,000) and the necessary expert servicing. However, the manufacturing companies are constantly improving it, and, like the electronic oscilloscope, a serviceable mass spectrometer may soon be available at a reasonable cost. Judging from the rapid advances of spectroscopy in the past few years it probably will become a valuable tool to science and engineering.

Anyone interested in house work, apply 356 M.E. Bldg.

—The office is being cleaned up.

The dear vicar's wife had just died, and in consequence he wished to be relieved of his duties for the weekend, so he sent his bishop the following message:

"I regret to inform you that my wife has just died, and I should be obliged to you if you could send a substitute for the weekend."

Campus Hi-Lites

—Jane Strosina, c'46

Mildred Smith, m'46

After much research on the subject, Allen Hamby, and Hanke, insulting engineers, have developed a slack factor.

Prize Boner of the Month—Overheard at a recent open-house held at President Fred's:

President Fred to new V-12: "How do you do. I'm Fred."

New V-12: "How do you do. I'm Ray."

Why, after a birthday celebration, did June Hartnell have to have a glass of water constantly at her side?

In the romance department we have the engagement of Jim Verchota, June M.E. graduate, to Gail Frostad . . . We have also heard of the future triple wedding plans of Welch, Woboril, and Whitney in New York — but we haven't been able to figure out who Whitney plans to marry.

We are sorry to have E. H. Haft, Jr., senior M.E., leave us. Uncle Sam has sent him a greeting card.

It must have been nice for Don Arntzen to have the little woman home with him between semesters, wake him at 10 or 11 in the morning.

Glad to have Chuck Aten back from the hospital. We hear he had an operation because his nose wouldn't run.

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AIEE:

The first meeting of the University of Wisconsin branch of the American Institute of Electrical Engineers for the summer term was held Friday, July 20, in the Memorial Union. The meeting, which was an informal smoker, was for the purpose of acquainting new students with the institute. After a talk by the president, Gerry Keppert, on the advantages of membership, films entitled, "Sight Seeing in the Home," and "The Story of FM" were shown. There was free food, beer, coke, and cigarettes.

Officers of AIEE are:

President .... Gerry Keppert
Vice-President .... Vernon Pillote
Secretary-Treasurer .... Gene Daniels

•

MESW:

At the July 17th meeting, Professor G. L. Larson, the speaker, spoke on "A Canoe Trip Through Canada."

Officers are:

President .... George Hlavka
Vice-President .... Jim Bakken
Secretary .... Robert Fleming
Treasurer .... Mildred Smith

•

AICE:

At the last AICE meeting, new officers were elected and plans for "snagging" new members were made. Activities for coming meetings were discussed.

Officers are:

President .... Bob West
Vice-President .... Bill McCoy
Secretary .... Morris Rhude
Treasurer .... Bob Lee

•

AIChE:

The chemical engineers held a picnic on July 21 and are now engrossed in a membership drive.

Officers:

President .... John Henderson
Secretary .... Bob Potts
Treasurer .... Robert Axtell

POLYGON BOARD:

New members of Polygon Board include:

Officers:

President .... George Hlavka, MESW
Secretary .... Ray Pett, ASCE
Treasurer ...... John Henderson, AIChE

Members: Ed Art, MESW; Bill Gabriel, AIEE; Gerald Keppert, AIEE; Ralph Sherden, AIChE; Bob West, ASCE.

They have been discussing plans for possible social activities for the coming year.

ALUMNI NOTES . . .

(continued from page 20)

Electricals

REINHARD, G. A., '08, visited his Alma Mater last fall, with his daughter. He and Prof. Price exchanged reminiscences.

DAY, L. N., '41, is employed by the General Electric Co. as a field engineer. He is at present their technical representative on the B-29 electrical equipment with the Army Air Forces.

•

Mining and Metallurgicals

STICKNEY, L. NORMAN J., '46, has recently been promoted to first lieutenant and now is on furlough awaiting further orders. While on duty he has completed thirty-five missions as navigator with the 8th AAF. At his base in England, Norm met Kenny Carlton who is serving with the same bombing group.

FRISKE, WARREN, '44, completed his training and has been ordered to San Diego to await assignment.

PAZIK, GEORGE J., '43, sends his regards from a frontline position with the Combat Engineers near Rouen, France.

PUHL, JOHN, '44, stopped in to chat with his Profs on his way to Seattle, Wash., where he will be attached to the crew of a new aircraft carrier.

SWENSON, WILLIAM, formerly employed by the Anaconda Copper Co., recently completed boot training at Great Lakes and is now at the Great Lakes Radar Technicians' school.

(please turn to page 29)

GAS TURBINE . . .

(from page 18)

fuel consumption being as much as 30% to 40% of that at full load. On the other hand, for each fractional load there is a best lower speed, and if the set is run at this speed the no-load fuel consumption will be about 1/2 as much. The simpler gas turbine without the regenerator suffers somewhat worse in this respect. These are modifications in design, however, which can be made to improve this light load fuel consumption, but generally some other factors may have to be sacrificed.

This variable speed presents certain difficulties, particularly for a-c generator drive. This can be overcome to some extent by dividing the gas turbine part of the set. Either a series or parallel arrangement may be used. Thus a high pressure element may exhaust into a low pressure element or two separate turbines operating between the same initial and exhaust pressures may divide the gas flow between them. With either arrangement, one turbine drives the compressor and the other delivers the net output of the set. The compressor set can then run at the best speed for economy at each load and the power turbine can run at fixed speed or any speed suited to the load. This has many other advantages and also several disadvantages.

Starting

The gas turbine must be started by external power. This is simpler if the compression ratio is not too high, and if the compressor does not have an intercooler. The starting power will probably be from 1% to 3% of the net power output depending upon conditions. Under certain conditions it may even be less.

Compressor and Turbine Arrangements

Multi-stage centrifugal compressors could be used, and would probably be satisfactory if intercooled, but would be bulky and lower in efficiency based on any known designs than would be true with properly designed axial flow machines. Some designers are considering the new Lysholm type constant displacement blowers. These machines are reputed to have a good efficiency when used as a two or three stage compressor, but are much heavier and more bulky than the axial flow type. They might not be so susceptible to loss in efficiency and pressure rise with dirt, however.

As mentioned earlier, the turbine may be in one unit on the compressor shaft, or may be divided into two or more sections with some sections driving the compressor and the other the power shaft. Each turbine, aside from its simplicity and low cost, has two other very distinct advantages: One, a very substantial temperature drop takes place through the stationary nozzles and before the jet strikes the buckets. Further, the wheel disc can be easily cooled and so run at high peripheral speeds. Both of these factors permit higher initial temperatures to be used than with a multi-stage turbine. These advantages must be offset against the disadvantage of a somewhat lower turbine efficiency than if a multi-stage turbine is used. Much experience will be required before this matter is finally settled.

Other Types of Gas Turbines

The variations possible in gas turbine cycles, types, and design are legion; many years will probably pass before they are sorted out, and many will probably survive, each for different applications.

One early type was the explosion gas turbine, and its principal advantage is that it greatly reduces the work of the compressor.

Another early proposal was that the turbine be subatmospheric with the air compressor on the exhaust side after cooling. One advantage being that if water is injected in the exhaust the CO_2 and H_2O would be absorbed and so the work of compression would be reduced.

Neither of these will probably be revived. The possibilities in the constant pressure cycle with different arrangements and amounts of regeneration, intercooling, water injection or steam generation, single or multiple turbines, with or without reheating in between, single and multistage turbines, axial flow or constant displacement compressors, furnish a wide possible variety of arrangements.

An interesting gas turbine cycle is being actively promoted by Escher Wyss in Switzerland. This is the closed cycle with external combustion and cooling. As such, the cycle is substantially as shown in Figure 2, but the cycle is closed using a definite amount of air or gas as the working medium. In place of heating by the internal combustion of fuel, the working fluid is heated by being passed through tubes in a fire box of a furnace, and ahead of the compressor it is cooled by passing over water cooled tubes. The working fluid remains clean, and the capacity of the plant can be changed at will by increasing or decreasing the density of the working fluid in the cycle.

The output for a given weight of fluid in the cycle depends upon the heat put into the furnace. The disadvantages are the large amount of high temperature heat exchanger surfaces required, probably 3 to 5 times that of a steam plant, and the very low pressure drops which must be maintained through them. So far as is known to the writer, no efforts are being made in this country to exploit this cycle with external firing.

The Gas Turbine in Combination With The Internal Combustion Engine

One field that looks very promising for the future is to combine the gas turbine and the internal combustion engine. This has already been done with great success in the case of the exhaust gas turbine driven supercharger for the airplane engine and the Diesel engine. By increasing the supercharging pressure, the output of the gas turbine can be increased until it is equal to the engine output; under which conditions the engine can, if more convenient or otherwise desirable drive the compressor and turbine the load. In one type of two-cycle Diesel combinations it is

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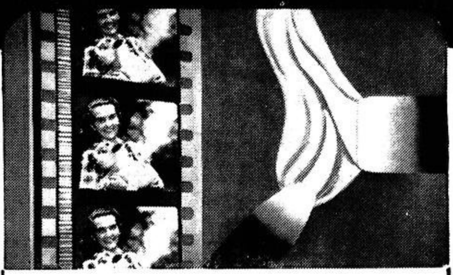
Light for your favorite Stars...



The large picture you see on the movie screen is projected by the carbon arc from tiny frames of film, each about one-half square inch in area.

Through intensive and continuing research, National Carbon has made the carbon arc brighter and brighter. This progress made possible the intense light required for enlarged screens in large theatres. It was also a major factor in the development of improved studio techniques, and in the present day excellence of pictures in color.

Today National Carbon can produce light from the carbon arc that is actually more brilliant than the sun.

YOUR ENJOYMENT of Hollywood's brilliant productions is dependent on the blackest substance known to man—carbon.

From a booth at the rear of your movie theatre, the intense snow-white light of a carbon arc projects the tiny pictures from the film, enlarged as much as 300,000 times in area, onto the screen.

Only the carbon arc with its concentrated brightness can do this difficult job.

The carbon arc—a subject of years of research by NATIONAL CARBON COMPANY, INC., a Unit of UCC—also serves in many ways other than on the motion picture set and in movie projectors.

Military searchlights, as well as lights for photoengraving, employ the carbon arc. It is also used to increase the Vitamin D content of milk and other products. It has opened up new scientific methods in the analysis of metals. It brings the beneficial effects of ultraviolet rays to man. Even in agriculture, uses are being found for the carbon arc in the study of plant growth.

▼

For further information on the carbon arc... write for booklet P-8, "Radiant Energy."

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INDUSTRIAL GASES AND CARBIDE—The Linde Air Products Company, The Oxweld Railroad Service Company, The Prest-O-Lite Company, Inc.

GAS TURBINE . . .

(from page 24)

proposed that the engine drive the compressor which discharges through the engine cylinders at the exhaust position and then into the turbine. The compressed air acts as scavenging and supercharging air at the same time, and the exhaust heat is added to the work done on the air by the Diesel. Efficiencies are said to be possible with good compressor and turbine efficiencies which are substantially higher than that of the Diesel itself. This looks like a very promising combination, and has been built in an arrangement with the Diesel and compressor cylinders on the same rod and without a crankshaft.

Fuels

The question of whether or not cheap fuels can be successfully used by the gas turbine is one of the greatest unknowns at this time. Up to this time, aside from experimental units, all gas turbines have been built for liquid fuel, although it is true, I believe, that those in connection with the Houdry process are operating on the burning coke in the catalyst towers, and a few machines have been proposed to run on gas as a fuel. The use of oil presents the least difficulty; there will be a certain market for such machines, and it permits solving the problems of the compressor, turbine, control, etc., with the least complications from the combustion and ash standpoints. The burning of gas presents no difficulties other than the use of a separate compressor, since it seems somewhat unlikely that the risk of compressing the gas and air together in the compressor could be taken.

The burning of heavy residue or raw crude oils, such as are normally burned in boilers, and the burning of coal with low maintenance are the goals which the gas turbine designer must attain before he can really compete in the power field with the reciprocating steam railway locomotive and the steam turbine electrical generating plant. Here the question is one of the combustion and the handling of the ash and slag through the turbine, or else separating it at high temperature before the turbine is reached, together with the problems of control in the case of solid fuel combustion. When it is remembered that turbine efficiency is so important from the net power output standpoint, very little deterioration in turbine performance can be permitted from bucket or nozzle wear or deposits. From the separating standpoint, electric precipitators are, it is understood, out of the question at high temperatures, and the pressure drop available for kinetic precipitators is very small. It would seem that the easiest approach might be to gasify the coal under pressure and to burn the gas so produced without cooling or scrubbing. Such a producer would have to be built so as to retain the maximum amount of ash and slagging elements.

Advantages and Disadvantages of the Gas Turbine Power Plant

The advantages will probably be: light weight, greater unit capacities compared to internal combustion engines, simplicity, low first cost, low maintenance compared to internal combustion engines.

The disadvantages will probably be: moderate efficiency in the simpler forms, large regenerator surface in efficient forms, small unit capacities available compared to steam turbine plants, high maintenance compared to steam plants, cannot yet burn solid fuels, does not have good speed torque curve, may easily stall at low speed, requires a transmission to load to ship or vehicle, high light load fuel consumption, may lose efficiency and capacity due to blade deposits and erosion.

In respect to this last point, it cannot be overlooked that the high efficiency necessary in both turbine and compressor cannot be maintained unless the blade forms are unimpaired by deposits or erosion. This has been a major problem in steam turbines where it only occurs on a small percentage of the entire number of stages and where it generally affects the capacity less than the efficiency. In the case of the gas turbine where efficiency of the two elements causes such a drastic effect upon the net efficiency and net capacity, this matter cannot be overlooked. The dirt in the average industrial atmosphere is much greater than usually realized; and if any sticky substances are present such as oil or other similar materials, the problem of maintaining the cleanliness of the compressor blades with the passage of more than 6,000,000 lbs. of air per day through the compressor of a 5,000 net horsepower machine, can easily become a serious matter. Air filters for such large quantities of air also present serious problems of size, cost, pressure drop, and maintenance.

Capacities

Although by running at suitably lower speeds there is no theoretical limit to the capacities for which gas turbines can be built, it is quite probable that the upper limit for some time will be in the neighborhood of 10,000 kw. On account of the difficulty of building very small turbines and compressors with high efficiency, it is rather probable that the lower limit may be about 500 horsepower, although some engineers are projecting units of less than this. A supercharger open or closed cycle may permit higher capacities.

Probable Applications

The following represents the present writer's carefully considered opinions at this time and may, of course, be modified with subsequent developments not now in view.

Electric Power Production: The extensive application in the immediate future of the gas turbine to electric power production in competition with the coal fired steam turbine central station plant is probably extremely remote except under certain circumstances. It could not possibly compete economically burning oil as fuel.

The gas turbine has been widely hailed as a possible peak load plant. Even as such, under present public utility conditions its use is unlikely. In the first place, due to the rapid expansion of the electric utility business and the improvement in the art of steam power plants themselves,

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the power industry has always had a large amount of capacity in older stations whose economy was not as good as the newer stations and which could best be kept in reserve to carry the peak loads. It is true that the maintenance and operating cost on these older plants are high, but it has never been economical to scrap such plants in the past in any great numbers, and the first cost of a competing plant would have to be low indeed to permit it in the future. Further, in this country, in contrast to the practice abroad, all modern steam plants have been built with a considerable amount of "stretch" in them to permit handling peak loads, as has been amply demonstrated during this war emergency. In addition, the characteristics of the loads, due to summer air conditioning, refrigeration, daytime lighting, chemical plant use of electricity, and promotional rates and inter-connections have been such as to reduce or eliminate the old-fashioned "peak" load on many generating systems.

It is quite possible that the gas turbine will find extensive application in moderate size semi-portable power plants in the oil or gas fields, or to serve as portable emergency oil fired power plants on rail cars for which the steam turbine is now being used, but with some difficulty.

Another possible application is a mine-mouth power plant in connection with the mining of coal by subterranean gasification as is being pioneered (without the gas turbine) in Russia today. The elimination of the necessity for condensing water makes it quite desirable for this purpose, since water in sufficient quantities is not apt to be available very frequently near the mines.

Industrial Uses: The oil refining plants have already provided one of the most extensive applications for the gas turbine and may probably continue to do so, although the rapidity of change in this field of application makes prediction for one not closely in touch with the new developments here rather speculative.

It is quite possible that the gas turbine and the highly efficient axial compressor could be economically applied to blast furnaces. However, here it is to a great extent a question of how many of these will be built in the near future in this country, since it is possible that the wartime expansion recently forced on the steel business may have already built up with available types of equipment the normal expansion of the next decade.

As for the normal industrial power plant, it has been the past experience that a very large percentage of these, averaging over a nine year period about 85%, have been installed in connection with the furnishing of steam for process work for which the back pressure or extraction type steam turbine is excellently adapted. So far as this application is concerned, this has not yet reached the peak of its potential development with higher steam pres-

(please turn to page 30)

Short Circuits

—E. Daniels, e'46

A blotter is something you spend your time looking for while the ink is drying.

•

He knocked at the door of my room.

"May I come in? It's the room I had when I went to college in '09," he said.

I invited him in.

"Yes sir," he said, lost in reverie. "Same old room. Same old windows. Same old furniture. Same old view of the campus. Same old closet."

He opened the door. There stood a girl terrified.

"This is my sister," I said.

"Yes, sir. Same old story."

George can't do a thing without his sliderule.
—Westinghouse

There was a drunk who stared at a homely passenger in the elevator. He finally blurted out, "My God, you're ugly!" The homely one, in an effort to control himself, replied, "I can't help the way I look." This answer didn't seem to satisfy the drunk for he fairly screamed, "Well, you could stay at home!"

•

When a fellow breaks a date he usually has to.
When a girl breaks a date she usually has two.

•

I had a bunny,
His name was Jim.
Got sixteen now,
Her were no him.

"Who's your close-mouthed friend over there?"

"He ain't close-mouthed. He's waiting for the janitor to come back with the spitoon."

•

"My boy friend doesn't smoke, drink, or swear."

"Does he make all his own dresses, too?"

•

"I heard your kid bawling last night."

"Yes, after four bawls he got his base warmed."

•

Old Lady: "You don't chew tobacco, do you, little boy?"

Little Boy: "No ma'am, but I could let you have a cigarette."

•

There once was a maiden from Siam,
Who said to her love, young Kiam,
"If you kiss me, of course,
You will have to use force,
But God knows you're stronger than I am."

•

"What would you call a man who has been lucky in love?"

"A bachelor!"

•

Joe took his aunt out riding,
Though icy was the breeze.
He put her in the rumble seat,
To see his anti-freeze.

•

"My roommate fell down the stairs last night with a fifth of Johnnie Walker."

"Did he spill any?"

"No, he kept his mouth closed."

•

I cannot study when you're gone,
And books would bore me now, I fear.
I don't take notes; I sit and yawn,
Just like I did when you were here

•

"What's the idea of the black crepe on the door—somebody die?"

"Naw, that's just my roommate's towel."

•

Cursing and yelling in a London street was Clancy holding a doorknob in his fist. "Them damn Nazis will pay for this—blowing a saloon right out of me hand."

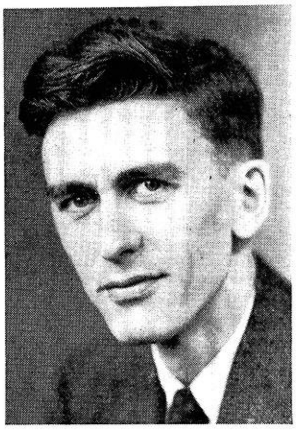
ALUMNI NOTES . . .

(continued from page 22)

Electricals

Hubbard, Edwin P., e'07, died at the Veterans' Hospital in Milwaukee on March 13, following a long illness.

Vea, O. F., e'32, has recently been placed in charge of a newly created Marketing and Promotion Section of General Electric Motor Division. After graduation in 1932, he was associated with several companies as production supervisor and electrical engineer. In 1936 he began his work for the General Electric Company as a test engineer, later transferring to commercial work there.



Gustafson, Richard B., e'41, is working on new types of hermetically sealed radar components, many of which are still in the experimental stage and can not be revealed. His work, which includes not only the designing of electrical and mechanical parts for radar equipment, but also the perfecting of the complete device. Mr. Gustafson is with the Power Transformer Engineering department of the General Electric Company's Pittsfield, Mass. plant.

Runstrom, Lt. George A., e'41, is stationed at the U. S. N. Mine Warfare Test Station, Maryland. His work consists of testing mines and torpedoes at the Solomons testing ranges. He was married to Josephine Aspenluter of Mt. Vernon, N. Y., and is the father of a six week old baby girl, Martha Jo. Prior to his present work, Lt. Runstrom worked for twenty months on the design of the new third locks in the Canal Zone.

Hagensich, Gardon C., e'43, is employed with the Westinghouse Electric and Mfg. Co. as a Junior Electrical Engineer. He is doing work on mercury arc rectifier development.

Bellard, Max H., e'43, is working for Allis Chalmers Mfg. Co. as assistant to the development engineer. He is doing work in development design, test calculator, and recording information for transformers.

Luebs, Art, e'44, is Specialist (X) 2/c in the Navy and is working in the Naval Ordnance Lab in Washington, D. C.

Swanstrom, Willard, e'44, is also a Specialist (X) 2/c in the Navy and working at the Naval Ordnance Lab in Washington, D. C.

Gilman, Art, is working with the A. C. Generating Engineering Department of Westinghouse Electric and Mfg. Company.

GAS TURBINE . . .

(from page 27)

sures. Preliminary studies which have been made indicate that, except under special conditions perhaps, the gas turbine has very little advantage to offer here.

As Steam Or Mercury Boiler Auxiliary: Where oil would be burned as fuel in any event, it looks now as though the gas turbine and compressor would be a very valuable auxiliary to the boiler plant; either to use the boiler as a cooled combustion chamber under pressure ahead of the gas turbine, as in the "Velox boiler" of the Brown Boveri Company, or to use the gas turbine plant as a super blower for a more orthodox boiler. Some surplus power might be produced at a thermal efficiency of substantially 100% as in a superposed plant, or all of the extra power might be used to blow the boiler and so reduce its weight and dimensions as would be valuable on shipboard. If the problem of coal combustion for the gas turbine can be solved, then this application may be extended to coal burning boilers with substantial advantages.

In Combination with Diesel Engines: As stated before, the gas turbine, particularly as improved by the addition of a highly efficient compressor may have substantial advantages and potential application in connection with Diesel engines. The simplest and most immediate of these will be to simply act as a supercharger to increase the output of the Diesel engine, and in the more refined arrangement the supercharger will have a new power output which can be added at no fuel cost to that of the engine.

Other arrangements will be to have the Diesel engine drive the compressor with all of the net power coming from the gas turbine. It is quite probable that this arrangement will provide an over-all thermal efficiency in the neighborhood of 40% or better; and in applications where very low fuel consumption is of paramount importance, this arrangement may be of considerable value. Great strides have been made in Diesel engine design and manufacturing facilities during the war; and the application of new materials to Diesel cylinders, rings, pistons, and valves may permit reasonable maintenance costs even at the high mean effective pressures and rates of heat release in the cylinders which would be required to make these combinations really effective in increasing the output and efficiency of Diesel engines. This factor will probably be the limiting element in this development.

Transportation—Airplane: There are a number of factors which make the gas turbine attractive as a prime mover for large airplanes. These are as follows:

1. The weight can probably be less than with existing types of engines.
2. Planes generally operate at low ambient temperatures.
3. High gas leaving velocities are permissible from a turbine on high speed airplanes.
4. Clean air available.
5. A high-grade fuel is now used.
6. The operating life of the present competitive prime mover is not as long as in other applications.

Low ambient temperature, as pointed out earlier, reduces the power to drive the compressor and so results in a high net output, and a high thermal efficiency. The advantage of the high leaving velocity permissible on a moving platform has not been generally understood and permits greatly increased output from a given turbine wheel. The reason it is permissible on the airplane is that at modern airplane speeds 60% to 80% of the leaving loss may be recovered as net power in the reaction of the jet from the exhaust if the design is properly carried out.

The freedom to design the gas turbine for a life comparable to that of existing superchargers, which now approximately equal the life of existing engines, will permit operation at higher initial temperatures and higher turbine speeds than would be considered permissible for normal land or marine applications.

Transportation—Marine and Navy: Many people are hopeful that the gas turbine will be of value in connection with marine and Naval application. It is possible that this will be so on certain classes of light weight, high speed boats. In the writer's present judgment, however, it is somewhat improbable that it can be applied advantageously on the heavier ships. There are a number of factors which point to this conclusion. In the first place, on marine applications the gas turbine will be competing with a condensing steam plant on the most favorable basis where ample supplies of cool, clean condensing water are available at the minimum cost. This means that generally the gas turbine would be at a disadvantage as to efficiency, or at least will have no advantage. Second, there are transmission difficulties in connection with transmitting the power to a propeller shaft from a gas turbine, and there is also difficulty in connection with reversing. These can only be surmounted at the present time with electric or hydraulic drive, a variable and reversible pitch propeller, or by separating the compressor and power turbines with all the difficulties of operating a reversing turbine at atmospheric pressure and on the extremely hot gases of the gas turbine. These difficulties can be overcome, but will not be unless the advantages are sufficient to warrant the effort. In this case the only advantage which is usually cited is the lower weight which such a plant would have, and this will be offset to an appreciable extent by the above difficulties in connection with transmission.

If light weight were an important factor in connection with commercial marine vessels the present steam power plant art would permit immediately, if it were demanded by the trade, a reduction of more than 2 to 1 with probably no sacrifice in efficiency or reliabilility, as evidenced by modern Naval power plants.

Another difficulty in connection with the application to Naval vessels is that of getting a very high degree of

(please turn to page 32)

GAS TURBINE . . .

(from page 30)

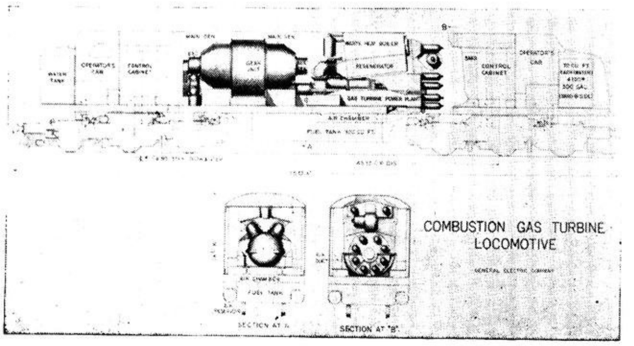
cruising economy as compared to existing steam plants. This might be overcome by a combination of Diesel engine compressor for cruising conditions if the gas turbine can otherwise be successfully adapted to the propulsion of such vessels.

On the other hand, in favor of applying the gas turbine to marine and Naval vessels is the fact that these vessels already use oil for fuel. However, the future need for oil conservation may dictate a reversion to coal for fuel or one of the newer combinations of powdered coal and oil which would permit saving some 40% of the oil now consumed under steam boilers. If real economy of fuel is ultimately demanded of marine propulsion equipment together with the use of the cheapest possible fuel, it is quite probable that the mercury-steam system might present a much better solution than any other form of prime mover.

Transportation—Trucks and Automotive Vehicles: This presents a possible but highly questionable application of the gas turbine, the primary difficulties being the inherent ones of producing a turbine unit in the small sizes, the transmission difficulties, and the poor light load economy.

The automotive gas engine and Diesel are well entrenched in this field and would be formidable competitors for any type of new motive power. The application of the gas turbine as an exhaust driven supercharger for engines on such vehicles is, however, well past the developmental stage in Europe and might conceivably have a wide application here.

Transportation—Railway: The application of the gas turbine to the railway locomotive appears as though it is almost as much a "natural" as the application of the reciprocating steam engine was at one time, or the possible application of the gas turbine to the airplane may be in the near future. The application of a turbine to a locomotive has long been a dream of engineers and much effort



has been made to carry it out. The difficulty of condensation has always thwarted efforts to apply a condensing steam turbine, and the gains of the non-condensing turbine over the reciprocation cylinders have never proved to be worth the extra transmission difficulties. On the other hand, if the gas turbine is so applied it need not use water or condensing surface, it will be light in weight and very compact; its optimum capacity will be about what the railway companies want; and it can produce sufficient by-product train heat from the exhaust. Electric or hydraulic drive will be suitable, and insofar as electric drive is concerned the transmission is already well developed. The maintenance should be low. Further, some of the competition now uses oil for fuel and of a higher grade than would probably be required of the gas turbine. If the gas turbine can be developed to use coal as fuel and if it can be made into a satisfactory machine from the maintenance and reliability standpoint, it would appear to have a most promising future as a railway prime mover.

Summary

To summarize the situation with respect to the potentialities, limitations, and probable future applications of the gas turbine, it would appear that industry has here a most promising new tool for the production of power. In certain places it has most interesting advantages as compared to existing prime movers. To predict limitations for any new development is always a hazard; however, in other places there seems to be good reason to believe that the gas turbine will not be able to compete or certainly not to displace existing machines.

In making such a study as this, one should never lose sight for an instant of the fact that the competition of any new machine such as this will be a moving target. The Diesel engine, steam turbine, or steam locomotive with which the gas turbine must compete two to five years from now when it begins to "come of age" from an application standpoint will not be the Diesel engine, but they will be new, different, and better machines as a result of the strenuous developments which will have been taking place during the past four and the next five years. Each will benefit to some extent by the new materials, the new discoveries, and the new techniques which in turn make the gas turbine a possibility today.

Out of it all, of course, are coming better and more efficient types of power plants for all manner of applications, in which the gas turbine is going to do some things better than they have ever been done before.

Mary had a little lamb,
Its fleece was white as snow,
She took it to the M. E. lab,
Now look at the damned thing.

•

A half breed is a man with a cold in one nostril.

•

"Is this dance formal or do I wear my own clothes?"

•

Two psychoanalysts met. Said one to the other, "You feel fine. How do I feel?"

•

An ash tray is something to put ashes into when the room has no floor.