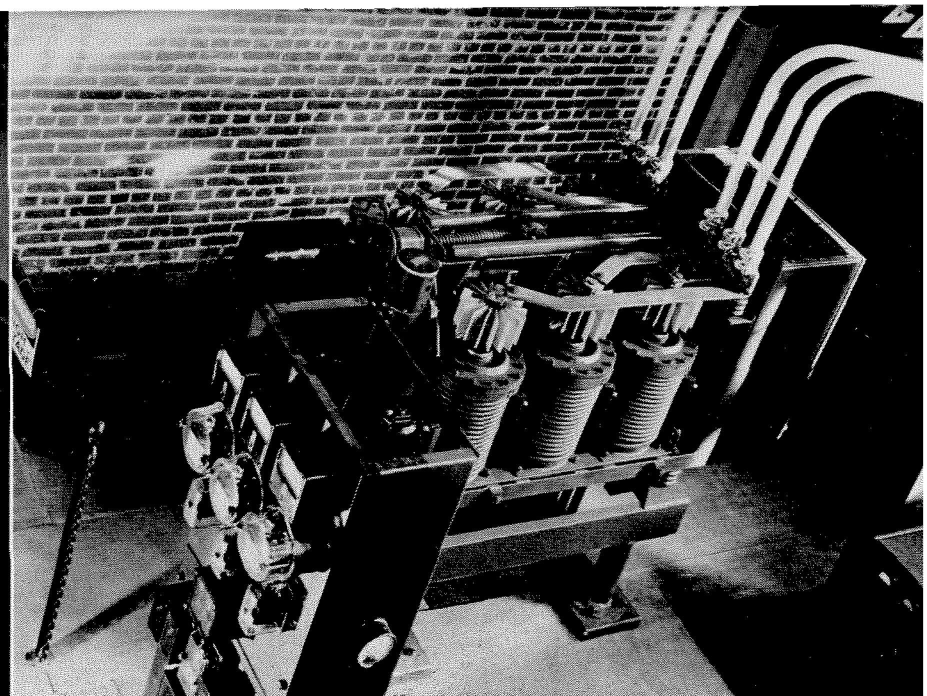


AT LEFT: A new mass spectrograph. This instrument uses beams of electrons and of positively charged particles to analyze the chemical constitution of complex organic gases. AT RIGHT: Typical ignitron rectifier substation for the production of d.c. power.

Electronics in a Postwar World

By WM. H. PICKERING

SOME of the most spectacular technological advances of the war have been in the field of electronics. Many of these are directed towards purely military ends and their details will not be divulged until the war ends. Many others, however, have been in industrial fields and these may serve to point the way for an estimate of the part electronics will play in the postwar world.

Until a few years ago the vacuum tube was used almost exclusively for communication purposes. Both radio and long distance telephone service would be commercially impractical without it. With the coming of sound motion pictures a major field outside of the communications services was opened up, and although this particular field involved essentially the same tubes and circuits as were used for communications, the possibilities of other applications gradually became apparent. In the early nineteen thirties the first tubes were produced for purely industrial use and, in a very small way, a new tool had been provided for industry.

Industry was not impressed. The circuit engineers could dream up various wonderful devices, perhaps they could even demonstrate their gadgets, but to the factory manager, vacuum tubes were used in radio sets and they were always burning out or getting broken. In general they were thought of as being fragile and unreliable and not to be trusted in a factory, particularly since most of their applications seemed to involve control or measurement. The criticism was partly justified. The design engineer had not yet learned how to make his circuits "foolproof," or to make his equipment stand up to the abuse accompanying its operation by unskilled personnel. In actual fact, however, these difficulties had been completely removed by the time the war began and there remained only the "sales resistance" to a new idea. Wartime necessities and production schedules have removed this last obstacle, electronic gadgets are definitely accepted by industry, and the next few years may well show the vacuum tube to be one of the most useful and universal tools yet invented.

In attempting to survey the future possibilities of electronics, let us divide the field into three categories: entertainment, communication and industrial applications. Of course there will of necessity be a certain amount of overlapping, but these will serve as a basis for discussion.

Every house has now at least one radio set under the family roof and probably another in the garage beneath the family steering wheel. Will the wartime developments make these as obsolete as the "Model T" Ford? There have been two improvements in radio entertainment that have been technically ready for a few years and that appeared commercially shortly before the war. These are television and frequency modulation. For various technical reasons both of these require the use of very high frequencies and they cannot be received by adaptation of ordinary receivers. Special sets will be necessary for these signals. These sets will probably be designed to receive the ordinary broadcast and short wave signals as well as the television and frequency modulation, so

AT LEFT:

Flyers call this the "Gibson Girl" radio, the name being derived from the equipment's rather well-defined curves. It is a hand-powered transmitter which can be used by flyers forced down at sea. The aerial is supported either by a kite or a balloon.

that one rather large and expensive set will receive all the entertainment provided on the ether.

Television has been "just around the corner" for so long now that its actual arrival may well be somewhat of an anti-climax. If it is to be adopted on a large scale, the following questions among others must be answered. How will the listening habits of the public be changed? At present we are accustomed to having the radio playing in the corner of the room while we go about our daily business, study or play bridge. With television we must watch the screen, and perhaps even darken the room. It will require a definite planning of our time to be able to sit down and enjoy the show. A second question concerns the matter of expense. How will the television show be financed? A good show will presumably cost much more than a sound broadcast. At the same time, the listening public will be few in numbers for some years. One possible means of spreading the cost will be to use televised films in the same way that transcriptions are used today. Another question concerns the audience. How will the householder know that he will have satisfactory reception? Television must use very high-frequency waves and one of the vagaries of these waves is the fact that for satisfactory reception there should be a clear line between the transmitting antenna and the receiving antenna. There are numerous exceptions to this rule, but by and large it is true. Consequently, to take our local situation, a resident in La Canada would not be able to receive the television signals from the Don Lee station above Hollywood. In some urban areas this might be a serious handicap no matter where the transmitter is located. One technical question, does television suffer from static? The answer is: from natural static, no; from man-made static, yes. The most serious source of static in residential areas is the automobile. Automobile ignition systems cause spots and flashes to appear on the screen. The only solution is an extensive use of suppressors and shielding in all automobiles.

Frequency modulation has been presented as a means of providing static-free entertainment of high quality, and indeed there is no question of the technical improvement possible. However, we must again ask, what about the listening habits of the public? The ordinary citizen is accustomed to having his radio sound like a radio. He usually adjusts the tone control to give lots of bass and is delighted with the result. It will take considerable education to persuade him that he wants to listen to a true reproduction of the original music. Furthermore, good quality of reproduced music is difficult to attain without using relatively large loudspeakers and baffles and without considering the acoustics of the radio in the room in which it is to be used. The cheap portable radio will not be able to offer any improvement of quality by the use of frequency modulations; it cannot yet take advantage of the quality of present broadcast music. Another factor with frequency modulation is the fact that these signals also use the very high frequencies. Among other things this means that the effective coverage of a frequency modulation station is only some 30 or 40 miles radius. Over these short distances, reception from standard broadcast stations is normally free from static except in some urban areas where man-made static is very bad or during thunderstorms. The advantage theoretically possible with frequency modulation might not prove so significant in practice.

These facts should be sufficient to indicate that the new types of signal will not supplant the present standard broadcasting. They will provide additional entertainment for those willing to pay the increased cost, and presumably, through the years, will become increasingly important. At the same time these developments will lead to some improvements in existing receivers and transmitters, but nothing startlingly new has yet been revealed.

In the field of communication, one of the more attractive new developments is the "walkie-talkie" of the Armed Forces. Some enthusiasts have jumped to the conclusion that after the war we will all have telephones in our automobiles. This is a very long extrapolation, and one which, although technically possible, is practically impossible. At one time or another we have all seen a little item in the newspaper about the local police radio getting mixed up with signals from Podunk and sending the patrol cars on a fruitless search for the drunk on First Street. Imagine the possibilities for confusion if one million automobiles had radios, and you tried to get a message to the wife about the flat tire that was going to make you late for dinner!

Although it will not be used as universally as the telephone, there are many places where the walkie-talkie will become invaluable. For example, on large construction jobs, in fire fighting, for short range marine service, in forestry service, in railroad service and in highway emergencies it is easy to see the value of such equipment. Doubtless the reader can imagine many other applications.

A second development in communication service is the practical production of ultra high frequencies or micro-waves. These are radio waves short enough so that they have many of the properties of light waves, including the useful property that they can be projected in the same manner as a searchlight beam. Accordingly they can be used for short range point-to-point communication with a reasonable degree of secrecy and with low power. Furthermore, a single micro-wave link may carry a very large number of separate telegraph or telephone channels. It would therefore be technically feasible to carry all the communication between two cities on a beam of micro-waves reflected from hill-top to hill-top between cities. The first commercial application of this sort was a telephone service across the English Channel which was set up in 1931. In the postwar period many such services probably will be established.

A wartime development closely allied to the communication field is the detection by radio of distant objects, now known as "radar." Until recently this subject has been surrounded by considerable secrecy in spite of the fact that all the belligerents have some sort of radar equipment. A few months ago, however, a series of articles appearing in the press gave a fairly complete account of what can be accomplished by radar. Basically, the radar equipment sends out a beam of radio waves which strikes the distant object, is reflected back and registered on some receiving equipment. By using a directive antenna system it is possible to obtain the bearing of the object, and by measuring the time taken for the waves to make the round trip, the distance to the object can be calculated. The military uses of this equipment are extensive and the results almost fantastic. In a peaceful world its application also will be most important. Primarily it will be used to aid in the navigation of ships and airplanes through fog and darkness. Particularly in the case of the airplane will it prove a powerful aid to the maintenance of schedules and the safety of travelers.

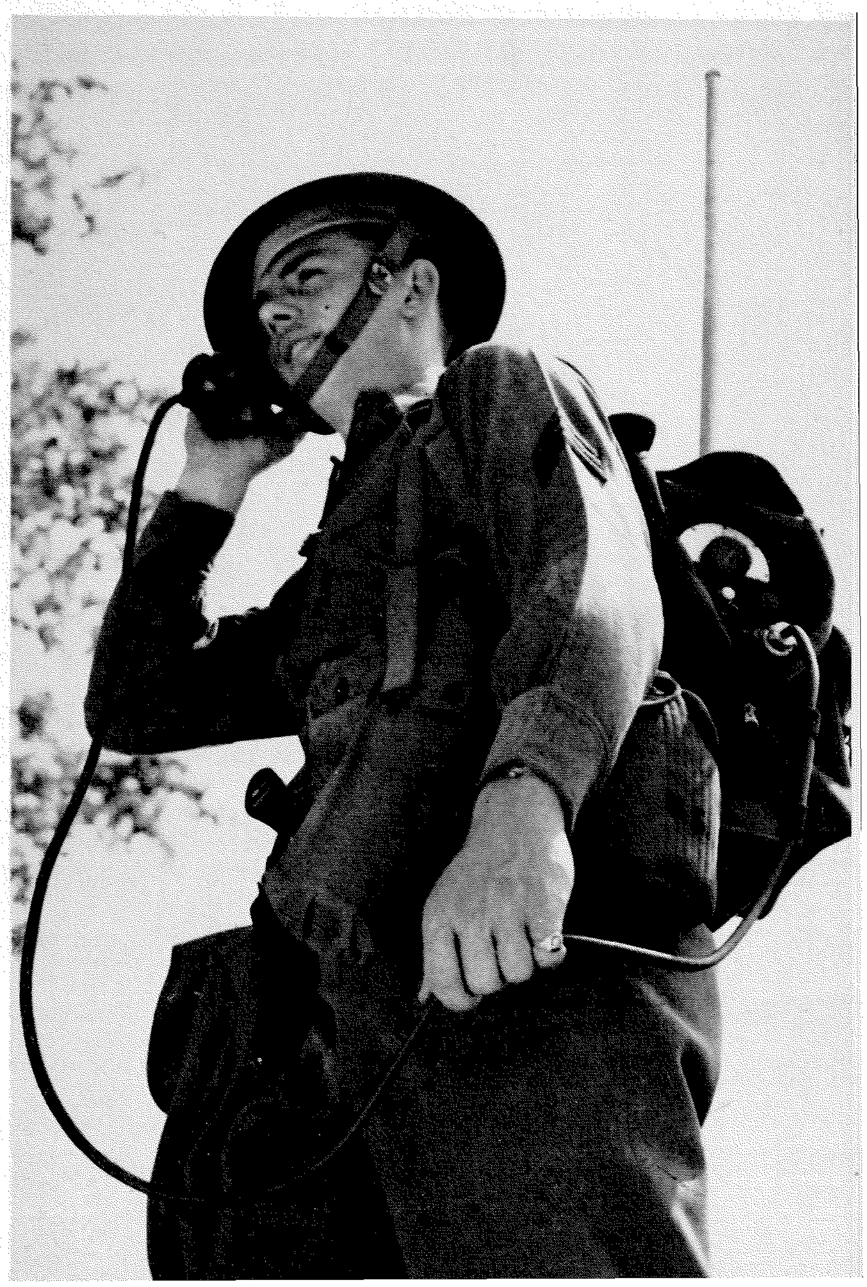
Industry offers the greatest field for new developments of electronics. These range from the high-power rectifiers and oscillators down through control devices of all kinds to gadgets which measure the vibrations of the smoothest machine, or count the rays emitted by the trace of radium in a piece of granite. Almost any sort of control or measurement problem can be solved by electronic means. In some cases this solution may be a fantastic Rube Goldberg, but in general the electronic solution will be at least as satisfactory as any other, and usually it will have some significant advantages.

Electronic rectifiers for the production of very large amounts of direct current power are now commonplace. Their advantages of quiet operation, ease of control and efficiency, particularly at light loads, are such that probably most new installations in this service will be electronic.

The high-power, high-frequency electronic oscillator is a relative newcomer to industry. These oscillators are used to produce power for two kinds of heating problems, heat treatment of metals where the control must be very accurate or where the heating must be confined to a thin skin, and the heating of non-conductors where heat must be generated uniformly throughout the thickness of the material. The induction furnace has been a useful tool of the metallurgists for many years, but the vacuum tube oscillator has come into the picture because it can provide power at almost any frequency. With rotating machinery, the highest practical frequencies are a few thousand cycles, while the vacuum tube can produce frequencies of millions of cycles per second. Large induction furnaces operating at relatively low frequencies probably will continue to be operated by rotating machinery. Vacuum tube oscillators will be used at high frequencies for special jobs. For example, at frequencies of the order of a megacycle per second, electric currents flow in a metallic skin only a few thousandths of an inch thick. Therefore, an induction furnace operating at this frequency will heat the part to be treated only in the surface layer. Furthermore, the heating will be rapid

AT RIGHT:

At present the "walkie-talkie," field radio with hand receiver, is used exclusively by the military. Postwar application may be developed for construction jobs, in fire-fighting, railroad service, highway emergencies, to mention only a few of its possible uses.



and accurately controlled. The result is a heat-treating technique which is very precise, yet flexible and adaptable to production processes, particularly with small parts.

An entirely different problem which also is solved with the high frequency oscillator is the problem of heating an insulating material such as plywood. In making large thicknesses of plywood, the problem of heating the wood uniformly in order to bond the sections together is rather difficult. However, if the wood is placed in a high frequency, high voltage electric field, heat will be produced uniformly throughout its thickness and bonding will be completed in much less time than with the usual steam press. Since the heating does not come from outside, there will be a uniform treatment throughout the wood and a more satisfactory product should result. Such "dielectric" heating may be applied to plastics of various sorts, and even, on a mild scale, to the human body. Diathermy machines have proven of considerable value to medicine.

Electronic control and measurement devices are too numerous to attempt to give more than a few general ideas as to their nature. First we might mention the direct control of a current by an electronic switch which is opened and closed automatically at precise instants of time. An example is the control used with resistance welding equipment. Second, the direct control of a motor. Various kinds of devices are available to control the speed and direction of small motors. Third, the use of photoelectric devices to operate relays or other equipment when a light is turned on or off, or two colors are matched. All sorts of counting mechanisms operate photoelectrically. Burglar alarms, smoke alarms are often photoelectric. Fourth, the use of amplifiers to increase a small control-signal up to the point where it can accomplish some desired result. The signal may come from a distant radio station, from a telephone, from the pounding of a fly's footsteps on a microphone, or from any conceivable electrical source. Fifth, electronic means to measure such quantities as time intervals as short as a millionth of a second, dimensional changes as small as a millionth of an inch, or to measure frequency, or count objects at speeds as high as 10,000 per second. Sixth, in a class by itself, the cathode ray oscilloscope, an instrument which can be used to visualize any transient or recurrent electrical phenomena, and which is thus of the utmost value in the analysis of complex electrical circuits. Furthermore, it can be used to great advantage in such diverse applications as the analysis of pressure variations in a gas engine cylinder and the measurement of the speed of rotating machinery, or it can serve as a remote position indicator. In electrical circuits it may be used as voltmeter, ammeter, phasemeter, frequency-meter, and modulation-meter.

As the possibilities of these circuits and gadgets become more widely appreciated, it is reasonable to expect that a great many new applications and devices will appear. When the full story of wartime industrial developments becomes known, it will be found that electronics helped to keep many a production schedule and to break many a production bottleneck.

Among the contributions of the twentieth century to technology, the vacuum tube must surely earn a place near the top of the list. Starting as a scientific curiosity it founded an industry which affected our lives almost as much as the automobile. Now doing its part in winning the war, it will prove useful in peace, not alone in its own field, but as a veritable handmaiden of technology in all its branches.

Nylon

(Continued from Page 8)

made, on an experimental scale, into tire cords, and tests indicate that it is by far the strongest fiber yet found for tire fabrics. In addition it permits the saving of weight and rubber in the manufacture of the tire, and it is particularly suitable where the tire undergoes severe punishment. The strength and adaptability of nylon in various forms—filaments, bristles, "wire" for experimental nylon window screens, sheets and molded plastic articles—indicate that its future should be as brilliant as its past.

One of the most interesting new projects developed in the nylon research laboratory is in connection with the nylon salvage program. This was undertaken because of the urgent need for more nylon for government use. The high-pressure synthesis equipment which makes nylon chemicals from coal, air and water, is already taxed to capacity, and to make additional equipment would require large amounts of strategic metals needed for airplanes, ships and ordnance. The logical alternative was to salvage nylon scrap and make new nylon out of it, and several months ago the Du Pont Company launched such a scrap campaign, offering to buy waste yarn from textile mills and waste dealers. Collection of this material is under government direction.

The waste nylon material is subject to a series of chemical treatments.

It will be, in effect, chemically "unraveled" until you arrive at the original two starting chemicals from which it was made—adipic acid and hexamethylene diamine.

First step is to boil the nylon scrap in a strong hydrolyzing agent. In the laboratory demonstration this is done in a glass flask, to which is attached a reflux condenser. On a plant scale it is carried out in a lead-lined vessel. By the end of the first hour of boiling the fabric has completely disappeared and the vessel contains only a dark brown solution. A precipitate forms on cooling.

Filtering through a glass fabric separates the precipitate, which contains the adipic acid, from the filtrate, which contains the diamine.

Each of the two components is now purified. The adipic acid, which is a powder and in the unpurified form may be any color depending on the amount of impurities present, is redissolved and recrystallized and is then treated with decolorizing agents. These steps yield a pure final product. The diamine solution is neutralized by addition of lime, which produces a precipitate of calcium sulfate. The mother liquor is drawn off and the water distilled off to leave the diamine. The diamine, which has a higher boiling point than water, is now distilled and it condenses as a colorless liquid, which becomes crystalline on cooling. The "reverse synthesis" of nylon into its chemical components is now complete.

As mentioned previously, the future is expected to find an ever increasing number of uses for this interesting product. For the present, however, all efforts of those concerned with the production and improvement of nylon are centered on making its contribution to the winning of the war as full and complete as possible.