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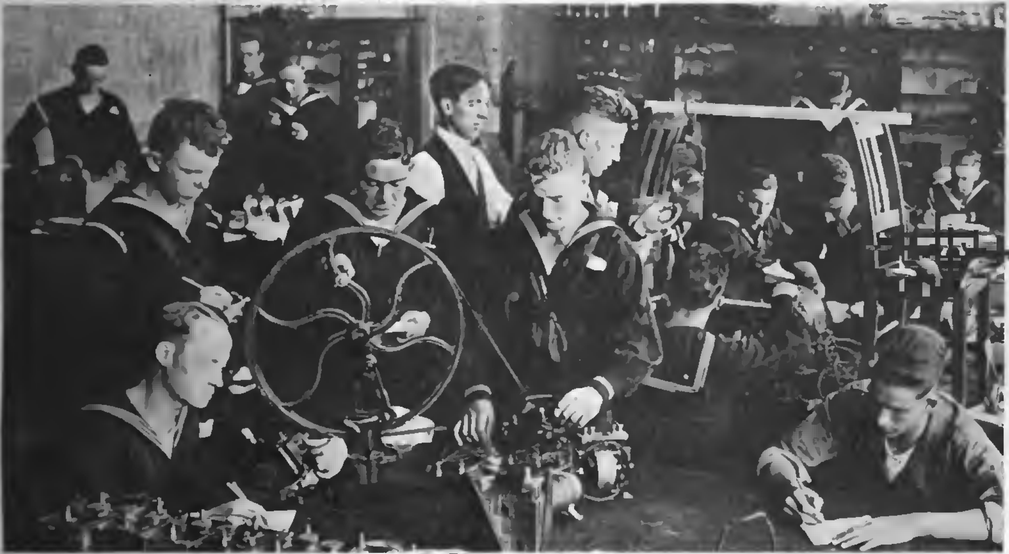

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THE WIRELESS AGE

An Illustrated Monthly Magazine of RADIO COMMUNICATION

Published by WIRELESS PRESS, INC., 42 Broad St., N. Y. City.
Edward J. Nally, Pres. Charles J. Ross, Vice-Pres. David Sarnoff, Secy. John Bottomley, Treas.
J. ANDREW WHITE, Editor. WHEELER N. SOPER, Asst. Editor.
Volume 5 (New Series) November, 1917 No. 2

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RENEWALS When your subscription expires you will find a renewal blank enclosed. You should fill out and return same with remittance at once to avoid missing a number. Positively no copies will be mailed on any subscription after same expires unless renewed, and we cannot agree to begin subscriptions with back numbers.

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ISSUED MONTHLY BY WIRELESS PRESS, INC.
42 BROAD ST., NEW YORK.
Yearly Subscription in U. S. $2.00; Outside U. S. $2.48; Single Copies, 20 cents
Entered as second class matter at the Post Office, New York.

WIRELESS AS AN AID TO COMMERCE DESTROYERS

WIRELESS has been employed so extensively in the operation of the German sea raiders that particular interest is attached to the news that two commerce destroyers are cruising about in the South Pacific. The submarine peril has been occupying the attention of most of us, but the notable exploits of the Emden and the Möewe have not been forgotten. The Emden, it has been suggested with good reason, was in constant communication by wireless with some one high in authority in Berlin who directed the activities of the cruiser. The Möewe had a scout ship which used wireless to locate vessels of the Allies and reported their positions by radio to the cruiser.

After the Möewe had performed some notable achievements there was considerable talk in Berlin about what Germany intended to do by means of sea rovers. It was said that their use precipitated fewer "diplomatic difficulties" than submarines.

It seems that the vessels now reported in the South Sea were taken and manned by the Seeadler which was heard of off Trinidad several months ago. The Seeadler was disguised as a neutral sailing ship when she set out from a German port. But after she had successfully eluded the patrol, the guns which were concealed in her hold, were mounted, a wireless apparatus was installed and she began to look about for victims, finding a considerable number of them, apparently among sailing ships. Of the manner in which she employed wireless on her cruise nothing has been said. It is reasonable to suppose, however, that the art proved as serviceable to the commander of the Seeadler as to the captains of the Emden and the Möewe.

The activities of the Seeadler passed out of notice for a time and it was believed that she had been captured or sent to the bottom. But it turns out that she was stranded and abandoned. Her guns were saved and perhaps her wireless apparatus too. At any rate, enough of her war equipment was transferred to the two ships she took to fit them out as commerce destroyers.

How much destruction they have accomplished has not come to light, but the Seeadler, in the early stage of her sea roving, had destroyed vessels amounting to more than 26,000 tons. The commander of the Möewe, after her second cruise in the Atlantic, reported the capture or destruction of twenty-seven vessels, with a total tonnage of more than 123,000 tons. In these cases wireless, contrary to the history of the art in the past, has been used as an agent of destruction rather than of salvation.

HOW AN AMERICAN STEAMSHIP WAS SAVED FROM A SUBMARINE

WHILE the brains of the Allied powers are being concentrated on a means to effectively combat the ravages of the U-boats, wireless continues to serve, in some instances, as the instrument of aid for prospective victims of the undersea craft. The art was called into service to advantage when an American steamer, a Luckenbach craft, which arrived at a French port on October 24, was attacked by a German submarine.

A lookout on the steamship sighted the enemy craft on the port bow soon after the vessel had entered the danger zone. Even before he had time to report the presence of the U-boat the latter fired a shot which barely missed its mark. The plight of those on the American steamship was desperate, for the submarine was in such a position that escape was practically impossible. So the captain ordered a wireless call for assistance sent out.

Meanwhile the gun crews of the submarine and the steamship began exchanging shots. The U-boat maintained an incessant fire and maneuvered at the same time to keep out of the range of the shots from the American vessel. Altering her course, the latter steamed ahead at full speed. But she could not get out of range of the submarine's guns and several shots took effect, putting her engines out of commission and placing her at the mercy of the under-sea craft. The U-boat steamed closer to the steamship, sending shot after shot at the vessel.

When the situation looked darkest for the steamship a low streak of black smoke was sighted in the distance. It came from the funnels of an American destroyer which had picked up the wireless call for aid and was speeding to the assistance of the distressed vessel. The destroyer headed directly for the U-boat which immediately submerged. It was not seen again.

The arrival of the American destroyer was unexpected by those on the steamship, although the former craft, while on her way to the rescue, had wirelessed encouragement in the form of such messages as "Hold on!" "Stick, we are coming!" "But the radio apparatus of the steamship had been disabled soon after the submarine began her attack and the messages were not received. However, the submarine was apparently aware of the destroyer's approach, for she took good care to disappear beneath the water before the destroyer got within range. So the wireless saved the day for the steamship.

CURTAILING THE ACTIVITIES OF GERMANY IN SOUTH AMERICA

THE Government of Argentina, it is declared in a dispatch from Buenos Ayres, has withdrawn permssion granted to a German wireless company to attempt to receive radio messages from the German station at Nauen. The German wireless service, consisting for the most part of messages from the semi-official Overseas News Agency, which were sent to the United States through the Sayville station before the entrance of this country into the war, is distributed from Nauen.

Since the United States declared war against Germany, it has been reported on several occasions that information was being sent to Germany from South America by means of wireless. It would seem that the revelations concerning the activities of Germany's agents are having practical effect.

THE RADIOPHONE FOG WARNING DEVICE

A STATEMENT from the office of the United States Naval Communication Service says that the attention of all ships navigating in the vicinity of Point Judith, near Newport, R. I., is invited to the recent installation at Point Judith Light of a radiophone fog warning device.

The apparatus will be of use to commanding officers in picking up the light in thick weather, as experience has shown that operators can judge to some extent the distance according to strength of signals with a known normal range. Although measurements have been taken to determine the limit of the range of this apparatus, too much reliance should not be placed in it until its worth has been proved under service conditions.

The apparatus will be in commission beginning about October 1, 1917, and will be in operation during fog, mist, rain and falling snow. The warning consists of the repeating of the words, "Point Judith Light," every five seconds, with limit of range of about eight miles. After every third repetition the warning, "you are getting closer; keep off," is sent out with a limit of range of about two miles.

The apparatus required for the reception of the warning signals is an ordinary radio receiver. Crystal detectors may be used. The wave-length is varied continuously between 550 and 650 meters.

It is requested that reports be forwarded to the lighthouse inspector, Tompkinsville, N. Y., concerning the range and value of this fog signal as found by experience under service conditions.

The system is yet in its first stages and it will doubtless be improved in the course of actual practice. The fact has been pointed out that before long every lighthouse will be shouting its name and other information so that the illumination will become of secondary importance.

FROM WASHINGTON TO HAWAII BY GOVERNMENT WIRELESS

THE opening of the United States Navy's high-power wireless station at Pearl Harbor, Hawaiian Islands, took place recently. Messages were exchanged between Washington and Pearl Harbor, a distance of approximately 5,000 miles. Reports of the tests indicate that communication between Washington and the Philippine Islands will be accomplished with the aid of one relay through the Pearl Harbor station.

The Pearl Harbor station is one of several high-power stations constructed by the United States Government.

COMMUNICATION OPENED BETWEEN JAVA AND CORREGIDOR ISLAND

THE Chief of the United States Signal Service recently announced the establishment of direct communication between the wireless station at Koeping, Java, and the army station at Corregidor Island at the entrance to Manila Bay. The Koeping station was opened on April 8 last, by the Colonial Governor of the Dutch East Indies.

A SUGGESTION FOR RELIEVING THE CONGESTED CABLES

THE congestion of cable facilities between the United States and Europe has brought forth the suggestion that the trans-Atlantic service, which was closed as a result of the war, be used. Secretary of War Baker, in explaining why permission to go to France could not be granted to any more newspaper correspondents, said that the American newspapermen now in that country were utilizing all the cable resources which it was possible to place at their disposal. Government messages, of course, receive first consideration and the frequent sending abroad of troops adds to the burden placed on the cable service. That the wireless should be employed as a means of conveying newspaper dispatches seems a not impractical idea.

A CALL FOR INSTRUCTORS IN WIRELESS AND BUZZER WORK

AT THE request of the United States Army, the Federal Board for Vocational Education has undertaken to aid the Army to secure the proper training of conscripted men as radio and buzzer operators (international or continental code) before they are called into service in the second and following drafts. A circular has been issued for the purpose of supplying information to school authorities who will undertake this work as a patriotic duty. In this circular is enumerated a list of those who may be admitted to classes. It follows:

Only conscripted men due for the second and following drafts should be admitted.

Only conscripted men should be admitted who have passed a physical examination and are certain to be called.

One of the chief purposes of the class should be to determine early what men are not fit to become successful operators, in order that they may be dropped at once.

Conscripted men from all occupations and professions who desire this training are to be admitted to the class if properly qualified. Most of these men will, of course, return to the practice of these occupations and professions at the close of the war. This training is for war service only.

For fear of a misunderstanding, it is again stated that these classes should not be open to anyone who is not due for service in the Army. This will exclude all such persons as: Girls and women, persons under military age, persons unconscripted, persons conscripted but unable to pass a physical examination, persons exempted for any cause, and persons who are seeking free training along commercial lines for service with railroads, telegraph companies and private concerns.

The Federal Board for Vocational Education has written to The Wireless Age asking its aid in supplying instructors in radio and buzzer work for schools throughout the country. Persons familiar with the international or continental code, should send their names, addresses and qualifications to The Wireless Age, which will forward them to the proper authorities. The basis of compensation will have been determined by the time this issue of The Wireless Age is off the press.

THE MEMBERS OF THE NEW CENSORSHIP BOARD

MEMBERS of the new Censorship Board authorized by the Trading with the Enemy act have been appointed by the Post Office Department and the Committee on Public Information. Its duties have to do with the censorship of wireless as well as other means of communication. Robert L. Maddox, Superintendent of Foreign Mails, was named as a member of the Board by the Postmaster General, and Edgard Sisson, head of the visé division of the Information Committee, by Chairman Creel. Mr. Sisson has had the advantage of having made a special study of European censorship methods. Major General McIntyre and Lieutenant Commander Belknap, representing respectively the War and Navy Departments, have also been appointed members of the Board. No other appointment remains to be made except that of a representative of the War Trade Board.

It is likely that the Board will continue, with few changes, the methods of censorships employed by the War and Navy departments. With the advantage of knowing the practices of the European censors, the American Board should make an excellent showing.

THE DEMAND FOR THE TECHNICALLY-TRAINED MAN

STUDENTS of wireless, whether they be amateurs or masters of the higher phases of the art, will find material for thought in the contents of a letter issued by the University of Illinois concerning the demand for men of engineering skill and training. It is pointed out that never in the history of this country has there been so great a call for men having technical training in engineering as at present. The war in Europe has been a war of engineers and of the product of engineers, and every effort has been made by the European powers to conserve and increase the supply of men who are competent to carry on the work of the industries upon which its success depends.

That the Government is also alive to the situation is shown by a letter from P. P. Claxton, United States Commissioner of Education, to the heads of the various technical schools and colleges in this country. The letter, which was authorized by the Secretary of War, says that the successful prosecution of the war depends in large degree on the services of scientific and technical experts. It is of the utmost importance that the supply of men who have had advanced technical training should not be cut off more than is necessary.

In view of this fact, the War Department believes that students in technical schools and colleges who are within the age limits of the selective draft should be treated in the same manner as the workers in the industries which are devoted to the manufacture of war materials. Under this ruling, the presidents of colleges and technical schools may properly urge the district exemption boards to exempt students in their institutions who give promise of special aptitude for the technical and scientific professions until these students have finished their courses. It is expected that institutional officers will exercise due caution and will not claim exemption for students whose success in technical careers is open to doubt.

Attention is called to the fact that each case is to be considered by the district exemption boards on its own merits. Students in technical schools are not exempt as a class.

From the New York World

His Day!

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By CAPTAIN FRITZ E. UTTMARK

ARTICLE II

THE MARINER'S COMPASS (continued)

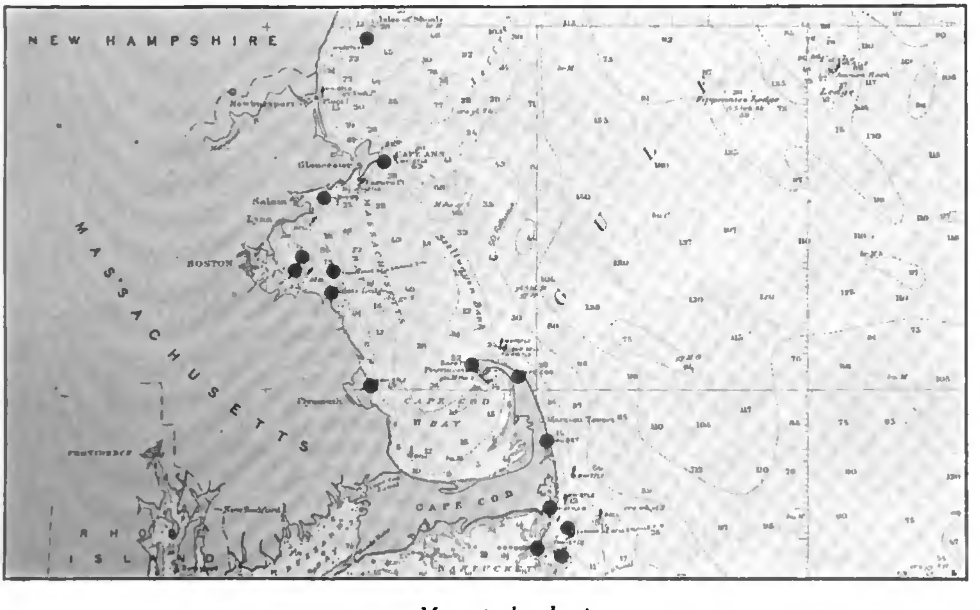
ON THE inner side of the compass bowl are marked two, or sometimes four, vertical lines called lubber lines. The compass should be placed so that a plane passing through two of these lines, opposite to one another, falls in with, or parallel to, the keel of the vessel. One lubber line always indicates the compass direction of the ship's head.

There are two types of magnetic compasses, the liquid or wet, and the dry type. In the wet type the compass card nearly floats in a liquid composed of alcohol and water; the weight is partly taken off the pivot, thus minimizing friction, and the compass works easier. The liquid has a tendency to decrease vibration of the card when the ship works its way through the water.

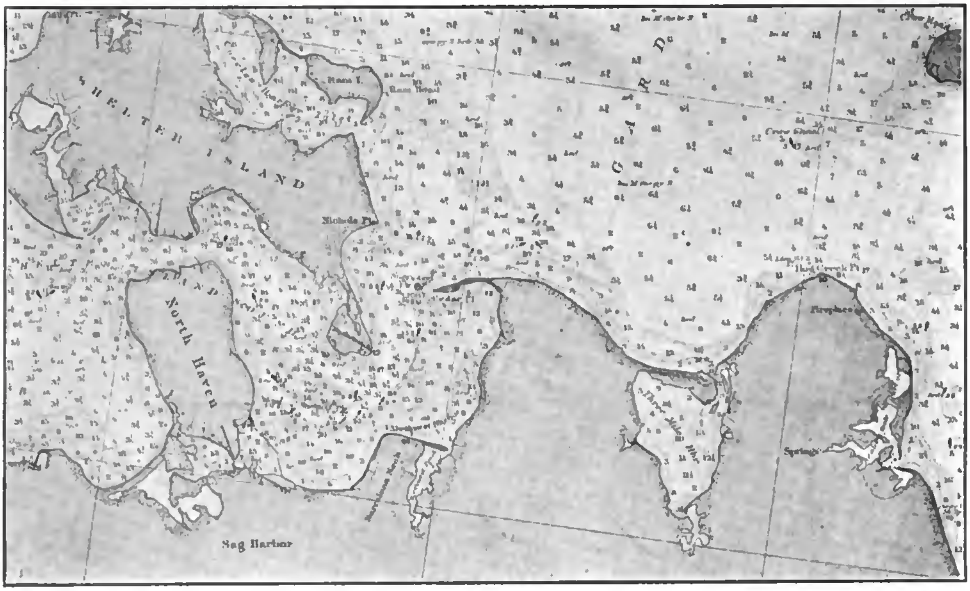
This type of compass is now generally in use as it has many advantages over the other type. The standard for the dry type compass is Sir William Thompson's (Lord Kelven) compass. It consists of a strong paper card with the central parts cut away to give it lightness; the outer edge is stiffened with an aluminum ring. The pivot is fitted with an iridium point on which rests a light metal boss fitted with a sapphire bearing. Silk cords are fastened to this boss by one end; the other end is fastened to the rim of the compass card and is in this way suspended. The cords are to some extent elastic and thus absorb some of the shocks due to motion of the ship. Eight small magnetic needles are suspended from the aluminum ring, keeping the center of gravity low.

THE MARINER'S, OR NAUTICAL CHART

A nautical chart is a map representing a miniature portion of the sea, lakes or navigable rivers with coast lines, depths of water, nature of bottom,



Mercator's chart

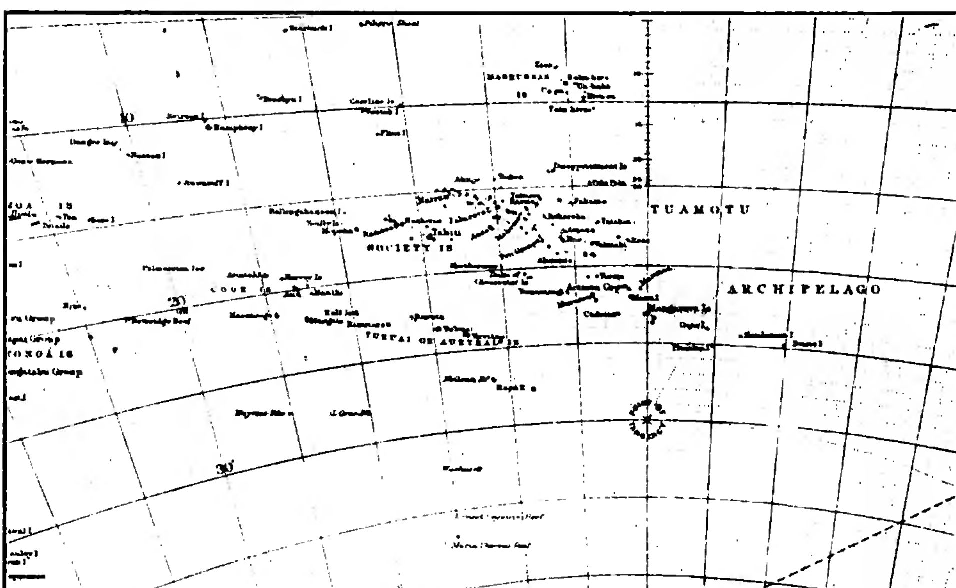


Polyconic chart

lights, lighthouses, buoys, currents and other useful information. There are three kinds of charts—Mercator's, polyconic and gnomonic projection chart.

On the **Mercator's chart** the meridians are made parallel to one another, and the distance between the parallels of latitude is lengthened, corresponding to the widening of the meridians. On this chart the earth is represented as a flat surface and the track of the vessel is shown as a straight line. This chart is used for coast and ocean navigation and is now being adopted for inland waters, bays, sounds and harbors in the United States.

The **Polyconic Chart.**—On a chart constructed on the polyconic principle,



Gnomonic projection chart

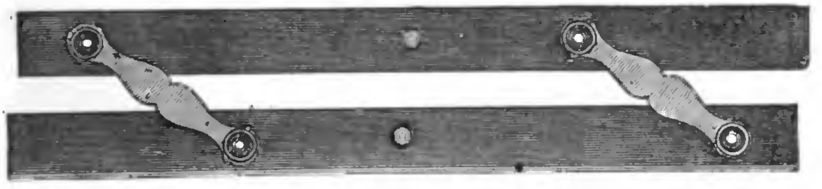
the meridians converge toward the poles and are in reality curved lines; the degrees of latitude and longitude are projected according to their true value. A straight line on this chart represents a near approach to a great circle, and cuts all the meridians at a slightly different angle. On account of the greater convenience of the Mercator's chart, however, this type of chart is not as much in use now as it was in former days.

The **Gnomonic Projection Chart.**—In a gnomonic chart, the straight line between any two points represents the arc of a great circle and is therefore the shortest line between those two points. This chart is used in the polar regions where a Mercator's chart cannot be constructed. It is also used for finding the course and distance in Great Circle Sailing.

The meridian of Greenwich is adopted as the first, or prime meridian, for charts constructed in the United States as well as in most of the countries of Europe and Japan.

PARALLEL RULERS

These rulers are used for drawing lines parallel to one another in any direction, and are chiefly used for transferring the course line (rhumb-line) on the chart to the nearest compass or diagram in order to ascertain the

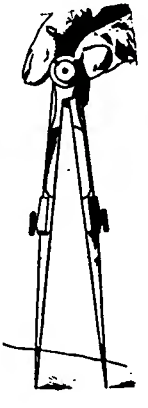


Parallel rulers

course or lay off course and bearings. They are generally made of hard wood, ebony or boxwood being preferred.

DIVIDERS OR COMPASSES

This instrument consists of a pair of metallic legs, movable about a point, and so arranged that they will open and may be set at any desired angle; the points are generally made of steel, but one point may be replaced by a pencil or pen. The instrument is called divider when used to measure distances and compass when used to draw circles or arcs.

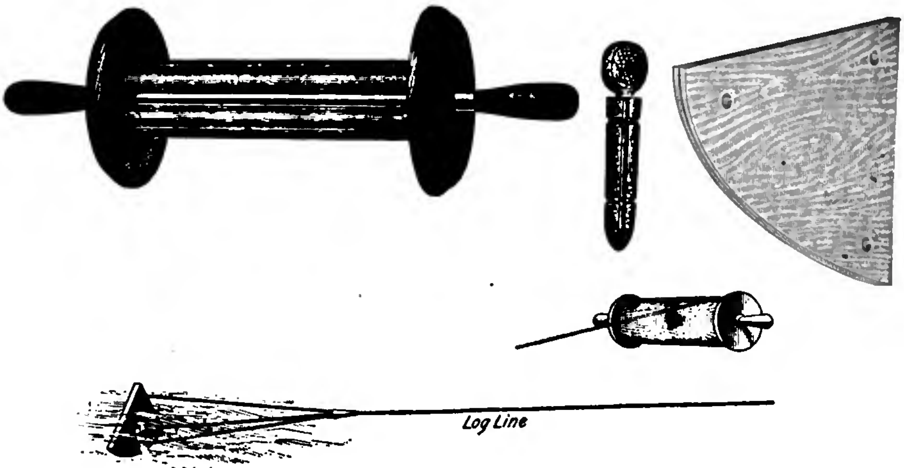


Dividers

LOG AND LOG-LINE

The chip log is used for measuring the speed of the vessel and consists of three parts, the log-chip, the log-line and log-glass. The log-chip is a triangular shaped piece of wood weighted with an insertion of lead at one edge in order to keep it upright as it floats in the water. The accompanying illustration shows clearly this part of the instrument.

The log-line is generally about 150 fathoms in length (depending on the speed of the vessel). One end is fastened to the log-chip the other end to the reel on which it is wound. About twenty fathoms from the log-chip end is fastened a piece of rag or bunting sufficiently large (about 6 or 7 inches long) so it may be felt even in a dark, cold night when gloves are used. The part of the line between the log-chip and the piece of rag or bunting is called stray line and allows the chip-log to get sufficiently far away from the disturbed water in the wake of the ship. The remainder of the line, when a twenty-eight second-glass is used, is divided into lengths of forty-seven feet, three inches, called knots; short pieces of marling or fish line are inserted between the strands of the log-line at these intervals and marked one, two, three, four knots, etc., according to the numbers from the stray line-rag.



Log chip, toggle and log reel (United States Navy pattern)

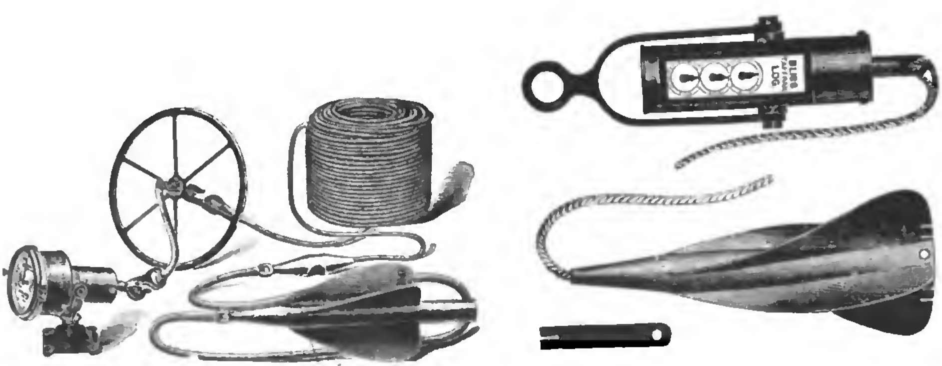
Each knot is further subdivided into four equal parts, marked by a piece of plain line without any knots. This indicates quarter knots; when a fourteen second-glass is used the indicated speed must be multiplied by two.

A nautical mile or knot is 6.080 feet and as the length between each knot on the log-line must be in the same proportion to a nautical mile as the number of seconds in the glass is to an hour, the following will be the formula for computing the length of a knot when a twenty-eight second-glass is used: One mile equals 6,080 feet; one hour equals 3,600 seconds, therefore:

$$3600 : 28 = 6080 : X$$

$$X = \frac{28 \times 6080}{3600} = 47 \text{ feet } 3.4 \text{ inches.}$$

The log-glass is a glass of the same shape or form as the old-fashioned hour glass. It is partly filled with sand; two glasses are used; one indicates twenty-eight seconds of time and the other fourteen seconds. The first is generally used when the speed of the vessel is about four to five knots; at higher speed the fourteen second glass should be used and the result mul-



Two types of patent logs

tiplied by two. Use your watch or chronometer to determine from time to time if the glasses are correct.

The **Ground-Log.**—In shallow water where the direction of the vessel is influenced by tides or currents, the log-chip may be detached and a lead attached to the end of the log-line; the lead is thrown overboard and the speed measured by the log-glass in the usual manner. The ship's course is opposite to the direction of the log-line; use your compass to ascertain this.

THE PATENT LOG

The patent log is a mechanical device to ascertain the speed of the ship. At one end is attached a rotator, and the other end is fastened to an indicator, which shows the number of knots on the dial the ship has travelled Several different models are in the market.

THE LEAD

This contrivance consists of a line with a lead attached to one end. This is a valuable aid to the navigator, especially in foggy weather, or when out of sight of land. The hand lead weighs from seven to fourteen pounds; the deep sea lead from thirty to one hundred pounds. The line is from one hundred fathoms upwards in length.

The hand lead has nine marks and eleven deeps; the marks are as follows:

At two fathoms from the lead with two strips of leather.
At three fathoms from the lead with three strips of leather.
At five fathoms from the lead with a white rag.
At seven fathoms from the lead with a red rag.
At ten fathoms from the lead with leather with a hole in it.
At thirteen fathoms from the lead with a blue rag, or three strips of leather.
At fifteen fathoms from the lead with a white rag.
At seventeen fathoms from the lead with a red rag.
At twenty fathoms from the lead with two knots.

The deeps are unmarked fathoms. The deepsea lead is marked the same as the hand lead up to twenty fathoms, after which it is marked as follows:

At twenty-five fathoms with one knot.
At thirty fathoms with three knots.
At thirty-five fathoms with one knot.
At forty fathoms with four knots.
At forty-five fathoms with one knot.
At fifty fathoms with five knots.

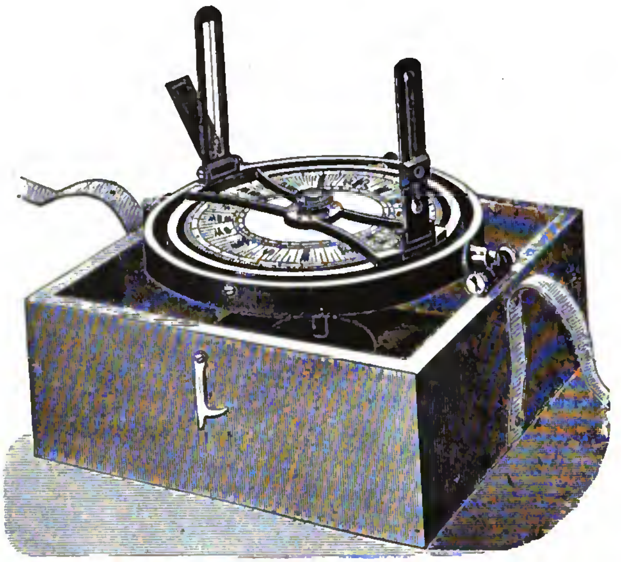
The lead

The markings of the line are continued so on up to one hundred fathoms or more.

Measure the lead line frequently while it is wet and re-adjust the markings whenever necessary. At the lower end of the deep sea lead is a hollow which should be filled (armed) with white lead or tallow in order to bring up samples of the bottom when using the lead.

SOUNDING MACHINES

There are several types of these machines in the market which are used instead of the deep sea lead, over which they have great advantage. Great depths may be measured quickly and accurately without stopping the ship.



The pelorus

Pelorus stand

THE PELORUS

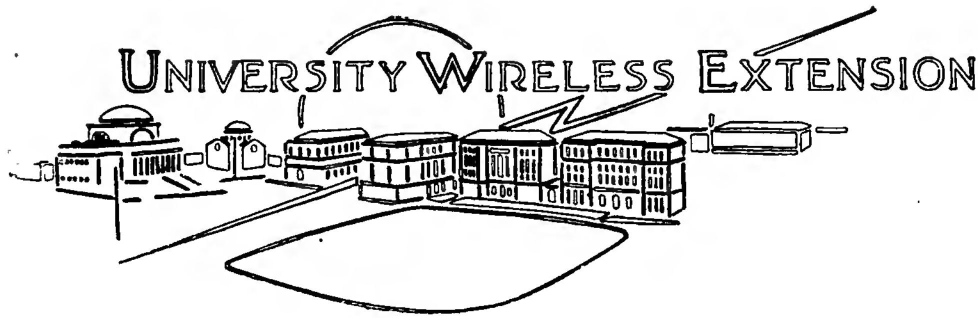
The pelorus, or dumb compass, consists of a circular disc revolving inside a metallic ring mounted in gimbals upon a standard which may be placed in any convenient part of the bridge or ship when a clear view all around the horizon may be obtained. This instrument is used for taking bearings of land objects, such as lighthouses, peaks, points, etc., as well as for observing amplitudes and azimuths of the heavenly bodies.

(To be continued)

THE WAR AND THE MERCHANT MARINE

One gratifying result of the war has been to show that there is no enfeebling of the American tradition of effectively handling great questions that concern the nation. The activities of the navy already indicate that it is prepared to keep up the standard which has been maintained in the past. Americans, as a rule, are fond of the sea and thousands of young men are finding now an opportunity of carrying out their ambitions to sail the ocean. In the ranks of the navy are many students from the Yale, Harvard and other seats of learning. It is not likely that the interest of these young men in the sea will cease with the ending of the war. Many will continue to follow the sea and consequently the strength of the American merchant marine will be strengthened.

America, it seems, has an excellent chance of swiftly developing her power on the sea. The country is building vessels under her own flag and, with the object of facilitating the work, sundry old ideas have been discarded and new ones substituted to advantage. The Shipping Board should have loyal support from every one in a position to give it in carrying out its plans.



Radio Telephony

By ALFRED N. GOLDSMITH, PH.D.

Director of the Radio Telegraphic and Telephonic Laboratory of the College of the City of New York

ARTICLE XI

CONTINUING our consideration of high current microphones for modulation in radio telephony, we come to a type of telephone relay used by Mr. W. Dubilier. The radiophone transmitter with which it is employed has been illustrated in Figures 34, 35 and 36. The inventor (in 1911) was well aware of the advantage of transferring speech from telephone lines to the radiophone transmitter and designed the relay for that purpose. A description thereof follows:

"Figure 127 shows a cross section of the relay. The complete transmitter consists of the magnets *A, A* wound with two-ohm winding *B, B,* and placed opposite to each other with the diaphragms and carbon containing cup between. (There had been adopted a type of transmitter with *two* diaphragms with the carbon between, both diaphragms swinging inward or outward in synchronism and thus producing greater changes in the resistance of the carbon between them than if one of them were fixed). The diaphragms are approximately 5 inches (12.7 cm.) in diameter and 0.036 inch (0.9 mm.) thick. The ebonite disc *D* is used to mount the diaphragms, and is drilled with large-sized holes so as to prevent "air packing" or talking against each other.

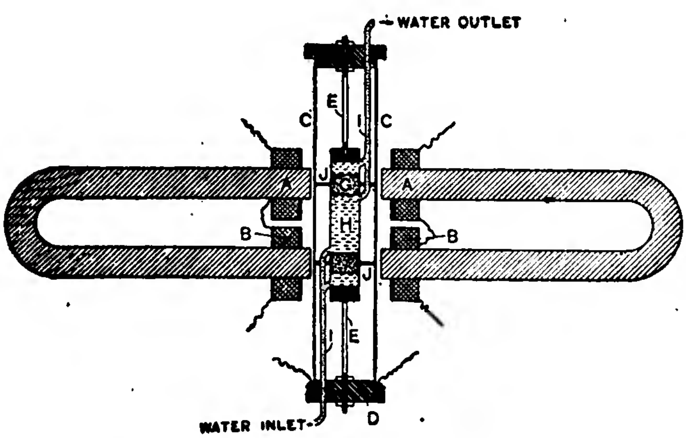


Figure 127—Cross section of Dubilier high current telephone relay

"A cross section of the carbon-containing cup is shown in Figure 128. It resembles three brass rings placed one within another, forming three independent containing portions. Water circulates through the chambers *F* and *H* by means of the inlet and outlet tubes *I*, and middle chamber *G* (of Figure 127) is used to retain the carbon granules. To make contact with the granular mass, circular rings of platinum, *J, J* are used, which are first soldered to the diaphragms *C, C*. The platinum rings are drilled with small holes round the entire circumference so as to allow a free circulation of air, and through one of these holes the small inlet and outlet tubes are run. The contact is made in the center of the granular mass. A mica disc is used to retain the granules in the chamber."

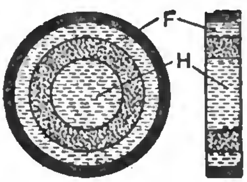


Figure 128—Cross section of carbon-containing cup of Dubilier high current relay

The transmitter in question was designed to carry currents up to 6 amperes. It seems to have been operative; since, as stated previously, radio telephony over 250 miles (400 km.) was accomplished with such apparatus.

In Figure 129 is shown in detail the high current microphone transmitter used by the Telephone Manufacturing Company (formerly J. Berliner) of Vienna. The entire radiophone set of which it is a part was illustrated in Figure 24. The microphone is seen to be mounted on a frame support with a ratchet clutch for holding it at any desired height. On the front of its case are the large mouthpiece and a double throw switch for "Calling" or "Speaking." Directly beneath the transmitter is placed a horizontal fan for cooling purposes.

In building high current transmitters, the granular carbon—carbon diaphragm type (e. g., as built by the Berliner Company) has been found to be suitable. The usual modifications made therein when used for the unusually large amounts of energy necessary in radio telephony are to replace the felt packing of the microphone chamber by asbestos packing or packing of some other uninflammable material, and to perforate the metal case so as to permit air cooling.

One of the most remarkable and effective ot high current microphones is that devised by Messrs. C. Egner and J. G. Holmström of Stockholm, Sweden. The inventors state that a normal microphone which, for a current of a few milliamperes has a resistance of say 200 ohms, at a current of 1 ampere has a resistance of only 5 to 8 ohms. The microphone is shown in plan in Figure 130 and in actual appearance in Figure 131. Corresponding parts are indicated by the same lettering. The whole device is provided with oil (or other fluid) cooling, by the attachment of the cooling reservoir *H* (of part *A* of Figure 131) to the back of the microphone chamber. Through this cooling chamber run the supporting and connecting rods from each of the microphones *A*. It will be noticed from Figure 130 and part *B* of Figure 131 that there are 16 of these microphones, which can be connected together in various ways, as indicated. The rods which run from the microphones through the cooling reservoir terminate on the connecting board *J* (part *C* of Figure 131). The cooling fluid is arranged to circulate in

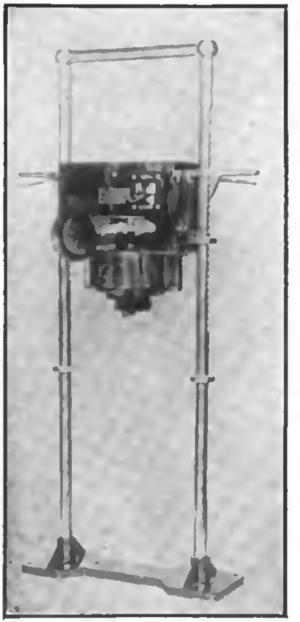


Figure 129—Heavy current Berliner microphone transmitter with fan cooling

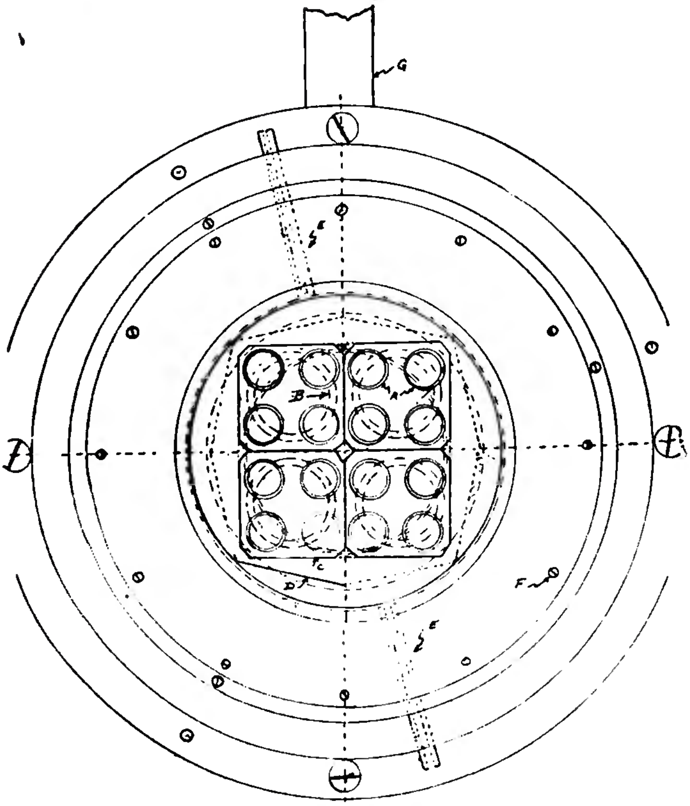


Figure 130—Front view of Egner-Holmström high current transmitter

a fashion similar to the "thermo-syphon" system sometimes used for gas engines, and heat is radiated from the flanges of the cooling chamber *H*. The cooling fluid must be an insulator.

The individual microphones are connected together permanently in 8 sets of 2 each, the 2 being always adjacent on the same row. The back of the microphone chamber is, in each case, a copper plate covered with thin carbon, and is fixed. From the copper plates pass the rods to the rear connecting board, previously mentioned. The vibrating electrodes *C* (of Figure 130 and part B of Figure 131) are 4 in number, each taking care of 4 of the microphones back of it. These microphones are insulated from each other by being supported on

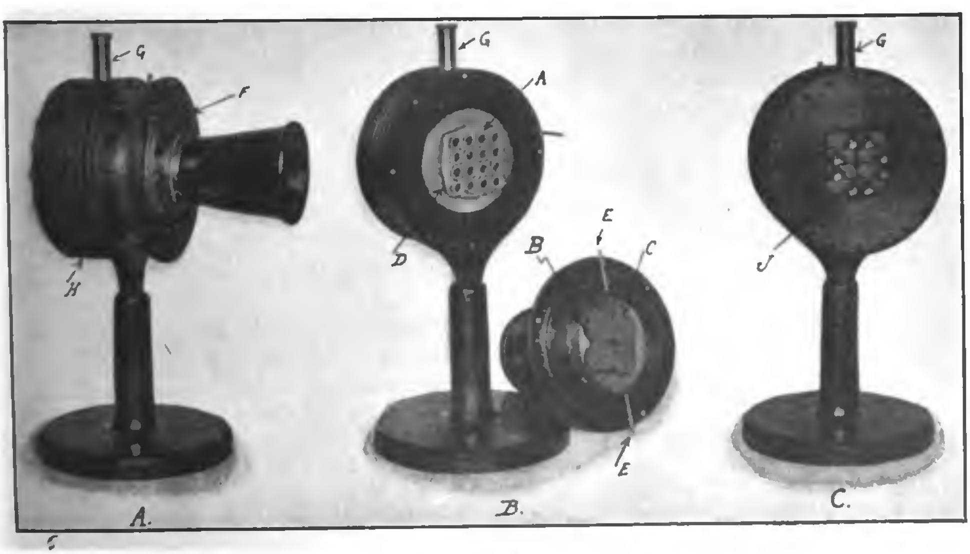


Figure 131—Egner-Holström high current microphone

cylinders of glass *B* (part *B* of Figure 131) which cylinders are in turn attached to the main vibrating diaphragm. The reason for the use of glass or a similar poor conductor of heat is that it is desired to prevent overheating of the main diaphragm since this has been found to lead to speech distortion. The individual microphone chambers are made up of rings of asbestos or a similar heat-resistant material, pressed by spiral springs against the electrodes *C* so as to close the microphone chambers.

The main diaphragm is a thin sheet (0.2 mm. or 0.008 inch) of aluminum or magnalium which is stretched as tightly as possible. The stretching is accomplished by tightening up, one after another, the screws *F* (Figure 130 and part *A* of Figure 131). Since the 4 vibrating electrodes *C* are attached rigidly to the central portion of the main diaphragm, they will vibrate in the same phase and amplitude. It is this fact which renders it possible to secure a stable arrangement of microphones in parallel in the Egner-Holmström transmitter.

In order to increase the internal resistance and resistance variations of the transmitter, hydrogen or some hydrogen-containing gas is passed through the microphone chamber by means of the inlet and outlet pipes *E*. Normally the gas supply required is practically nil after the air originally present in the microphone chamber has been displaced.

The various ways in which the individual microphones can be connected are shown in Figure 132. These are as follows:

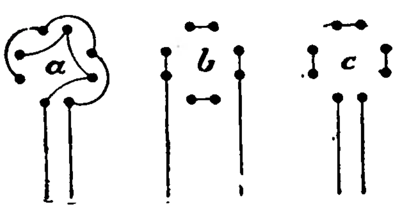


Figure 132—Connection arrangements of Egner-Holmström high current microphone

(a) 8 microphones in parallel, each of 2 in series. Proper applied voltage—10-15 volts. Proper current—up to 20 amperes.

(b) 4 microphones in parallel, each of 4 in series. Voltage—20-30 volts. Current—up to 10 amperes.

(c) 2 microphones in parallel, each of 8 in series. Voltage—40-60 volts. Current—up to 5 amperes.

It will be seen that the microphones can handle up to 200 to 300 watts (12 to 18 watts per individual microphone). The usual current (corresponding to case (b) above) is 10 amperes, but the makers of the transmitter, the Aktiebolaget Monofon of Stockholm, are prepared to build the transmitters to carry up to 16 amperes under these conditions. There are about 0.3 cubic centimeter (0.018 cubic inch) of carbon granules in each individual microphone.

Messrs. Egner and Holmström tried out their transmitter in connection with Professor Poulsen's apparatus shown in Figure 16. On June 29th and 30th, 1909, as previously stated, clear communication was achieved using this transmitter with 6 amperes in the antenna between Lyngby and Esbjerg, a distance of 170 miles (270 km.).

Another form of microphone transmitter of considerable interest was used by Mr. R. Goldschmidt of Laeken (near Brussels) in conjunction with the apparatus shown in Figure 60. The device in question is the invention of Mr. J. B. Marzi of Cornigliano (Liguria, Italy). The basis thereof is an attempt to prevent burning of carbon grains when heavy currents are used by the expedient of using a *moving stream* of carbon grains. Very finely powdered carbon will flow in practically the same manner as a liquid stream, and a portion of the carbon stream, passing between two electrodes, is used in this case as the microphone. The actual apparatus is shown in Figure 133, and the cross sections of several forms thereof and the mode of connection are given by Figure 134.* Referring to parts I, II, and III of the latter figure a reservoir, 5, is filled with finely powdered carbon and from this reservoir a fine stream of carbon flows through the hollow pipe 6 till it is compelled to pass between the platinum surfaces 9. These may be portions of concentric spheres (as in part I), or an obliquely cut cylinder and a plane surface (as in part II), or portions of two coaxial cones (as in part III). In any case the carbons stream between these surfaces, which are the terminal electrodes of the high current microphone. The upper one of these surfaces is usually fixed whereas the lower one is movable, either by the voice directly or, as shown in part I, by means of an armature 2 controlled by the electromagnets 1, 1. The current for these electromagnets is derived from the circuit of an ordinary telephone transmitter, or from a telephone line. It is this feature which makes the device a relay. In Figure 133 the

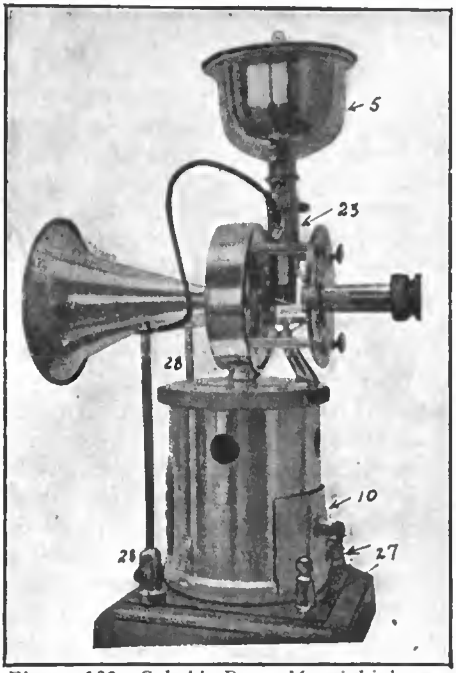


Figure 133—Scheidt-Boon Marzi high current microphone transmitter (relay type)

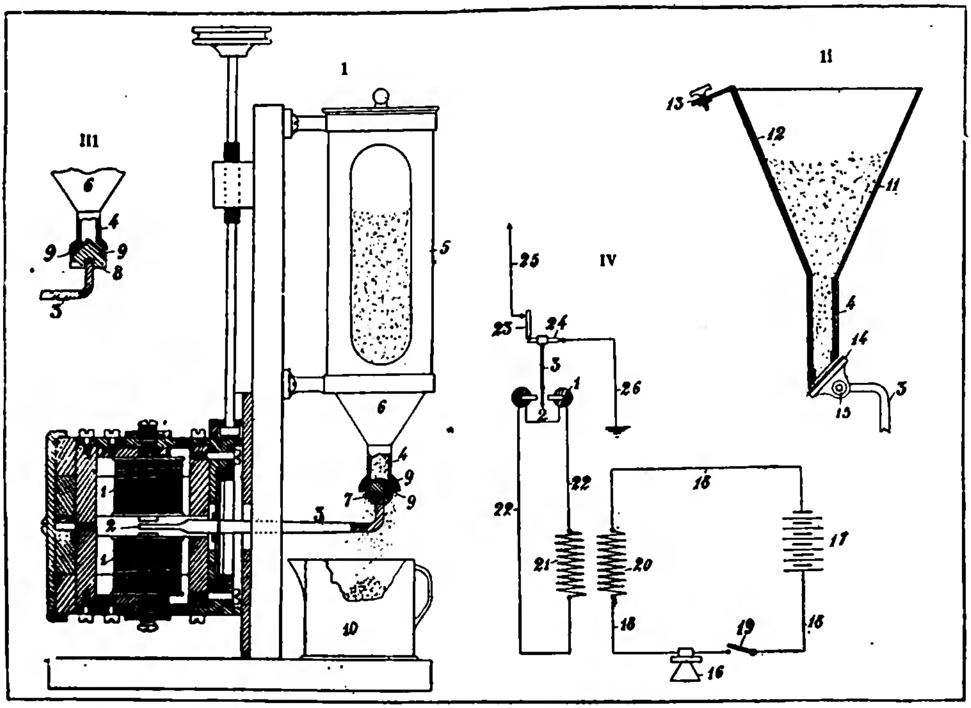


Figure 134—Details of Marzi high current microphones and relays

*Figures 133 and 134 are reproduced by permission from the French journal "T.S.F." and based on material from Mr. Scheidt-Boon of Brussels (1914).

terminals 27 are those of the electromagnets 1, 1 and the terminals 28 are the heavy current microphone terminals.

After passing the surfaces 9, 9, the carbon stream flows into the cup 10. At regular intervals, the contents of this cup should be emptied back into reservoir 5. The circuit diagram is indicated clearly in part IV of Figure 134. As will be seen, the ordinary microphone circuit is coupled through the induction coil 20, 21 to the circuit containing the electromagnets 1, 1 of the relay. The high current transmitter is shown placed directly in the antenna, though it can equally well be employed in any of the ways shown under ordinary "Microphone Transmitter Control". The .weight of the entire apparatus is only about 9 pounds (4 kg.) and height thereof 18 inches (45 cm.) As previously stated, this transmitter, carrying 3 amperes, permitted communication from Laeken to Paris, a distance of 200 miles (320 km.)

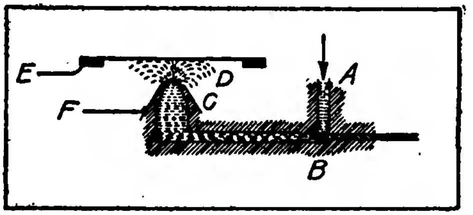


Figure 135—Essential parts of Chambers liquid microphone

Another method of attacking the problem of high current microphones has been the attempt to use conducting liquid jets of one type or another. Figure 135 shows the essential parts of a simple microphone of this sort devised by Mr. F. J. Chambers in 1910. At *A* a stream of electrolyte under a head of about 3 feet (1 m.) flows past the needle valve *B*. Here the flow is adjusted to a suitable amount. The liquid then passes through the conducting nozzle *C*, which is connected to *F*, one of the terminals of the microphone. After leaving the nozzle, the liquid stream impinges on the diaphragm *D* which is vibrated by the voice. The diaphragm is suitably connected to *E*, the other terminal of the microphone. It will be seen that the up-and-down motion of the diaphragm will alter the length and cross sectional area of the jet and consequently its resistance. It is found that such a microphone, because of the mechanical damping of the diaphragm by the jet, gives clear articulation without rasping side tone. The distance of the diaphragm from the nozzle is adjustable. The capacity of such a microphone is limited simply by the necessity of preventing the current-carrying electrolyte from boiling. In practice, Mr. Chambers found that about 400 watts could be handled by such a microphone.

Another type of liquid microphone, somewhat similar to that of Mr. Chambers, has been devised by Professor Giuseppi Vanni of Rome. The appa-

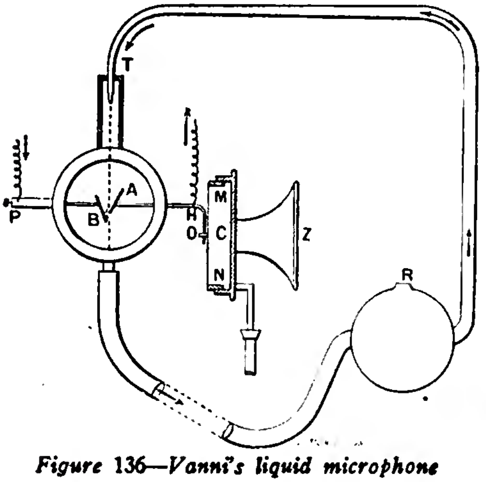


Figure 136—Vanni's liquid microphone

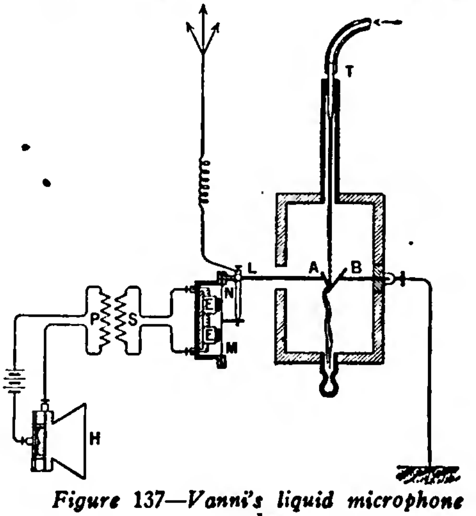


Figure 137—Vanni's liquid microphone relay

ratus is shown in Figure 136. A centrifugal pump *R*, made entirely of acid-resistant materials and operated by a small motor, forces a jet of dilute acid out of the ebonite nozzle *T*. The jet then falls on the inclined surface *A*, is deflected to the oppositely inclined surface *B*, is again deflected, and then passes back to the pump to resume its circulation. The pump pressure corresponds to 12 or 15 feet (3 or 4 m.) of water column. The terminals of the microphone, *H* and *P*, are connected mechanically to the electrodes *A* and *B*. *B* is fixed, but *A* is vibrated back and forth in an oblique direction practically perpendicular to the deflected jet. *Z* is the mouthpiece of the microphone, the diaphragm being connected at *O* to the mechanical control of *A*. The motions of *A* not only change the cross section of the jet from a cylinder to a flattened sheet, but also obstruct the stream more or less by the greater or less immersion therein of *A*. The electrode *A* therefore acts as a sort of shutter.

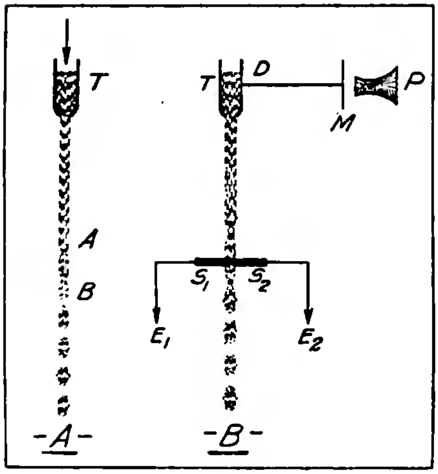


Figure 138—Essential parts of Majorana's liquid microphone

The Vanni microphone has also been arranged as a relay in the fashion illustrated in Figure 137. The usual transmitter *H* supplies fluctuating currents to the electromagnets *E*, which in turn control the liquid microphone by means of the iron diaphragm *NM*. This device was used in the experiments of Professor Vanni previously described, where it successfully controlled 1 kilowatt permitting radio telephony 625 miles (1,000 km.). The arrangement of circuits employed is given in Figure 59 in a previous article of this series.

Another principle which can be applied in liquid microphones is that of the instability of liquid jets, as first discovered by Chichester Bell in 1886. The phenomenon, which is based on the surface tension of the liquid, is illustrated in Figure 138, part *A*. This shows a jet of liquid escaping from a small tube, *T*. The orifice of the tube is supposed to be smooth and circular. The jet will proceed as a cylinder for a certain distance, and then a slight constriction will occur at the point *A*. Directly below *A* the stream will bulge, and then constrict still more below the bulge. At *B* the stream will break up into drops which, as they fall, will vibrate from oblate to prolate ellipsoids, passing through the spherical shape. We are not, however, concerned with the stream after it has broken up, but rather with its cross section at the bulge just above the breaking-up point. For it is found, by experiment, that the transmission of the least mechanical disturbance to the falling jet will move the breaking-up point up the stream toward the orifice, and the motion will be quite considerable even for very slight mechanical disturbances.

These facts have been utilized by Professor Q. Majorana of Rome in his hydraulic microphone, devised in 1906. Its essential parts are shown in part *B* of Figure 138. The tube *T* of glass or other insulator has a portion of its wall at *D* replaced by an elastic diaphragm which is attached to the larger voice-actuated diaphragm *M* by mechanical means. Placed in the jet just above the breaking-up point are the two electrodes S_1 and S_2 which form the terminals of the microphone. It is clear that the variations of cross sections of the jet at S_1S_2 will cause the necessary resistance variations. One unfortunate drawback with this form of liquid microphone is the excessive length of the jet (5 to 15 feet, or 2 to 5 m.) and its very great sensitiveness to slight shocks. As previously described, Professor Majorana succeeded in telephoning 270 miles (420 km.) with such a microphone control. It has been stated that the device can control 10 amperes at a terminal potential difference of 50 volts; corresponding therefore to 500 watts.

(g) VACUUM TUBE CONTROL SYSTEMS. As has been previously described in considerable detail, a ready means of generating moderate, and even high outputs at sustained radio frequencies is by the use of the various types of hot cathode vacuum tubes. These tubes depend for their operation as oscillators on the potential of small conducting members such as the grid in audions, oscillions, and pliotrons. Since the amount of energy required to change the potential of small-capacity conducting members is itself minute, it would seem *a priori* that one of the most ready means of modulating the output of such oscillators would be by altering the potential of the member in question in accordance with the voice vibrations. As a matter of fact, the proper control of the oscillations generated in such a tube is not a perfectly simple matter, for reasons which will appear.

There are at least two available methods of controlling the output of vacuum tube oscillators, and instances of each of these in practice will be described. The first of these is by variation of the grid potential, the assumption being that as the grid potential becomes increasingly negative, the current through the tube (and therefore the available radio frequency output) continuously and proportionately diminishes. Difficulties of stability of operation, however, arise and the conclusion must be somewhat modified. The second of these methods is by varying the plate potential, the assumption in this case being that as the plate potential becomes increasingly positive, the current through the tube (and therefore the available radio frequency output) continuously and proportionately increases. This conclusion also requires some modification because of temperature and space charge limitation of plate current and because of the limits of available energy which must thus be introduced into the plate circuit. (See under "Sus-

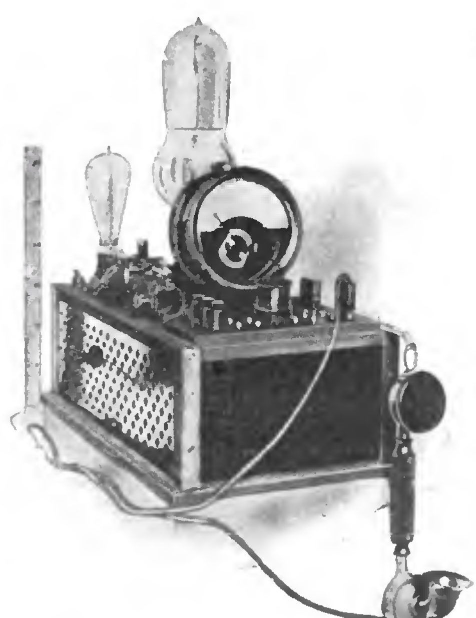


Figure 139—Telefunken Company-Meissner radiophone transmitter, 1913

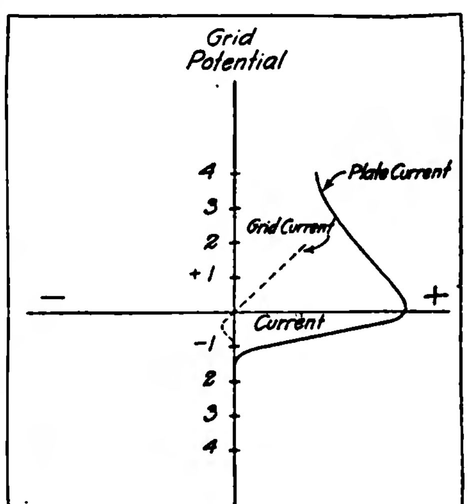


Figure 140—*Plate-to-filament and grid-to-filament characteristics of three electrode hot cathode tube containing gas* tained Wave Generator," part (c), "Vacuum Tube Oscillators"; and specifically the descriptions given of Figures 61, 62, and 63 in a previous article of this series.)

There are a number of differences between the operation of the two systems of modulation mentioned, such as the relation between the modulated radio frequency energy and the necessary controlling audio frequency energy; but these differences will best be brought out in considering the actual systems in use.

Dr. Alexander Meissner of the Telefunken Company, working with the tube shown in Figure 73, and the circuit shown in Figure 71 for producing the oscillations, succeeded in carrying out some interesting experiments in radiophone transmission. He states that using a plate circuit voltage of 440, it was possible to obtain a radio frequency output of 12 watts in the antenna. This corresponded to an antenna current of 1.3 amperes with an antenna resistance of 7 ohms at a wave-length of 600 meters. No statement was made as to the mode of control, though for such small powers it is probable that a heavy current microphone would suffice if placed directly in the antenna or in a suitably associated circuit as indicated under the description of Figure 119.

The radiophone equipment used by Dr. Meissner in June, 1913, for transmission between Berlin and Nauen, a distance of 23 miles (36 km.), is shown in Figure 139. The von Lieben-Reisz bulb is mounted at the rear of the apparatus box.

While these experiments were significant, it must be noted that Mr. H. J. Round states that when the Lieben-Reisz tubes were used at such outputs, they lasted only 10 minutes because of disintegration of the filament by the positive ionic bombardment! This would naturally render their use under such conditions impracticable commercially.

We consider next the radiophone experiments carried out by Mr. Round of the Marconi Company. To begin with, we shall give the grid potential-plate current curves found for his tubes by Mr. Round. One of these is shown in Figure 140. It should be carefully compared with that shown in Figure 66 for the care of pure electron discharge tubes. Mr. Round's description of Figure 140 (with some added comments and slight alterations) will be given: "Suppose the plate to be made so positive that the whole tube would be glowing (i. e., filled with blue glow of the usual ionised gas discharge) except for the presence of the grid. Then, starting with the grid strongly negative, notwithstanding the plate being highly positive, the electrons cannot get through the grid because the grid is nearest to them. At a very small negative value of the grid potential, a few electrons can get through the grid and will fall to the plate and the number that will get through will rapidly increase until the grid is at zero potential; the current to the plate then having the value it would if the grid were absent. Afterwards, as the grid becomes positive, the current will decrease because the grid will absorb some electrons."

The detailed wiring of a Marconi Company radiophone transmitter (the receiving set of which will be shown under "Receiving Sets") is given in Figure 141. It will be seen that oscillations are produced by coupling the grid circuit $L'C$ with the plate circuit $L''C'$ by means of the inductive coupling $L' L''$. The grid circuit also contains the 30 volt battery B' and the 3,500 ohm resistance R', which latter is shunted by a suitable by-pass condenser permitting the transfer of radio frequency currents but preventing excessive direct grid current. Similarly, the plate circuit also contains the resistance R_1, R_2, R_3, each of which is 500 ohms and the resistance R_4 of 10,000 ohms. These prevent excessive plate current, "blue glow," and tube breakdown. In series with these is the plate battery B of 500 volts. The aggregate of resistances and battery is shunted by the capacity C' of the plate oscillating circuit. The radio frequency energy thus produced is transferred to the antenna circuit at L_1 by an inductive coupling. The presence of oscillations in the antenna is indicated by glowing of the test lamp *TL* which can be short-circuited when not in use. The microphone *M* is directly inserted in the antenna circuit, and can also be short-circuited for purposes of tuning. The battery *B″* used for lighting the filament is an ordinary 80 ampere-hour storage battery. The battery *B′* for providing 500 volts consists of four cases of dry cells. These were found suitable for the needs of the occasion since only 10 to 20 milliamperes (0.010 to 0.020 ampere) were required. Thus the input is from 5 to 10 watts. The set is arranged so that it can also be used for telegraphy by manipulating the key *K* in the grid circuit. The change-over switch from sending to receiving is simple and is so arranged that it can be controlled from a distance thus permitting handling the set from any part of a ship, e. g., the chart room. Needless to say, the duplicate transmitter (microphone) and receiver could also be placed there. The set delivers 0.6 amperes in the antenna, and is guaranteed for communication over 30 miles (50 km.) with ship antennas 100 feet (30 meters) high and 200 feet (60 meters) apart. The set can, however, be pushed to give 1 ampere in the

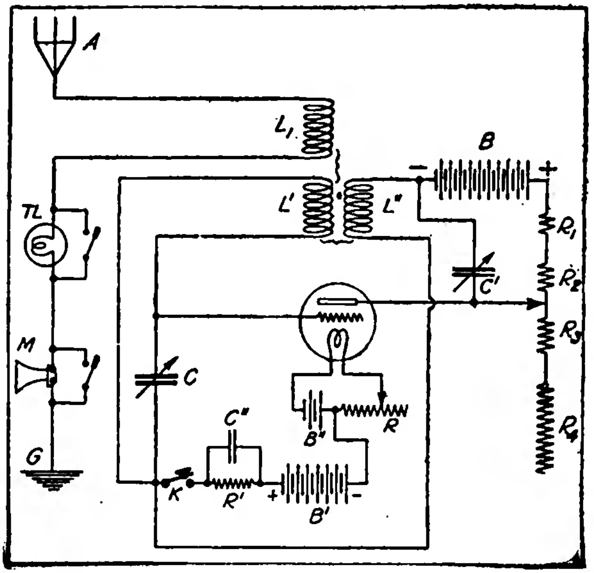


Figure 141—*Marconi Company radiophone transmitter*

Figure 142—*Marconi Company radiophone set* antenna with an estimated sea range of 100 miles (160 km.). As a matter of fact, communication was established with such a set between Aldene, New Jersey, at the station of the Marconi Company and a station in Philadelphia, Pennsylvania, a distance of 65 miles overland (105 km.). The Aldene antenna was supported on two 200-foot (60 m.) towers 450 feet (145 m.) apart. The actual appearance of the set is given by Figure 142. The large generating valve is shown at *V* between the vertical supports. To its right is placed the small receiving valve.

It is stated by Mr. Round that the telegraphic range of these sets is twice the radiophonic range. The tuning is found to be unusually sharp, in fact, almost uncomfortably so. It was also found somewhat difficult to start these tubes rapidly in cold weather. Just before the war, work was proceeding with such equipment in the direction of a selective call system, but this had to be suspended.

Using tubes of the sort described, Mr. Round succeeded in getting 3 amperes in the antenna, which would probably correspond to about 50 watts output. The input was about 0.100 ampere at 2,000 volts or 200 watts, thus giving an

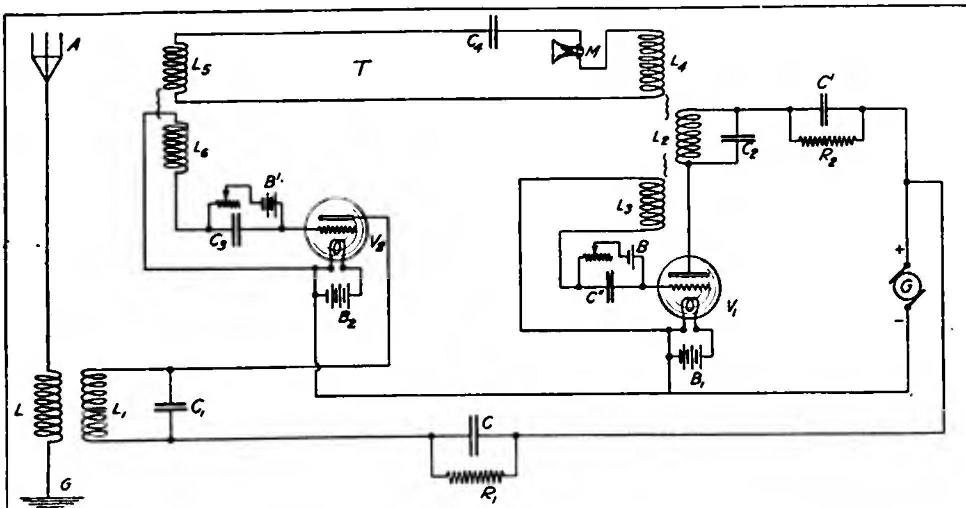


Figure 143—*Marconi Company-Round radiophone transmitter of* 1914

efficiency of about 25 per cent. The efficiency here referred to is the so-called "electron efficiency;" that is, it does not include in the input the energy required for lighting the filament, but considers only the plate circuit input and the radio frequency output. Mr. Round considers 2,000 volts to be excessively high for tubes of this sort, and states that experiments are being conducted whereby it is hoped to make the tubes available for use at lower voltages. The serious objection to lower voltages is that the high supply currents then required for appreciable outputs produce very rapid filament disintegration if gas be present.

Another form of the Marconi Company's radiophone transmitter is shown in Figure 143. Here a master oscillator V_1, is used, the output of which passes through an intermediate circuit *T* to the grid circuit of an amplifier, V_2. The output of amplifier V_2 is transferred to the antenna through an inductive coupling. The modulation control in this system is accomplished by placing a microphone in the intermediate circuit, thus varying the radio frequency voltage impressed on the amplifier grid. This system of master oscillator and amplifier is of considerable interest and the illustration shows one of the earliest forms thereof. The details of the master oscillator, V_1 are seen to be those of Figure

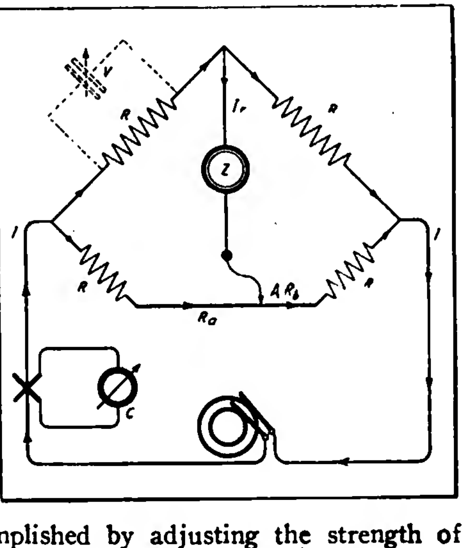
141. The amplifier V_2 is very similar except that its grid and plate circuits are not coupled. It will be noted that both the master oscillator and the amplifier are fed from the same plate generator *G*. Here we have a case where the microphone does not have to handle the whole of the antenna energy, and indeed the amount handled by the microphone *M* is roughly the antenna energy divided by the amplification produced in V_2. A modification of this system omits the amplifier but uses the microphone as part of the coupling between L_2 and L_3 in the master oscillator, thus suitably varying its output.

This is the eleventh article of a series on "Radio Telephony," by Dr. Goldsmith. In Article XII, which will be published in the December issue, oscillion radiophone transmitters are considered. The apparatus used is described and an account of long distance experiments is given.

MEASUREMENT OF THE AUDIBILITY CURRENT OF A TELEPHONE RECEIVER

A MEASUREMENT which has been the subject of much discussion among radio engineers is that of the strength of the least value of current required to produce a sound in the telephone which can just be recognized. The value of such a measurement is widely recognized, but owing to the complicated factors involved it has not been found convenient to carry out the complete set of measurements giving results adaptable to all circumstances.

At a meeting of the American Physical Society, E. W. Washburn presented a paper on a method for determining the audibility current, which is somewhat unusual. As shown in the accompanying drawing, a Wheatstone bridge is employed, having the resistance R, R, and R-1, R-1. These are noninductive and are constructed to have no self-capacity. A resistance wire, R_a, is fitted with a sliding contact and a scale, and is stretched between the ends of R-1 as shown. The sliding contact is inserted between the resistance coils, R, R, with the telephone receiver, Z, connected in series.



To ensure a balance of reactances, either of the resistances of the bridge arms may be shunted by a small variable air condenser, V. The arms of the bridge are supplied with current from a high-frequency alternator, H F, in series with which is placed the thermo couple, D, with the milli-voltmeter, C.

The resistance of that part of the slide wire which lies between the central position and the position occupied by the sliding contact when the audibility current, I_r, is passing through the telephone, is designated by ΔR_b. The strength of the current flowing through the bridge is determined by the thermo couple and milli-voltmeter previously mentioned.

The complete measurement is accomplished by adjusting the strength of the current, I, from the alternator, H F, until the range of silence on the sliding wire contact is found to have a measurable value. The range of silence is therefore equal to $2\Delta R_b$ ohms. It is obvious that the value of I_r can be obtained from the ordinary equation of the Wheatstone bridge.

Radio Science

HETERODYNE AMPLIFICATION BY THE ELECTRIC RELAY

THE amount of amplification to be expected by the use of the heterodyne receiver has been the subject of much discussion. In fact, investigators heretofore have found it difficult to account for the large degree of magnification thus obtained, and in some instances have drawn conclusions based on unwarranted assumptions.

In the earlier types of heterodyne receivers in which radio frequency oscillations were generated locally by an arc and the signals detected by a crystal rectifier, it was assumed by Messrs. Cohan and Hogan (who contributed largely to the development of the system in its earlier stages) that the complete process amplified the antenna or incoming signal energy, the detector being employed merely to rectify the local current. It has been shown also by Benjamin Liebowitz that theoretically the maximum amplification that should be obtained by the heterodyne system is four. However, owing to the remarkable amplification obtained by the perfection of the regenerative electron relay as a self-heterodyne by Armstrong, he was induced to make a deeper investigation of the subject.

In the "Proceedings of the Institute of Radio Engineers" for April, 1917, a method for determining the relative sensitiveness of the various methods of heterodyne amplification is described in detail by Armstrong, the complete circuits and general procedure being shown. It was not only determined that Liebowitz' conclusions in the main are correct for the simple heterodyne receiver, but that the amplifications to be expected from the regenerative electron relay are astonishing in the extreme.

In the self-heterodyne circuits of the regenerative type, where the combined functions of detection, amplification, and generation of a local source of radio frequency oscillations are accomplished in a single bulb, there are two methods of amplification which occur simultaneously in the same circuit, each one operating its own particular way, practically independent of the presence of the other. On account of the involved nature of the various phenomena, the problem of measuring the total amplification and separating the values into their component parts by direct measurement is not simple, hence an indirect method had to be employed.

Up to the time of the researches made by Armstrong, there was no reason to believe, in the light of present knowledge, that the magnitude of the self-heterodyne amplification would in any way differ from that obtained in an ordinary circuit with an external heterodyne, but practical results apparently indicated a disproportionality which had not been explained.

The problem was attacked by first measuring the amplification produced in a simple vacuum valve circuit and then measuring the total amplification produced when the same tube is provided with a regenerative circuit and used as a self-heterodyne.

The complete circuits for carrying out the investigation are shown in Figure 1 where the closed oscillation circuit of a receiving system is represented at N, an artificial antenna circuit at *M*, and two sources of radio frequency oscillations at X and Y. The oscillations generated by X were employed as a substitute for the incoming signaling energy at a given receiving station, and those generated by Y, as a source of oscillations for the heterodyne effect. The relative amplitude of the current flowing in the receiving circuit and that produced in the local circuit of the vacuum valve were measured by the galvanometer, G-1, with the detector, D-1, and the galvanometer, G-2, with the detector, D-2, respectively.

In order to separate the various components of the plate current from its continuous component, a telephone transformer, T, was inserted as shown. Other precautions were taken to separate the audio from the radio frequencies. The reading of the galvanometer, G-1, was also shown to be proportional to the square of the radio frequency current in the circuit, *N*, and the reading of the galvanometer, G-2, proportional to the square of the audio frequency component in the plate circuit. Since the alternating current energy available for producing sound is proportional to the square of the current, the reading of the galvanometer, G-2, may be taken as a direct measure of the telephone signal strength.

To determine the amplification due to the heterodyne method during continuous wave reception, a difficulty was encountered in that there was no audible signal during the absence of the locally generated radio frequency current, and

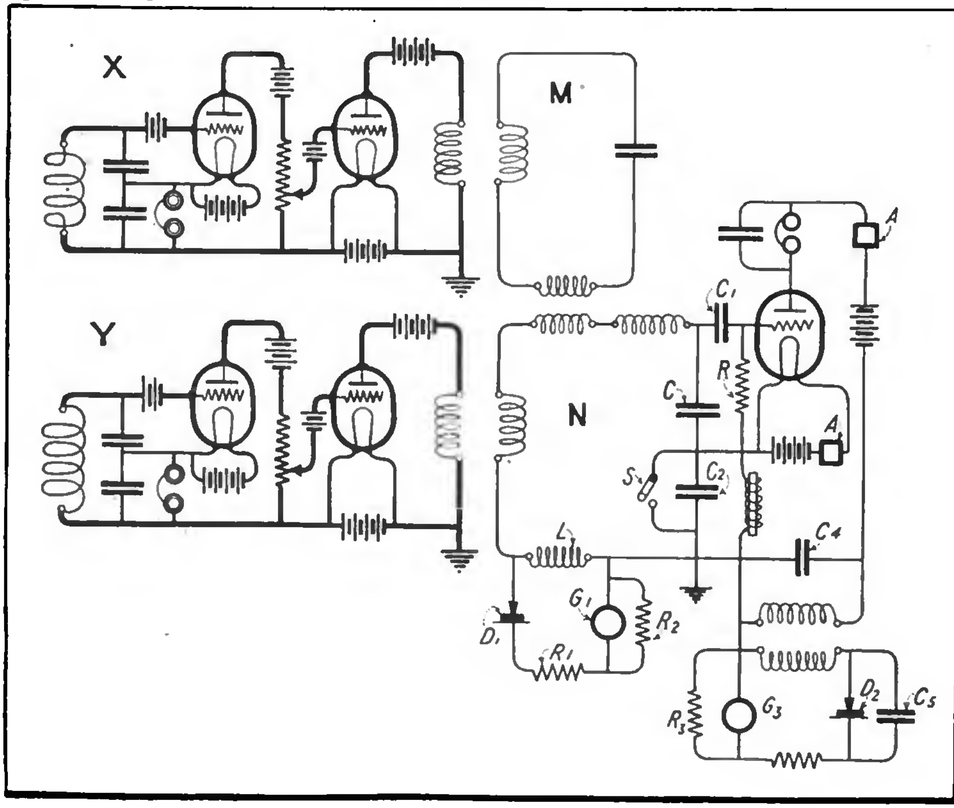


Figure 1

in order to obtain an audio frequency tone, a chopper had to be inserted in some part of the receiving system.

The first series of measurements were made for the purpose of comparing the signal strength obtained with the chopper and that given by the heterodyne when the local current was equal in amplitude to the signaling current. A special notation was given to this method of signaling namely, *the equal heterodyne,* that is, the incoming signal and the locally generated radio frequency current were equal in amplitude. The exact process of adjustment was described in detail and comparisons were made over a wide range of signal strength. It was found that the equal heterodyne gave a signal which was from four to ten times as loud as that given by the chopper, the greatest amplification being obtained on the weaker signal.

The four-fold amplification generally attributed to the heterodyne was fully realized, but the ten-fold amplification was rather unexpected but easily explained.

The second series of measurements involved the determination of the signal strength of the equal heterodyne, and that obtained when the locally generated radio frequency current is increased to its critical value, i.e., to the point of maximum response. This system has been termed by Armstrong, the optimum heterodyne. The results indicated that the magnification varies over a very wide range and depends on some inverse power of the signaling current. On the stronger signals the response for the best adjustment of local current was only about one and one-half times as great as that of the equal current; whereas, on the weaker signal the response was at least fifty-five times, and the general shape of the curve indicated that the increase would be greater for weak signals, perhaps several hundred fold.

The next series of measurements were made for the purpose of determining the relation between the maximum signal strength obtainable with a simple electron relay with the separate heterodyne, and the signal obtainable when the relay is supplied with a regenerative circuit and operated as self-heterodyne, i. e., the Armstrong circuit.

The results obtained were extremely irregular, due to the critical adjustment necessary for the self-heterodyne, but there was found to be an average amplification of about fifty times with respect to the signals produced by the external heterodyne. It was also brought out that the so-called "ultra audion," in spite of the claims of its patentee, is a distinctly regenerative circuit and gives an amplification about fifty times greater than the simple connection with the external heterodyne.

Summed up in its entirety, the total amplification obtained by the regenerative oscillating relay as compared to the signal obtained with the same relay in a simple circuit with a chopper, was found to be taking average values about *five times for the equal heterodyne,* a further magnification of at least *twenty times for the optimum heterodyne,* and finally, a *fifty-fold magnification by the operation of the regenerative circuit,* making a total of approximately *five thousand.*

In view of the two main theories concerning the operation of the heterodyne, namely, that the amplification to be obtained by this system is unlimited, the practical limit being determined by the disturbances produced in the receiving system by the local frequency and the current-carrying capacity of the detector, and the second theory, that of Liebowitz, which states that the maximum true amplification of the heterodyne is four, which is obtained when the local current is equal in amplitude to the signaling current, the author attempts to explain the true nature of the heterodyne phenomena. The latter theory (that of Liebowitz) says further that any increase in response beyond the factor of four obtained by an increase in local current is due to some improvement in the efficiency of the receiving apparatus. It is shown by Armstrong that the true key-note of this increase of amplification lies in what may be called "heterodyne characteristic," i. e., the relation between the telephone signal strength and the ratio of the local to the signaling current.

A number of experimental curves were taken and in all cases beyond the one to one point, an increase of the local to the signaling current produced a very rapid increase in the telephone signal strength which rose to a maximum value rather rapidly and fell off to zero. This critical point in the curve is explained, by Armstrong, to be due to the shape of the rectifying or valve characteristic of the electron relay which he discusses at some length. He remarks finally:

"The shape of the valve characteristic also explains the interesting fact discovered by Dr. Austin, that the plate current is proportional to the second power of the radio frequency current in the non-oscillating state but to the first power in the oscillating state. In the non-oscillating state, the rectification takes place on the lower part of the curve where the square law holds (with reference to zero current). In the oscillating state the operation takes place on an upper part of the curve which, for small changes of potential, is practically a straight line.

"It is evident from this that a regenerative receiver in the oscillating state delivers to the telephones an amount of energy which is proportional to the energy of the radio frequency current in the antenna. The relative amplitude of stray to signaling current in the telephones is therefore independent of the size of the antenna, and barring physiological effects and the possibility of overloading the tube, the readableness of signals should also be independent of antenna size. In ordinary practice this seems to be the case.

"In the non-oscillating state the first power proportionality between antenna and telephone energies is maintained only for strong signals. For weak signals or even moderately strong signals the telephone current will fall off very rapidly with a decrease in antenna energy with the result that the smaller the antenna the greater the ratio of the intensities of srays to signals in the telephones. Hence it follows that the larger the antenna the more readable the signals."

A LOW FREQUENCY RECTIFIER

GEORGE S. MEIKLE, of Schenectady, N. Y., has developed an apparatus for the rectification of low frequency currents. The device shown in Figure 2 is an extension of a former conception in which the inventor showed a filamentary cathode inserted in a vacuum valve with an anode, the device being used as a rectifier. Although the earlier construction was convenient and operative, it sometimes had a very short life, due to breaking of the filament caused by localized electrical erosion.

Mr. Meikle uses a rugged main cathode and a separate or auxiliary electrode which operate in conjunction to spring a starting arc which heats the cathode to incandescence preliminary to starting the main arc. This rectified current may be used for any desired purpose; for example, to charge a storage battery as shown at arc 2.

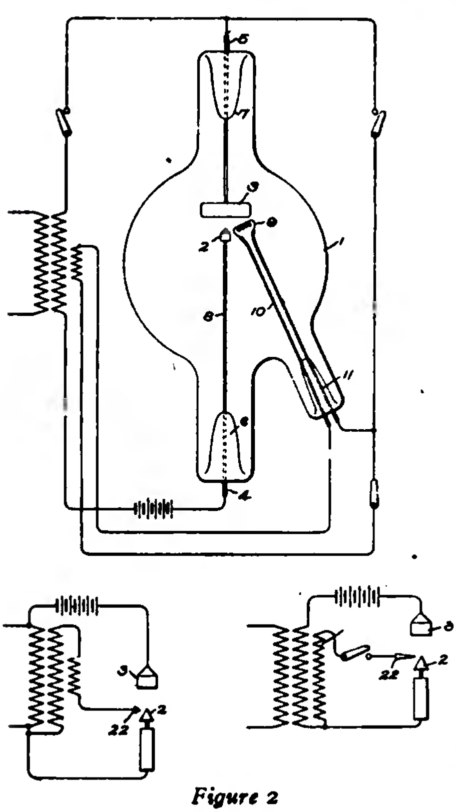


Figure 2

It is to be especially noted that the main electrode, 2, consists of a very rugged conductor so that a small amount of electrical erosion will not shorten the life of the device. The starting electrode or filament, 9, is only used for short periods and therefore is substantially unaffected by erosion.

There are several means by which the same current which is applied to the rectifier can be stepped down through a third winding and made to heat the filament for starting purposes. In one arrangement shown in the right hand lower drawing of Figure 2, a high potential discharge occurs from the pointed electrode, 22, to the electrode, 2, as the anode. This discharge heats the electrode, 2, to incandescence, whereupon the main arc starts between the electrode, 2, as cathode and the electrode, 3, as anode and a rectified current is therefore supplied.

In the Service

CAPTAIN EDWIN H. ARMSTRONG

Something About the Young Inventor of the Regenerative Circuit Who Has Received a Commission in the Signal Corps

EDWIN H. ARMSTRONG, who has won considerable recognition in wireless because of his invention of circuits in connection with receiving apparatus, has been appointed a captain in the United States Signal Corps. He also has the distinction of being the first recipient of the medal of honor of the Institute of Radio Engineers.

Captain Armstrong was born December 18, 1890. He was graduated from Columbia University in 1913 with the degree of E. E. and since then has been associated with Professor Michael I. Pupin in the work of the latter at Columbia laboratories.

The invention of Armstrong circuits in connection with wireless reception took place in 1912. This was during the period when he was active as an amateur and consequently experimenters have shown considerable interest in his progress in the wireless field. The medal which he received was awarded in acknowledgment of his invention. It was the outcome of the action of the Board of Direction of the Institute of Radio Engineers who decided to award annually a medal of honor to persons who had distinguished themselves by unusual achievements in radio telegraphy and telephony.

In his testimony before the Congressional hearing on the proposed bill to regulate wireless communication Professor Pupin referred to the invention of Captain Armstrong in these words:

"In 1910 Dr. Austin, director of the Wireless Research Bureau of the Army and Navy, published a paper in which he compared the efficiency of the various types of receivers. Among the receivers he examined was a new one, the so-called audion, the very audion receiver which is today used almost universally. Dr. Austin found that this audion was one and a half times as good as the best receiver they had prior to that time . . . . At that time a young inventor (Captain Armstrong) to whom I refer was a student in Columbia University, a sophomore . . . . In 1912 when this student graduated . . . . he had the invention, a very simple thing, consisting in taking that audion tube and by a simple transposition of the circuits making it five thousand times as sensitive as the one which Dr. Austin examined."

Captain Armstrong is a director of the Institute of Radio Engineers and President of the Radio Club of America.

Signal Officers' Training Course

A Wartime Instruction Series for Citizen Soldiers Preparing for U. S. Army Service

SIXTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

THE war has brought about sweeping changes in the organization of the Signal Corps. In former days a field battalion comprised a radio company and a telegraph company, each of 3 officers and 75 men. The total strength of this branch of service in the United States Army was 46 officers and 1,212 men. This was in the days, but a short time since, when we conceived the regular army of the United States at a maximum strength of 100,000. Now that the figures of our fighting forces are mounting up into the millions, the Signal Corps shows corresponding increase. It is purposed to build up this technical corps to a strength of 150,000 men, or half again as large as the entire army, as we formerly conceived it.

With the enormous increase in personnel have come corresponding changes in organization. The field battalion now consists of three companies, as follows: A wire company, containing 1 captain, 2 first lieutenants, and 75 enlisted men; a radio company, containing 1 captain, 2 first lieutenants, and 75 enlisted men, and an outpost company containing 1 captain, 4 first lieutenants, and 75 enlisted men. The battalion is commanded by a major, with a first lieutenant as battalion adjutant and quartermaster, and an enlisted headquarters detachment of 13 men.

The specific duties of these units are covered in detail in the author's "Military Signal Corps Manual," in which volume not only the tactical use of companies is dealt with but instruction in technical employment given in detail. The following outline of the general use of battalion units and some details of the drill of the radio company are abstracted from this work.

OBJECT AND COMPOSITION OF FIELD SIGNAL TROOPS

Field Signal troops comprise those Signal Corps units permanently assigned to divisions, army corps, and armies for the purposes of establishing and maintaining tactical lines of information and for transmitting over these lines such information as is incident to operations in the field.

One field battalion is assigned to each division, one to each army corps, and such number as is necessary to each army.

Field signal troops assigned to army corps and armies are intended to furnish a reserve for the field battalions in advance, to supplement the work of the latter when necessary or desirable, and for use with separate brigades and expeditionary forces. In emergency, these troops may assist telegraph troops in establishing and maintaining the necessary strategical lines of information.

Field signal troops assigned to army corps and armies normally constitute a reserve and, except for the use of wagon radio sets for communicating with divisions, their active employment otherwise is to be regarded as exceptional.

FUNCTION OF THE WIRE COMPANY

The wire company is the field signal organization used by the commander of a division for establishing and maintaining those tactical lines of information which radiate from headquarters, and which serve, in general, to connect these headquarters with the major subordinate units. Normally the wire company is used to connect division headquarters with the headquarters of the various brigades within the division, with the divisional artillery, and, in some cases, with the divisional trains. Opportunity for its use in maintaining communications with the divisional cavalry will occur so rarely that its employment in this manner is prohibited except in emergency.

FUNCTION OF THE OUTPOST COMPANY

The general function of the outpost company is to extend the lines of information in the division forward of the brigade. Specifically, its normal function is to furnish telephone communication between the infantry brigade commander and his regimental commanders in combat. In addition, it may be called upon to supplement the work of other companies of the field battalion wherever the same may be necessary or desirable.

Conditions of employment will probably cause the frequent dispersion of the fractions of the company among the divisional units for long periods of time. For this reason the personnel should be inculcated with the highest possible degree of discipline and should have unquestioned ability to maintain itself in the field.

FUNCTION OF THE RADIO COMPANY

It will now be well to consider the operations of one unit in the field battalion from the viewpoint of its training under drill regulations to acquire field efficiency. As with the training of technical combatant troops, the subject is a broad one and comprises instruction from the time when the recruit learns his duties as an individual soldier, through his instruction in technical features of the apparatus he is required to handle, and his finished instruction in drill regulations as a mounted soldier. Some of these subjects have been covered in outline in previous articles; in considering the radio company, therefore, we will confine the instruction in this article to a few details of drill regulations which will throw some light on the handling of the unit in training for field service abroad.

Employment

The radio company is used by the commander of a division for maintaining communication with adjacent columns with the divisional cavalry, and in other instances when distance, the character of the service, and the nature of the terrain prevent the laying of wire lines. The radio company usually serves to connect division headquarters with the divisional trains and, pending the construction of semi-permanent lines, with the radio station at army corps headquarters in the rear. These radio facilities may also be used to intercept messages sent by the enemy or to interfere with the operation of his radio stations.

Organization

The radio company is organized into the necessary headquarters and company staff, two platoons of two pack radio sections each, and one wagon radio section.

For drill the company is formed, as above, the wagon radio section forming a provisional platoon on the left of the company. In the field or on the march the company instrument wagon forms a fourth platoon under command of the supply sergeant.

The organization, in detail, is as follows:

1 captain.
2 first lieutenants.
1 master signal electrician.
1 first sergeant (sergeant, first class).
1 supply sergeant (sergeant).
1 stable sergeant (sergeant).
1 mess sergeant (sergeant).
1 horseshoer.
1 clerk (corporal).
1 farrier (corporal).
1 saddler (corporal).
1 mechanic (corporal).
2 cooks.
1 driver (private, first class).
2 buglers (private, first class, one acting as guidon).
4 radio sections, pack.
1 radio section, wheel.

DUTIES OF INDIVIDUALS

The captain commands the company and is responsible for its training and efficiency.

The lieutenants command platoons, and will be assigned to such other duties as the captain may deem necessary.

The master signal electrician is responsible to the captain for the condition of the technical equipment of the company. To this end he will make frequent and regular inspections of same and, when parts of the technical equipment are found or reported unserviceable, will make or supervise the necessary repairs. Under the direction of the captain, he will order such precautionary and corrective measures as he may deem advisable concerning the care and repair of technical equipment. Master signal electricians also act as substitute chiefs of platoons.

The first sergeant is the assistant of the captain, and is responsible to him for the general order, police and discipline of the company. In action he remains with the captain and under his immediate orders.

The supply sergeant is responsible to the captain for the care and preservation of the material not issued to the sections.

The stable sergeant is responsible to the captain for the general care of the public animals assigned to the company, the good order and police of the stables and picket lines, and the conduct of the stable personnel, when on duty.

The mess sergeant is responsible to the captain for the efficient and economical handling of the ration, for the conduct of the kitchen personnel when on duty and for the cleanliness of the company kitchen and surroundings.

The mechanics, under the orders of the supply sergeant, are responsible for the repair of the material pertaining to the company.

Chiefs of sections command the sections and will be held responsible to the captain for the condition of their equipment and the training and efficiency of their sections. They will make, or cause to be made, such minor adjustments or repairs to technical equipment as can be effected by the personnel of the section, promptly reporting more serious deficiencies to the master signal electrician.

The drivers are directly responsible to their chiefs of sections for their animals, harness and equipment. They will report at once to their chief of section any injury to animals and material.

The operators are responsible for the serviceable condition of their instruments and will report at once to their chiefs of sections any need of repairs.

Messengers are responsible for the delivery of all messages, no matter what the conditions.

THE PACK RADIO SECTION

Composition

The pack radio section is normally composed of 10 mounted men and 3 pack mules, designated the "generator" mule, the "chest" mule, and the "kit" mule. If a fourth pack mule be present with the section it will be designated the "supply" mule.

The organization, in detail, is as follows:

1 section chief (sergeant, first class).
2 operators (1 sergeant, 1 corporal).
1 messenger (private, first class).
4 antenna and counterpoise men (1 corporal, 3 privates, first class).
2 horseholders (1 private, first class, 1 private).
Total, 10.

Formation

The section is formed in column of twos. Each mule is led by one of the men and, with its driver, forms a two.

Posts and Duties of Individuals

The chief of section is on the left of the leading two except that when the section is acting alone he may go where his services are most needed.

The other men are numbered from 1 to 9, Nos. 1 and 2, the operators, form the leading two, No. 1, the sergeant operator on the right. These are followed by Nos. 3 and 4, horseholders, and No. 5, the messenger, leading, respectively, the kit, generator, and chest mules. Mule drivers march on the left of their led mules. The mules are followed by Nos. 6, 7, 8, and 9, antenna and counterpoise men, in column of twos with Nos. 6 and 8 on the right. It is the duty of No. 6 to observe the packs and keep up any lagging mules. The antenna squad corporal is No. 9. If a supply mule be present it is led by No. 6, and the duty of observing packs and keeping up lagging mules devolves upon No. 8.

The pack radio section in the field, showing method of transporting equipment by mule pack

The U. S. Army pack radio station open and working, an illustration of the completed erection of field equipment in accordance with drill regulations

It is the duty of all men so far as they may be able in addition to leading their own mules, to urge forward the mule immediately in front.

TO OPEN STATION

Being in normal formation: 1. **Open station,** 2, **DISMOUNT.**

At the command *Open Station,* Nos. 3 and 4 stand fast; No. 1 executes individual right about, chief of section and No. 2 left about; No. 6, moving along right flank of column, comes in alongside No. 1; No. 8 comes in alongside No. 6; No. 7, moving along left flank of column, comes in alongside the chief of section; No. 9 comes in alongside No. 7; No. 5 leads his mule left front into line on No. 4. At the command *Dismount,* all pass reins over horses' heads and dismount. Chief of section, Nos. 1, 2, 6, 7, 8, and 9 turn their horses over to No. 3, and proceed to unpack the generator and chest mules. Nos. 4 and 5, holding their mules in place, move their horses out of the way. No. 1 working on right side and No. 2 on left side, with No. 8 assisting, unpack generator mule. No. 6 working on right side and No. 7 on left side, No. 9 assisting, unpack chest mule. The equipment will be placed on ground 1 yard in rear of mules, iron ferrules of mast pointing to rear. Nos. 4 and 5, after seeing that all loose straps and cinchas are crossed over mules, lead off their horses and mules and turn them over to No. 3. As soon as the mules are unpacked Nos. 6 and 7 open antenna bag and distribute antenna reels, the chief of section places top insulator into top joints of mast, and distributes pins to Nos. 1, 2, 6, and 7, who secure antenna, snap their antenna into insulator, and reel out their antenna wires. No. 1 goes to right and No. 2 to left of horses, their antenna wires forming an angle of 90 degrees, No. 6 opposite No. 2 and No. 7 opposite No. 1, and then face mast and watch the chief of section for signals. The chief of section and No. 4 then raise the mast hand over hand; No. 5, assisted later by No. 4, connects up chest and generator, antenna, and counterpoise leads. As soon as bottom joint is in place and mast vertical, chief commands tie in, when the antenna men secure their antenna cords to pins and return to mast; Nos. 8 and 9 reel out the counterpoise directly under the antenna wires. In their absence this will be done by Nos. 6 and 7. The chief of section details the necessary operators, messengers, men to turn generator, guards to protect antenna and over animals.

Each man, having a permanent assignment of duty, soon learns to do his part quickly, and after the men have become proficient in handling the equipment the entire operation of unpacking and opening station may be effected by the command *open station.*

TO CLOSE STATION

At the command *Close Station,* the chief of section and No. 4 immediately start lowering the mast; Nos. 1, 2, 6, and 7 move rapidly to their respective antenna cords, face the mast, and watch for signals. They place their antenna pins in leggings and, when the mast is down, reel up without waiting for command. The chief of section unsnaps all antenna wires from top insulator, throws them clear, and then reels up antenna from top insulator, throws them clear, and then reels up antenna lead. No. 5 closes and secures chest for packing, while No. 4 attends to generator, after which they secure their respective horses and mules and spot the latter for packing. Nos. 8 and 9 reel up the counterpoise and place it in bottom of bag. In their absence this will be done by Nos. 6 and 7. The chief of section packs away antenna reels and secures pins. Nos. 1 and 2, No. 8 assisting, pack generator mule. Nos. 6 and 7, No. 9 assisting, pack chest mule. Men, when they find themselves no longer of assistance in packing mules, will promptly secure their horses, mount up, and form column, No. 2 being the base. The section forms in column, facing in the same direction as when open station was given.

THE WAGON RADIO SECTION

Composition

The wagon radio section is normally composed of 20 men, and one wagon radio set drawn by four horses. All men are individually mounted except the driver and the engineer, who ride on the wagon.

The organization in detail is as follows:

- 1 section chief (sergeant, first class).
- 3 operators (1 sergeant, 2 corporals).
- 3 mast men (1 sergeant, 2 privates, first class).
- 1 engineer (corporal).
- 8 antenna, counterpoise and guy men (1 corporal, 7 privates, first class).
- 1 messenger (private, first class).
- 1 driver (private, first class).
- 2 horseholders (privates).

Total, 20.

Formation

The mounted men of the section, less the chief of section and one horseholder, are formed in column of fours. The wagon is posted so that the lead horses are two yards in rear of the column of fours and in such a position that the pole of the wagon is in prolongation of the interval between the numbers 2 and 3 in the mounted ranks.

Posts and Duties of Individuals

The chief of section is on the left of the leading four, two, or file, except that when the section is acting alone he may go where his services are most needed. Beginning with No. 1 on the right of the leading four and going to the left of each succeeding four, the remaining mounted men of the section are numbered consecutively from 1 to 17 for the purpose of describing their duties. Nos. 1, 2, and 3 are operators; No. 1 being the senior operator; No. 4 is the messenger; Nos. 5, 6 and 7 are the mast men; No. 5 being the senior and in charge of the mast detail; No. 8 is a horseholder; Nos. 9, 10, 11, and 12 are the antenna men; No. 9 being the senior and in charge of the antenna and counterpoise detail; Nos.

13, 14, 15, and 16 are the counterpoise and guy men; No. 17 is the remaining horseholder and marches on the left of the leaders except that on the march he may ride in rear of the wagon.

The Wagon Radio Set

The wagon radio set is carried on a pintle-type wagon. It consists of the necessary technical radio apparatus, an engine, a dynamo, a jointed mast, antenna any guy ropes, and the counterpoise. The technical radio apparatus is attached to the front, and the engine and dynamo to the rear element, and electrically connected with the instruments by cable. On the rear vehicle are also carried the mast, consisting of 10 sections 8 feet in length; the antenna, which has nine cords, one of which is the connecting cord; two sets of guy ropes, four in each set; and the rubber insulated wire counterpoise, consisting of eight branches.

Drill of the Section
Maneuver

The section is maneuvered by the methods and means prescribed for the wire section, where applicable.

TO OPEN STATION

The chief of section indicates the location of the station and commands: 1. **OPEN STATION.**

At this command the driver halts and unhitches his team. The chief of section moves the mounted men a sufficient distance to be out of the way of the antenna and guy ropes when the mast is raised and dismounts them. The horses are turned over to the horseholders (Nos. 8 and 17) and the remaining men proceed to unpack the wagon, each man assisting in unpacking and making ready that part of the equipment which it is his duty to handle in establishing the station.

Nos. 1 and 2 place the counterpoise in position; Nos. 3 and 4 take position on top of the front element of the wagon prepared to raise the mast; Nos. 5, 6, and 7 unpack the sections of the mast and place them on the ground convenient to the point at which the mast is to be raised; Nos. 9, 10, 11, and 12 unpack the antenna and pins or stakes and pay out the antenna under direction of the chief of section; Nos. 13, 14, 15, and 16 unpack and pay out the two sets of guy ropes under direction of the chief of section.

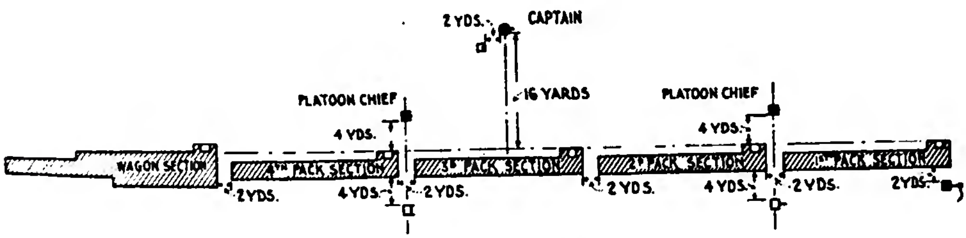
As soon as the top joint of the mast is unloaded, No. 7 places the top insulator, with antenna attached, in top of the joint and raises it vertically to Nos. 3 and 4. He then places the remaining joints successively in place and assists Nos. 3 and 4, who raise the mast vertically. The five smaller joints form the upper part of the mast. No. 7 also places the guy rings in place at the top of the fourth and seventh section.

No. 9 should be in front of the wagon, with Nos. 10, 11, and 12 in sequence to his left, in a circle around the mast. This will bring No. 11 opposite No. 9, and No. 12 opposite No. 10. Each man holds two adjacent antenna cords, carries necessary pins in his leggings and a hammer in his belt. Nos. 13, 14, 15, and 16, the guy men, each with an upper and lower guy rope, a hammer, and necessary pins take position, in a corresponding manner, in a smaller circle around the mast, No. 13 being between No. 9 and the mast. This will bring No. 15 opposite No. 13, and No. 16 opposite No. 14. As the mast is being raised the antenna and guy men, standing facing it, will keep it vertical by proper handling of the antenna and guys, under direction of Nos. 5 and 6. No. 5 will direct 9, 11, 13, and 15, and No. 6 will direct 10, 12, 14, and 16. When it is desired that an antenna or guy be pulled out, the command *out* will be used, as No.—*Out.* When it should be slacked off, the command *in* will be used. The guy ropes which each guy man holds are referred to, respectively, as *upper* and *lower*.

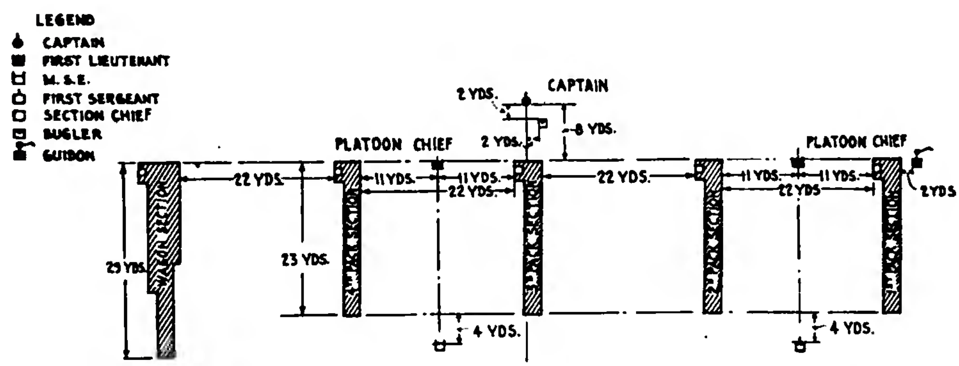
When the mast is up to the required height the chief of section commands **TIE IN.** At this command the guy men, with the assistance of Nos. 6 and 7, if necessary, drive pins in the ground and secure their guys. Antenna men, with the assistance of Nos. 6 and 7 or guymen, if necessary drive a pin in the ground and secure the proper antenna cord. They then secure the remaining cord in a similar manner midway between those first placed. In doing this all move to the right from the antenna cord first secured.

As soon as the command *tie in* is given, No. 5 makes the proper connection for the antenna and counterpoise, while No. 6 supervises the tying in and sees that cords and ropes are kept taut.

As soon as the driver unhitches his team, the engineer will see that there is sufficient gasoline in the tank, oil in the cups, water in the proper receptacles (if the engine is water cooled), and connect the dynamo to the instrument by means of the cable and generally make ready to start the engine and dynamo.



Formation of the radio company in column



Formation of the radio company in line

When the mast is up the chief of section details the operators, messengers, and guards for the antenna and guys, and makes such disposition of the remaining men as the situation demands. If the station is to be maintained open any length of time, he also directs that the picket line be established or the horses otherwise disposed of.

The driver takes care of his team.

TO CLOSE STATION

At the command *close station,* the operator removes the antenna and counterpoise connections, the guy men take up the pins and hold the guys, each antenna man first takes up the pin and frees the end of the antenna cord which he last secured and turns it loose, then proceeds to his other antenna cord, pulls up the pin, and holds the cord while the mast is being lowered. The mast is lowered by the same men in the same positions as when being raised. Nos. 5 and 6 direct the antenna and guy men. The counterpoise men recover the counterpoise; the engineer shuts off all valves, the driver brings his team close to wagon, and when the mast is down hitches it to the wagon. All men assist in packing the equipment which they unpacked. When all the apparatus has been securely packed the chief of section commands **stand to horse,** when all men proceed to their horses and obey this command. The men are then mounted and the section formed by the appropriate commands.

In opening and closing station, all men who have finished the duty herein assigned to them may be directed by the chief of section to perform such other duties as may be necessary.

THE RADIO PLATOON

The radio platoon is composed of two radio pack sections commanded by a lieutenant.

The interval between sections in the order in line is approximately 22 yards.

EMPLOYMENT IN THE FIELD

General

The main equipment of each pack radio section is one pack radio set actuated by a hand generator, and that of the wagon radio section is one wagon radio set actuated by an engine-driven dynamo. Component parts of these sets are as indicated from time to time in War Department orders. The company instrument wagon carries a spare pack radio set. The pack radio set has a range of 20 to 30 miles, depending on conditions. The set can be unpacked, the mast erected, station opened, and messages started in 2½ minutes. The wagon radio set has a range of 150 to 250 miles, depending on conditions. The set can be unpacked, the mast erected, station opened, and messages started in 10 minutes.

Assignment of Sections to Duty

In general, the wagon set remains with headquarters. The pack sets can be so disposed that the division commander can send to and receive messages from the divisional cavalry and other important units with which radio communication is desired.

The field battalion at army corps headquarters can, if desired, make use of the large and more powerful motor truck radio sets available there for keeping in touch with the advancing organizations.

Selection of Station Sites

The selection of station sites involves on the part of those charged with that duty a suitable reconnaissance of the terrain, knowledge of the possibilities and limitations of the station to be erected and a consideration of the tactical needs and probable developments. The locality for the station will be selected with as much care as the time available and conditions will permit.

High open ground as far from near-by hills as practicable is to be preferred, due regard being had for cover and security of the station. The nearer the station is placed to the commanding officer or to the headquarters of the command with which the section is serving, the better.

If not impracticable, the site selected should permit the full spread of antenna and guy ropes. The greater the spread of the antenna wires, the farther they are from the ground and the greater the capacity.

Instructions for Those in Charge of Field Radio Stations

Be sure you know the organization which you are serving and the commander to whom you report and are responsible.

Familiarize yourself promptly with the call letters and locations of all stations with which you are in communication; likewise, with the location of your own troops and the names of commanders.

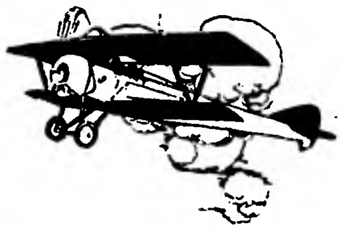
Arrange for the subsistence of the men and the foraging of the animals.

Constant attention to instruments and minor repairs made immediately will avoid serious breakdowns.

In receiving, attention to the insulation of the set and the mast from the ground is very important.

How to Become an Aviator

The Fourth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By HENRY WOODHOUSE

Author of "Text Book of Naval Aeronautics"

THE military aviator, to whom these articles are dedicated, can insure proficiency only through acquisition of a sound knowledge of the characteristics of design which govern the construction of an aeroplane.

No greater mistake can be made by a prospective military pilot than skimping the study of fundamentals. Air tactics in warfare, while a subject for military experts, are insoluably a part of the mechanics of aeronautics. While the manner of conducting air battles is subject to daily changes, it must be remembered that the effective observer or air fighter who creates new evolutions is logically one whose knowledge of engineering features of design is sound. Skill in manipulation of controls is essential of course, but it can readily be recognized that attempted creation of new tactics might well be fatal unless an aviator has an intelligent understanding of the limitations of his machine and what it can accomplish within the safety factor.

In this article some consideration will be given to the factors upon which a military aeroplane must base its superiority.

In the preceding installment fundamental principles of flight have been given; it now devolves upon the student to recognize that in military use of flying machines two important features are encountered:

(a) Superiority in climbing rate.

(b) Greatest speed.

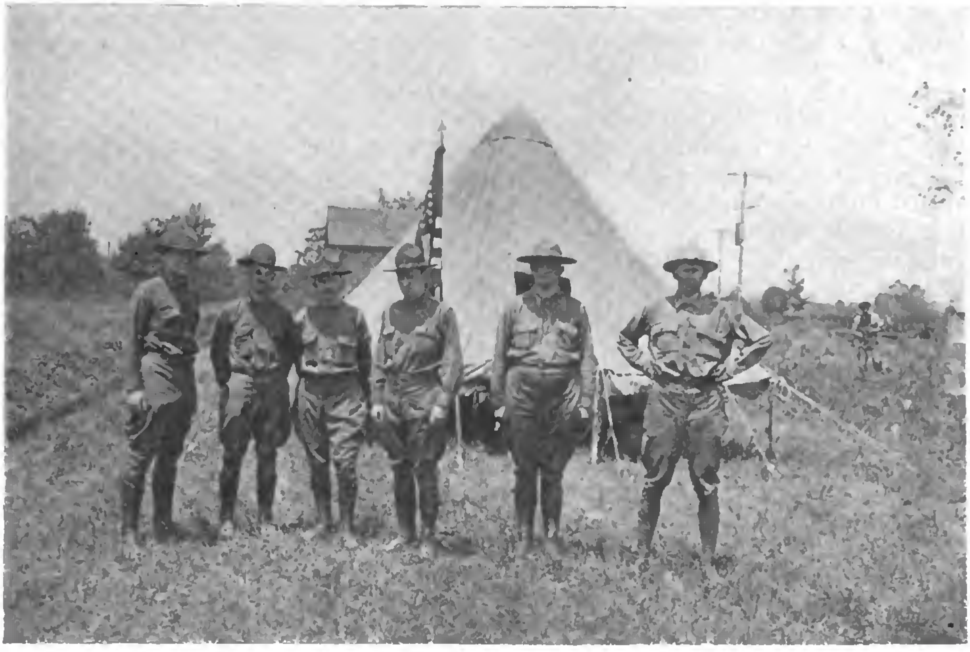
It is obvious that the machine which excels in speed and ability for fast climb will be most effective against the enemy. An aeroplane which attains speed at the sacrifice of climbing ability can be out-maneuvered by fast-climbing enemy aircraft in air battles, and the same is true of reverse qualities of climb versus speed. The combination of great speed with maximum climb is the ideal striven for in military aeroplane design.

As in all mechanical devices, however, the ideal must be subjected to compromise, and it is now purposed to apply the knowledge of fundamentals previously gained to consideration of the engineering factors which govern the design of machines for maximum climb and greatest velocity.

America's new material for the air fighting forces is well represented in this group of army flyers

Thus far in this series the reader should bear in mind that the aeroplane is being studied in two distinct divisions; viz., the **lifting surfaces** and the **propelling mechanism,** or (a) the aeroplane structure, (b) engine and propeller.

In the October issue the factors of lift-drift ratio were outlined and commented upon. As a thorough knowledge of the proportion of lift to drift is essential to an aviator, further considerations of design will be mentioned.



Officers of the Signal Corps, U. S. A., the greatly enlarged branch of service in which the aviation section is included

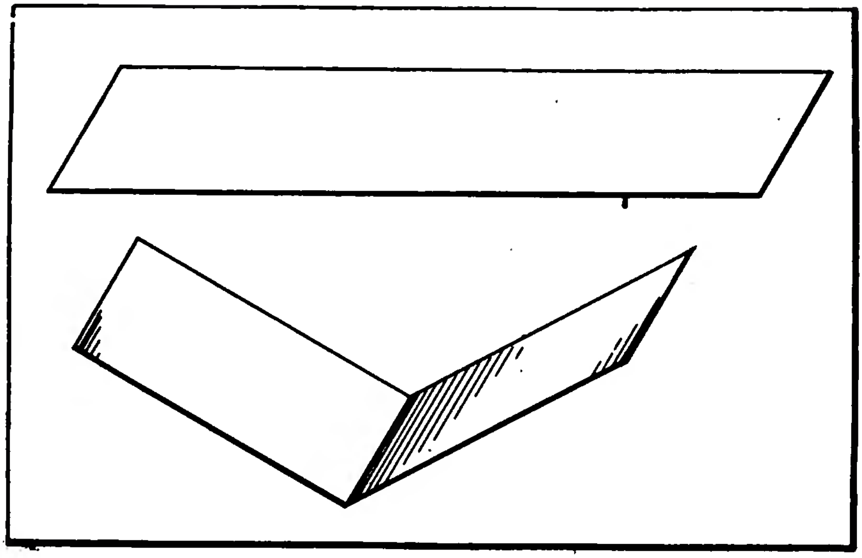


Figure 10.—*Lifting surfaces of same area but different horizontal equivalent*

The efficiency of the aeroplane structure is determined by the lift-drift ratio, and an item in relation to lifting surfaces which must be considered in addition to those covered in the October issue, is:

HORIZONTAL EQUIVALENT

This is determined by the arrangement of lifting surfaces and is important because lift (vertical component of the reaction) varies as the horizontal equivalent of the surface, but drift remains the same. That is, with reduction in horizontal equivalent (H. E.) of aerofoil the ratio of lift to drift is lessened.

Figure 10 *gives front views of two lifting surfaces.*

Both have the same surface area, but the upper, having its full horizontal equivalent, has the best lift-drift ratio.

The lower surface, being inclined from its center, has lessened H. E. and in consequence less lift.

Therefore, as the lower surface containing the same area as the upper surface, produces the same amount of drift, but less vertical lift, its lift-drift ratio is less than the upper's.

Sacrifice of efficiency in lift-drift ratio is often made to gain lateral stability; such employment of surfaces tilted from the center will be considered later.

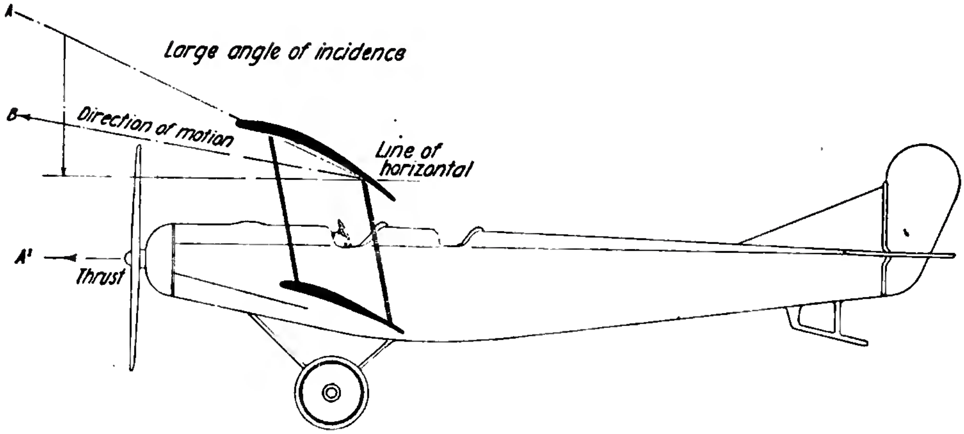


Figure 11.—Aeroplane designed for maximum climb

Aeroplane design is restricted by opposing essentials which require the aerofoil (lifting surface) characteristics and velocity to produce either Maximum Climb or Maximum Velocity. A compromise between the two is represented in all aeroplanes.

DESIGN FOR MAXIMUM CLIMB

The factors in an aeroplane designed for maximum climb are:

(a) Large aerofoil.
(b) Low velocity.
(c) Large angle of incidence to propeller thrust.
(d) Large angle relative to direction of motion.
(e) Large camber.

(a) *LARGE AEROFOIL—A Large area of lifting surface is required to engage the mass of air necessary for flight with a low velocity.*

(b) *LOW VELOCITY—Speed must be sacrificed to secure the best lift-drift ratio.*

(c) *LARGE ANGLE OF INCIDENCE TO PROPELLER THRUST—The most efficient aeroplane is one with inclined lifting surfaces propelled by horizontal thrust, therefore a flying machine for maximum climb to be driven along an upward sloping path with propeller thrust horizontal has its aerofoil at a large angle to the direction of the thrust.*

See A—A[1] figure 11.

In the preceding article it was shown that the lift drift ratio falls with increased velocity where the angle of incidence is great, because with a large-angled aerofoil increased speed creates more eddies in the air reaction. These air reactions require power to produce them, yet they have no lift value; they therefore represent drift and lower the lift-drift ratio.

(d) *LARGE ANGLE OF INCIDENCE TO DIRECTION OF MOTION—With low velocity the angle's relation to the direction of motion should be large.*

See A—B, figure 11.

(e) *LARGE CAMBER—With low velocity and large angle of incidence the camber of the aerofoil should be large.*

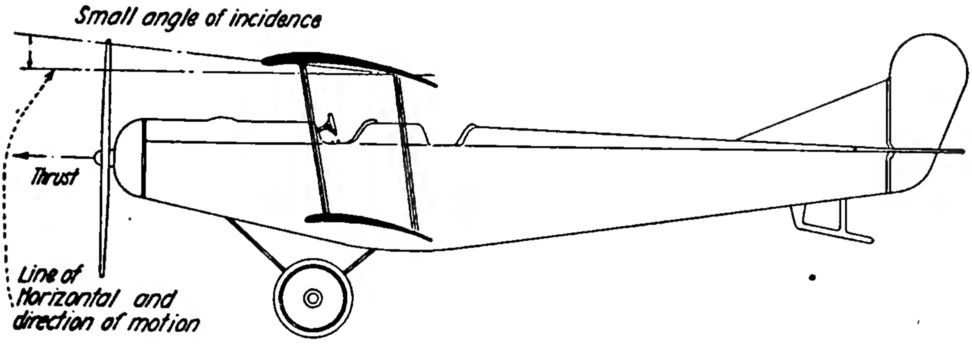


Figure 12.—Aeroplane designed for maximum velocity

The aeroplane designed mainly for speed has a small margin of lift at low altitudes when its propeller thrust is horizontal. In the rarefied atmosphere of higher altitudes engine efficiency is lowered and the margin of lift disappears. Then only horizontal flight is possible. Flying thus with its thrust horizontal it is at maximum efficiency, if loss of engine and propeller efficiency is not considered.

DESIGN FOR MAXIMUM VELOCITY

The factors in an aeroplane designed for maximum speed with given surface and power are exactly opposite the requirements for maximum climb. Thus:

(a) Small aerofoil.
(b) High velocity.
(c) Small angle of incidence to propeller thrust.
(d) Small angle relative to direction of motion.
(e) Small camber.

(a) *SMALL AEROFOIL—By its increased velocity the speedier propelled surface engages a greater mass of air in a given time and the required lift is secured with smaller surface.*

(b) *HIGH VELOCITY—Lessened aerofoil angle produces less drift, and velocity may be increased without loss in lift-drift ratio.*

(c) *SMALL ANGLE OF INCIDENCE TO PROPELLER THRUST—As both propeller thrust and direction of motion are horizontal, a small angle of incidence is most efficient for speed.*

(d) *SMALL ANGLE OF INCIDENCE TO DIRECTION OF MOTION—Where velocity is a consideration paramount to lift, a small angle of incidence is most efficient.*

(e) *SMALL CAMBER—Lessened camber at high velocity produces the best lift-drift ratio.*

The aeroplane built in accordance with the above is intended to possess only sufficient lift to get off the ground. The types illustrated on this and the preceding page are extremes, but the compromise of an aeroplane with climb and velocity equal considerations, i.e., a practical all around type, is designed by consideration of the factors disclosed in these examples.

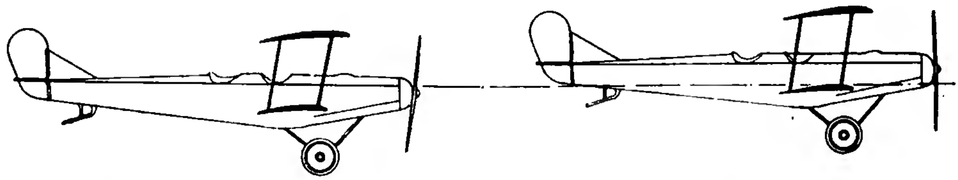
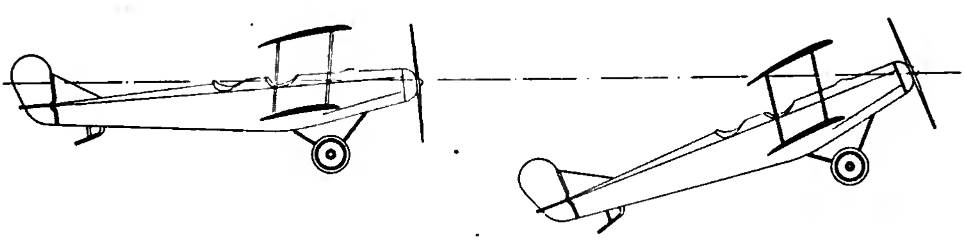


Figure 13a.—Minimum angle *13b.—Optimum angle*

In the illustrations on this page an aeroplane of practical utility is shown at varying angles of incidence while in flight.

At low altitudes the aircraft shown has slight margin of lift when the thrust is horizontal.

The fighting machine usually flies at an altitude where maximum velocity is gained at sacrifice of maximum lift. It is obvious that with slight margin of lift at low altitudes, the margin of lift disappears with the rise of the aeroplane, because of loss of engine power in the rarefied air. But when the machine arrives at the altitude where horizontal flight is just possible, it is given its maximum velocity because, even though engine and propeller efficiency is lowered, the margin of lift has disappeared and the surfaces are at their best flying efficiency for horizontal flight.



Figures 13c.—Angle of best climb *13d.—Maximum angle*

ANGLES OF INCIDENCE IN FLIGHT

Minimum—(See figure 13a). The angle of the aerofoil is the smallest at which, with amount of power and area of surface fixed, the machine can maintain greatest velocity in horizontal flight at low altitudes.

An aeroplane having less camber and smaller angle of incidence, i.e., so designed that the margin of lift is negligible, or just sufficient to maintain horizontal flight, would attain greater velocity with the same surface area and power.

Optimum—(See figure 13b). Here the axis of the propeller is horizontal and the angle of incidence that which is required for best lift-drift ratio. Velocity is lessened at this angle, at which slight climb is developed at low altitudes.

Best Climb—(See figure 13c). This angle is about midway between maximum and optimum angles of incidence. Here the increased angle has added to the drift and thereby decreased the velocity.

With the angle fixed, a decrease in velocity lessens the drift, but where the angle has been increased the lift thereby gained in a measure offsets the loss in lift through lessened velocity.

Beginners should never exceed the angle of best climb.

Maximum—(See figure 13d). Horizontal flight is just possible at this angle, because drift has been greatly increased and velocity materially lessened in consequence.

If the angle were further increased the lift-drift ratio would be so lowered that the lift would be less than the weight and the aeroplane would fall. This fall is known as the "pancake."

In the December issue the problems of stability in flight will be considered and explanations given of the arrangement of devices to insure correction of disturbances caused by the treachery of the atmosphere, the flight medium.

MILITARY AIRMEN

BRIGADIER GENERAL BENJAMIN D. FOULOIS

He says:

"Wireless men are indispensable in connection with aeronautics, particularly in aero reconnaissance."

"WIRELESS men are indispensable in connection with aeronautics, particularly in aero reconnaissance," is the important message to readers of The Wireless Age sent by General Foulois, 36-year-old commander of the army's aviation section.

An excellent type of the American airman, young but widely experienced and wholly fearless, is the army's air chief. Few officers have risen so rapidly. A native of Connecticut, Foulois early in his career was sent to the Philippines where he served five years, taking part in upwards of fifty skirmishes.

In view of the fact that the United States was the first country to use aircraft in its army, the early official flights made by Foulois are doubly historic. He was selected by the Wright Brothers to be the passenger in the first army test flight in history in any country. This flight was between Fort Myer and Alexandria, Va., a distance of seven miles. In 1911, when Robert J. Collier lent his Wright biplane of the old type to the Government for official tests, flights were made by Foulois, assisted by Phil Parmalee, in the vicinity of Eagle Pass, in Mexico, which attracted wide attention. In the same year Foulois was placed in charge of all aviators connected with the National Guard.

It is not generally appreciated that the first flying in active war service was done by an American airman in the Mexican campaign. When Villa made his famous raid, sacking Chihuahua City, Foulois chanced to be at San Diego. He was detailed with six machines and a squad of picked flyers to enter Mexico. The dangers and difficulties faced by these pioneer army airmen were unprecedented. The dry heat caused the propellers to fly apart, the water boiled in the radiators, while unexpected air currents rendered air navigation extremely perilous. Despite these handicaps excellent work was accomplished.

One of the most daring flights was made by Foulois himself while carrying General Pershing's dispatches from San Antonio, Texas, to the American consul at Chihuahua City, Mexico. The reception of the American airmen was very uncertain, for feeling ran high. Foulois dropped down unexpectedly and quite defenseless in the Mexican stronghold. On landing he hurried under armed guard to the Consulate, and hurrying back sprang into his machine and flew away so quickly that the populace had not had time to act. During another air trip he camped for two nights in a country infested with bandits.

General Foulois, although a veteran airman of such varied experience, is today but thirty-six years of age. It is to such men as he that the country looks with confidence to establish American supremacy in the air in the great world war.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE VII

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

Editor's Note.—This is the seventh installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of The Wireless Age. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively. In the next issue the phenomena of electrostatic capacity will be considered, together with its relation to the production of high frequency alternating currents.

THE ELECTRIC MOTOR

FUNDAMENTAL FACTS CONCERNING THE MOTOR

(1) We have already mentioned that, essentially, there is no difference in the construction of a direct current dynamo and a direct current motor.

(2) If a direct current dynamo be connected to **an external source of direct current,** its armature will be set into rotation, converting the **electrical power supplied to it into mechanical power,** i.e., it will become **a motor.**

(3) We have shown a dynamo armature when set into rotation induces an electromotive force in each wire and it makes no difference whether the armature be driven by an external source of mechanical power (such as a steam engine) or whether it be set into rotation by an external source of electric current. In either case an E.M.F. will be generated, but in the case of an electric motor this E.M.F. will be **counter to** or act against the driving E.M.F. This back E.M.F. is termed, **counter electromotive** force (abbreviated C.E.M.F.). The generation of this counter E.M.F. of course follows the same law as the dynamo, namely, the greater the speed, or the stronger the field flux with a given speed, the greater will be the C.E.M.F.

(4) Since the counter E. M. F. acts against the driving E. M. F. it is readily seen that **the greater the C.E.M.F. the less will be the current flowing through the armature.**

(5) Because the counter E.M.F. thus governs the amount of current admitted to the armature, we see that it is an important factor in motor design and operation.

(6) It is now evident that the **effective resistance** of a motor armature when in rotation, is quite different than its D.C. resistance when it is standing still.

(7) For instance, the steady resistance of a motor armature when stationary may be .05 ohm, but its effective resistance when rotating at normal speed may be 5 ohms.

(8) Suppose, then, we connected this stationary armature directly to a source of 110 volts D.C. According to Ohm's law a current of $\frac{110}{.05}=2200$ amperes will flow. A current of this amount obviously would immediately destroy the armature, melting both the brushes and mains leading thereto (provided the circuit was not protected by a fuse).

(9) We also see that when in full rotation, the current would equal $\frac{110}{5}$ or 22 amperes. It should now become apparent that some safety measure must be taken to protect the armature of the motor during the starting period. In fact, it is necessary to insert an external variable resistance coil in the circuit to reduce the strength of the starting current. This device is known as a **motor starter.**

(10) A **motor starter** consists of a number of **resistance coils** connected to the contact points of a multipoint switch. At the start of the motor all the resistance coils are connected in series with the circuit, but as the armature increases its speed these coils are progressively cut out of the circuit by the operator, until finally the full voltage of the external source of current is applied to the armature terminals.

(11) Motor starters may be **hand-operated** or **automatically operated.** If, for instance, it is not convenient to place the motor starter near to the operator, an automatic starter is employed which is placed near to the motor and a small control circuit leads therefrom to the controlling point.

(12) The running speed of any direct current motor can be regulated within reasonable limits by means of a variable resistance coil known as a **field rheostat** or field **regulator.** This is connected in series with the shunt winding and an increase of its resistance i.e., a reduction of the field current will cause the motor to increase its speed. This is accounted for by the fact that the motor armature generates less counter E.M.F. when the field current is reduced.

(13) It is desirable, under fluctuating loads, that a motor maintain a **constant speed.** If the load does not vary too rapidly an ordinary shunt wound motor will afford the necessary speed regulation, but if a severely fluctuating load is applied, a special winding must be provided to maintain the necessary speed regulation. A motor wound for such regulation is said to have a **differential field winding,** that is. its field circuits consist of a series and a shunting winding through which the current circulates so that their magnetic fields will oppose.

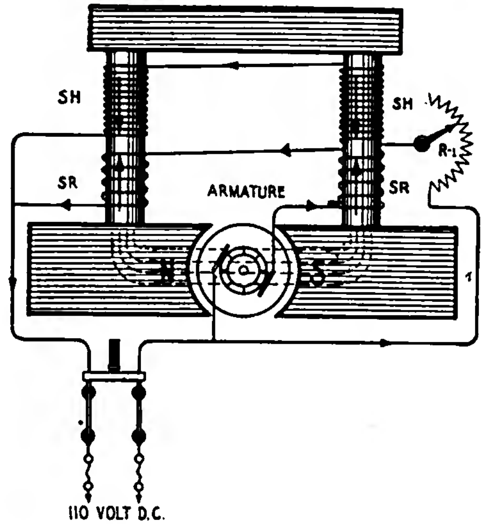


Figure 45

OBJECT OF THE DIAGRAM

To show the fundamental circuits of a differentially wound motor.

PRINCIPLE

By magnetically opposing the shunt and series field windings of a motor, proper design enables the flux of the series winding to act against the flux generated by the shunt winding according to the load to which the motor is subjected. A practically constant speed is thus maintained.

DESCRIPTION OF THE APPARATUS

The cores of the field poles N, S, have a series winding, S R, connected in series with the motor armature to the line and a shunt winding, S H, connected in shunt to the power mains. The current circulates through these windings in opposite directions.

A field rheostat, R-1, is connected in series with the shunt field coils.

OPERATION

An increase of the load applied to the armature will cause a slight reduction in speed, and owing to the reduced counter E.M.F. in this circumstance, increased current flows through the armature coils and series winding. This action weakens the flux generated by the shunt winding, causing a still greater reduction of the counter E.M.F. which permits increased current to flow through the armature. This regulation takes place according to the load imposed. A practically constant speed may thus be maintained.

QUES.—How may initial adjustments of speed be made with this motor?

Ans.—By means of the field rheostat, R-1. An increase of resistance at R-1 will increase the motor speed, whereas a decrease of resistance will reduce the motor speed.

QUES.—In what connection with wireless telegraph apparatus does a motor of this type have particular application?

Ans.—The motor employed to drive the generator in a motor generator set must be designed for a constant speed regulation because the generator is subjected to a severe fluctuating load during the manipulation of the telegraph key.

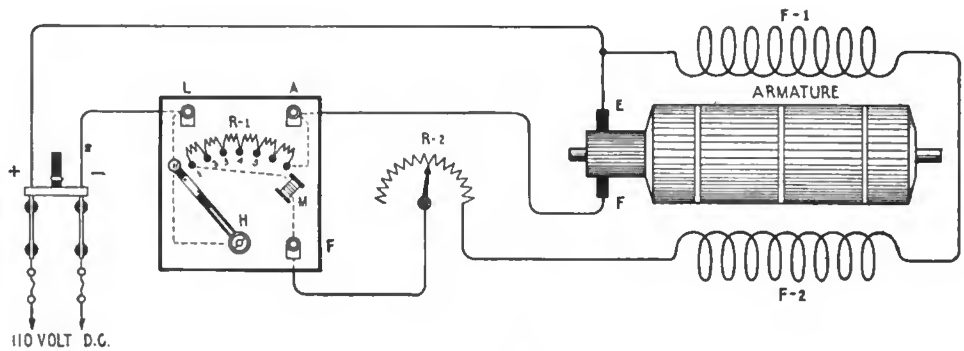


Figure 46

OBJECT OF THE DIAGRAM

To indicate the circuits and to show the use of a hand-operated motor starter (Cutler Hammer type).

PRINCIPLE

Because of the reduced counter electromotive force in a motor armature during the starting period, a resistance of variable value must be inserted in series with the circuit to keep the starting current at a safe value.

DESCRIPTION OF THE APPARATUS

The hand-starter has the binding posts, L, A, and. F. The field coils of the motor are indicated at F-1 and F-2, and the armature brushes at E, F. A field regulating rheostat is indicated at R-2. A release magnet, M, is connected in series with the shunt winding of the motor. This holds the arm of the starter in the full running position.

OPERATION

To start the motor close the D.C. main-line switch. Draw the handle H, clockwise, slowly across contact studs, 1, 2, 3, 4, 5, etc. When the last point of contact is reached the magnet, M, grips the handle, H, holding it in this point so long as the current flows.

Should the circuit from the main line to the motor or the field circuit of the motor suddenly open, the magnet, M, will lose its magnetism, releasing the handle, H, which is thrown back to its original position by a spring mounted on the shaft.

QUES.—What precaution must be taken in starting a motor with a hand-starter?

Ans.—The starting arm should not be drawn over too rapidly or too slowly; if too rapidly, the motor armature may be burned out or the fuses blown. If too slowly, the starting resistances mounted within the box may be burned out.

QUES.—How can the proper acceleration of the starting handle be gauged?

Ans.—Generally, experience enables the operator to determine the proper speed of acceleration. This varies with different types of motors and the load to which the motor is subjected at the start. The average motor employed in wireless telegraph work for driving generators should not require more than twenty seconds for starting.

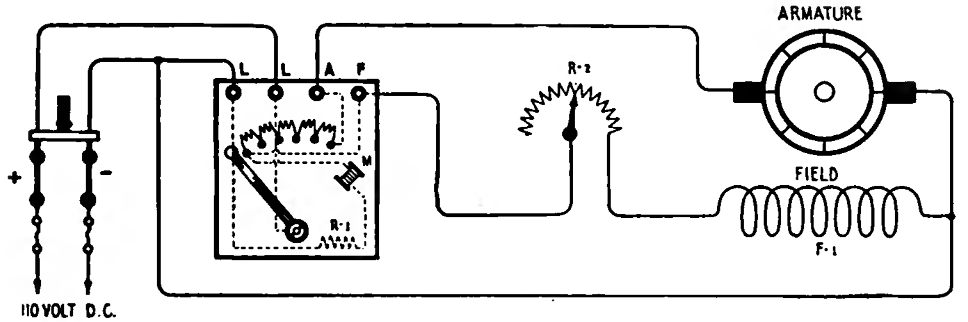


Figure 47

OBJECT OF THE DIAGRAM

To indicate the general circuits of the General Electric Company's hand-operated motor starter connected to a shunt wound motor.

DESCRIPTION OF THE DIAGRAM

The starter has four binding posts, L, L, A, F. The release magnet, M, is connected in shunt to the main D.C. line with the resistance coil, R-1, connected in series to reduce the flow of current.

OPERATION

The handle of the starter is drawn clockwise, as in the case of the Cutler Hammer type, being slowly moved across the contact studs until the arm is gripped by the magnet, M.

SPECIAL REMARKS

(1) If current from the power mains is turned off, the release magnet, M, loses its magnetism, releasing the starting handle which returns to its original position. The circuit to the motor armature is thus broken.

Figure 48.—Showing the general construction of the Cutler Hammer hand motor starter. The main resistance coils are mounted on porcelain spools and embedded in a heat-proof insulating cement. These are placed within the box. Taps are brought from the coils at regular intervals and connected to the studs on the front of the starter. The starting handle is held in the zero position by a spring in the shaft and in the full running position by the small release magnet at the right

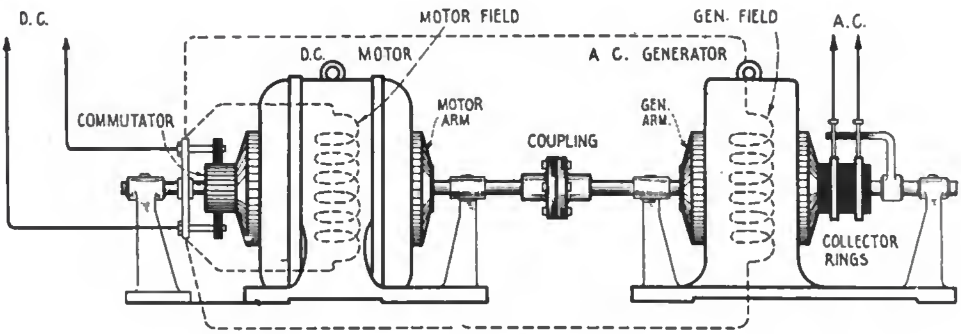


Figure 49

OBJECT OF THE DIAGRAM

To outline the general construction of a motor-generator for the production of alternating current at frequencies suitable for radiotelegraphy.

PRINCIPLE

If a source of direct current only is available and an alternating current is desired, a direct current motor can be connected to a source of direct current and made to drive an alternating current generator of any frequency required. By the insertion of field rheostats in the motor and generator field circuits, both the voltage and the frequency can be carefully regulated.

DESCRIPTION OF THE SKETCH

A simple shunt wound direct current motor is mechanically coupled to a simple alternating current generator.

OPERATION

When normal voltage is applied to the main D.C. terminals of the motor, an alternating current can be collected from the collector rings of the generator.

SPECIAL REMARKS

(1) The frequency of the generator can be altered within reasonable limits by increasing or decreasing the speed of the driving motor. The alternating current voltage may be increased by an increase of motor speed, or if the speed remains constant, by an increase in the field current.

(2) Generators for radio telegraph communication by spark discharge methods are designed for frequencies from 60 to 500 cycles per second.

(3) The motors of motor-generators for commercial ship installations are generally designed for connection to 110 volts D. C., but in certain special cases 65-volt motors are in use.

The generators are generally designed to deliver voltages varying from 110 to 500 volts. Some are designed with special characteristics, namely, a certain amount of magnetic leakage takes place under load which causes a sudden drop in voltage. A machine of this kind assists in quenching the spark discharge of a wireless transmitter.

(4) Motor-generators operate at speeds of from 1,800 to 2,400 revolutions per minute according to their design.

(5) Some types have four bearings and others have two bearings, the shaft being strengthened at the center to withstand the peripheral strain.

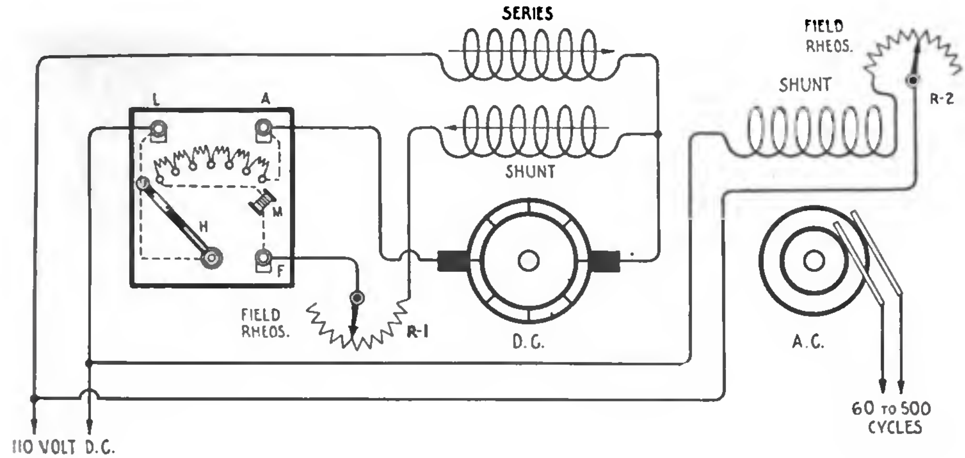


Figure 50

OBJECT OF THE DIAGRAM

To show the circuits of a motor-generator connected to a Cutler Hammer hand starter.

DESCRIPTION OF THE APPARATUS

The motor has a series field winding connected in series with the armature to the main D.C. line, and a shunt winding shunted across the armature terminals. The starter is of the type previously described. The motor speed regulating rheostat R-1 is connected in series with the shunt field of the motor and a second rheostat R-2 in series with the shunt field of the generator. The generator fields obtain their current from the same source as the motor.

OPERATION

The motor is started in the same general way as with the type previously described. The frequency of the generator can be increased by increase of resistance at R-1. The voltage of the generator can be increased by reduction of resistance at R-2 or decreased by the addition of resistance at R-2.

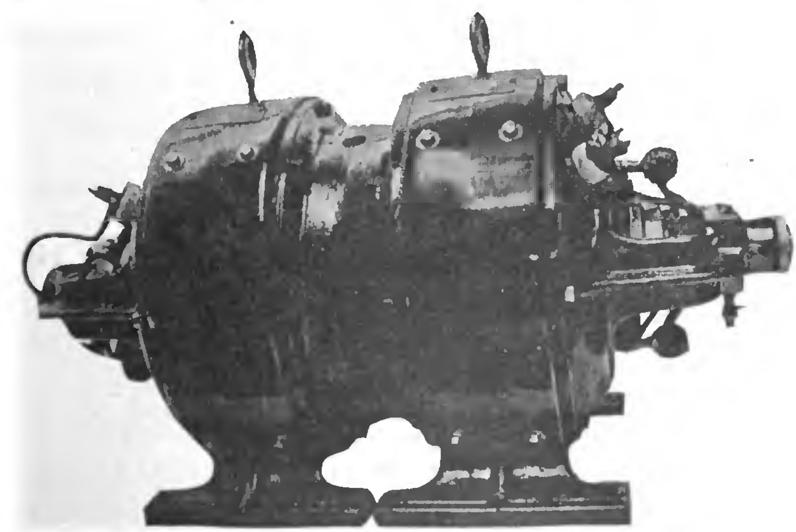


Figure* 52.—*Showing a 1 K.W. 60 cycle motor-generator of the Robbins & Meyers type. A simple shunt wound motor is directly coupled to a 60 cycle alternating current generator. This is a two bearing unit, the armature being strengthened at the center to withstand the strain. The bearings are of the self-oiling type and the generator has a special series winding (in addition to the shunt winding) which is connected in series with the motor armature. By means of this connection a practically uniform voltage is maintained at the generator terminals under fluctuating loads

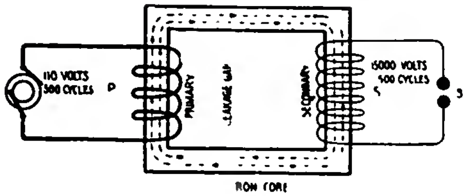


Figure 52

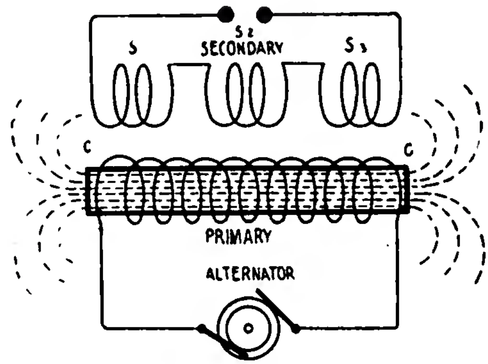


Figure 53

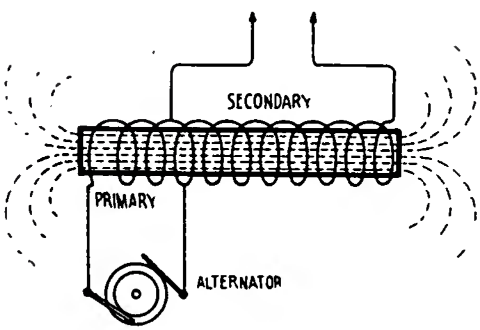


Figure 54

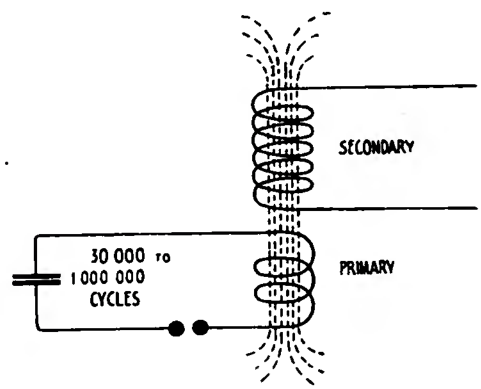


Figure 55

OBJECT OF THE DIAGRAMS

(1) To show how electrical energy may be transferred from one circuit to another by electromagnetic induction.

(2) To outline the apparatus whereby an alternating current of low voltage may be raised to one of high voltage or vice versa.

(3) Figure 52. To outline the construction of a closed core step-up voltage transformer.

(4) Figure 53. To outline the construction of a step-up voltage open-core transformer.

(5) Figure 54. To outline the construction of a step-up voltage auto-transformer.

(6) Figure 55. To outline the construction of an air-core radio frequency transformer.

PRINCIPLE

By placing a coil of wire in inductive relation to a second coil through which an alternating current is flowing, the magnetic flux generated in the latter coil will act upon the former and induce a current in it (provided the circuit is closed). By properly proportioning the ratio of turn in the two coils, the E.M.F. of the current may thus be increased or decreased.

DESCRIPTION OF THE DIAGRAMS

In Figure 52 the primary winding, P, and the secondary winding, S, are wound on a rectangular iron frame.

Winding P has a few turns of comparatively coarse wire such as No. 10 B. & S., but winding S may have several turns of fine copper wire such as No. 32 B. & S.

The iron core is laminated, i.e., it is built up of a number of sheets of soft iron, each piece of which is insulated from the neighboring piece (coated with shellac). This prevents the induction of current in the iron core which would occasion energy losses, but does not hinder the passage of the magnetic lines of force.

In Figure 53 the primary and secondary coils of the transformer are wound on a straight iron core which may be made of a bundle of fine iron wires or long strips of iron.

As a matter of protection (to prevent the breakdown of the insulation between layers) the secondary winding is often split into sections such as S-1, S-2, and S-3. (The primary winding is shown connected to the terminals of an alternating current dynamo.)

In Figure 54 a single coil performs the function of both the primary and secondary windings. This coil is wound on a straight iron core, a portion of the turns acting as the primary and the remainder as the secondary. Although a step-up ratio of turns is shown in the diagram, this type is more often employed as a step-down transformer, for example, to convert 110 volts A.C. to 6 to 15 volts A.C.

In Figure 55 the primary winding comprises a few turns of heavy copper tubing or heavy copper strip; the secondary may have a greater or lesser number of turns of approximately the same diameter.

OPERATION

If the primary winding of either of the foregoing types of transformer is connected to a source of alternating current, the flux generated thereby cuts through the secondary winding, inducing in it a current of similar frequency but of greater or less voltage according to design.

The strength and direction of flow of this flux, of course, follow the alterations of the primary current, rising, falling and reversing therewith.

SPECIAL REMARKS

(1) The transformer of Figure 52, if employed in connection with radio transmitting apparatus, is generally designed to produce secondary voltages up to 15,000 volts or greater. This high voltage current charges a condenser which, upon discharge, generates what are termed radio frequency oscillations.

(2) The open-core transformer of Figure 53 is also employed for the production of high secondary voltages of the order of 10,000 to 50,000 volts, and is employed for the same purpose as the transformer of Figure 52. By proper design it can be made as efficient as the closed core transformer, but it is more expensive to construct.

(3) The auto-transformer of Figure 54 is shown as having a step-up ratio of turns, but it is more often employed as a step-down transformer to produce in the secondary an E.M.F. of from 6 to 15 volts when the primary is connected to a 110-volt source of current supply. This type of transformer is frequently employed in radio receiving apparatus, but when used in this way it is not provided with an iron core.

(4) The radio frequency transformer of Figure 55 is employed in the high frequency circuits of the spark discharge type of radio telegraph transmitters to transfer extremely high frequency alternating currents from the generating circuit to the aerial wires where the energy is radiated in the form of electromagnetic waves. It is also employed in the receiving apparatus of wireless telegraphy but for radio-frequency work it is not provided with an iron core.

(5) The transformers of Figures 52 and 53 for purposes of wireless telegraphy are designed so that the primary current remains practically constant when the secondary is placed on short circuit. This is a natural inherent characteristic of the open core transformer, but to obtain the same effect with the closed core transformer of Figure 52, a magnetic leakage gap must be provided to prevent the reaction of the secondary circuit upon the primary circuit.

(6) The radio frequency transformer of Figure 55, if used in the transmitting circuits of a radio telegraph set, must have its primary and secondary turns well insulated by means of porcelain or any of the well known insulating materials. Owing to what is known as the "skin effect" of high frequency currents, a hollow conductor will possess the same current carrying capacity as a solid conductor. These coils, therefore, if not made of copper strip, are generally constructed of copper tubing. Owing to the phenomena of electrical resonance (to be explained further on) a step-up ratio of turns in this type does not necessarily indicate a step-up voltage.

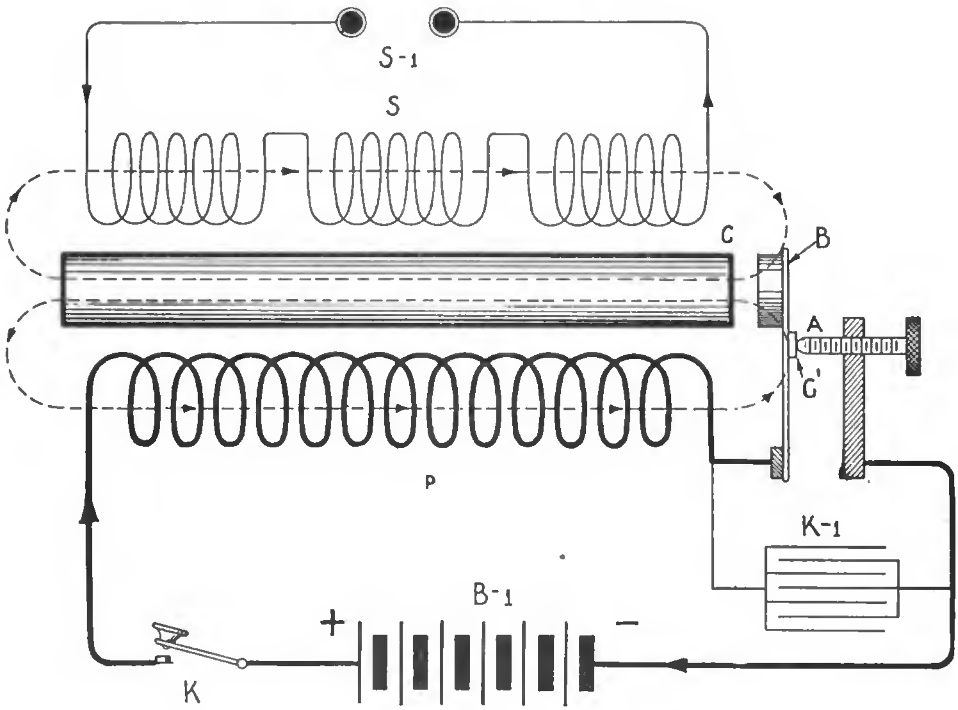


Figure 56

OBJECT OF THE DIAGRAM

(1) To show how a low voltage direct current may be transformed into a high voltage alternating current.
(2).To indicate the fundamental construction of the induction coil.

PRINCIPLE

If a number of turns of wire are wound about an iron core and connected in series with a battery, and further, a second coil of a considerable number of turns wound about the first coil, then if the circuit of the first coil is broken an E.M.F. will be induced in the second coil.

DESCRIPTION OF THE APPARATUS

The induction coil of Figure 56 consists of the iron core, C, the primary winding, P, the secondary winding, S, and the spark gap, S-1. The battery circuit is opened and closed by the key, K, and is automatically interrupted by a magnetic interrupter or vibrator mounted on the end of the shaft. This consists of the soft iron button, B, mounted on a phosphor bronze strip to which is attached also a platinum point, C-1. The stationary contact, A, also is fitted with a platinum point. The interrupter is bridged by a condenser of high capacity, K-1.

OPERATION

If the key, K, is closed and the stationary platinum point is screwed up until it makes contact with C-1, the circuit of the primary winding, P, is closed and the iron core, C, becomes magnetized. This attracts the soft iron button, B, which opens the circuit at C-1 whereupon the magnetic lines of force, generated by the primary winding, collapse. The vibrator spring is then released and C-1 again makes contact with the stationary contact, A. This process is repeated from 50 to 100 times per second, depending upon the over-all design of the apparatus.

If winding S consists of a great number of turns of very fine wire the E.M.F. generated in the secondary winding will be sufficient to break down the gap at S-1, even if the sparking points are separated several inches.

SPECIAL REMARKS

(1) Although the induction coil can be employed to generate high voltages it possesses a distinct disadvantage compared to the alternating current transformer. The amount of power that can be handled efficiently by the magnetic vibrator is limited to about 1 K.W. Furthermore, the wave form of the secondary current is such that it practically amounts to a uni-directional current, i.e., the current pulses induced in the secondary have much greater amplitude in one direction than in the opposite direction.

Figure 57.—Showing the general appearance of the Cutler Hammer type of field rheostat for regulating the field current of a dynamo or motor. The rheostat is made up of composition resistance wire baked in a heat-proof insulating cement and mounted in a metal case. The wire is tapped at intervals and leads are attached to brass studs over which a sliding contact moves

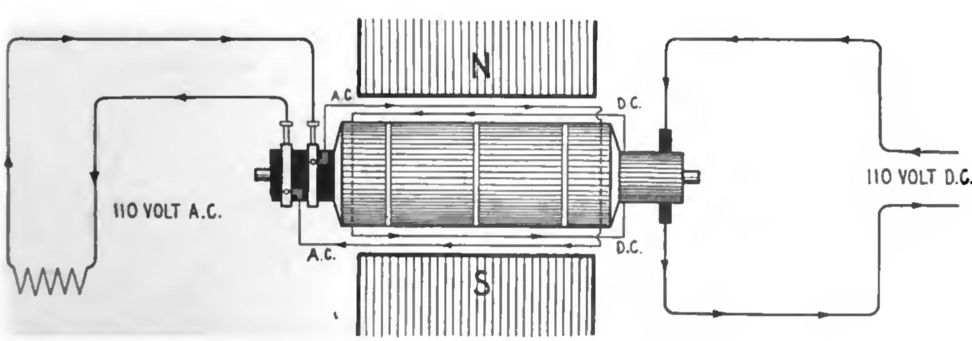


Figure 58.—Showing the complete circuits of the dynamotor for the conversion of direct current into alternating current. In this machine a single armature possesses two distinct windings one of which generates alternating current at the frequency for which the machine is designed, and the other acts as an ordinary motor armature winding. If direct current at 110 volts is fed to the motor winding, by proper design the generator winding can be made to generate an E. M. F. of any voltage required. These machines are not widely used in commercial radio telegraph installations and are desirable only on account of their simplicity, the principal disadvantage being that the frequency and voltage cannot be controlled as closely as with the motor-generator

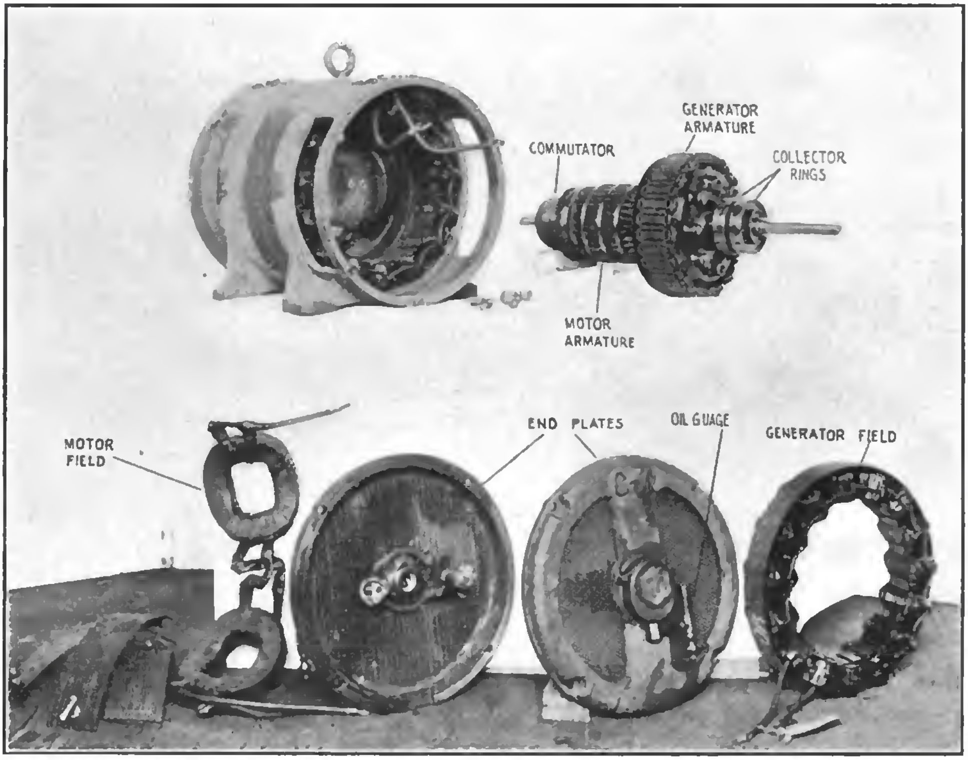


Figure 59.—Showing the general details of the Crocker Wheeler 2 K. W. 500 cycle motor-generator of the type used in modern Marconi radio sets. A two-pole direct current motor, taking current at 110 volts' pressure, drives a 2 K.W. 500 cycle alternating current generator. The armature revolves at 2,000 R.P.M. and the alternator delivers current on open circuit at an E.M.F. of 880 volts. When the armature circuit is closed the voltage drops to approximately 120 volts. The motor is designed to operate at a constant speed on D.C. voltages varying from 95 to 115 volts

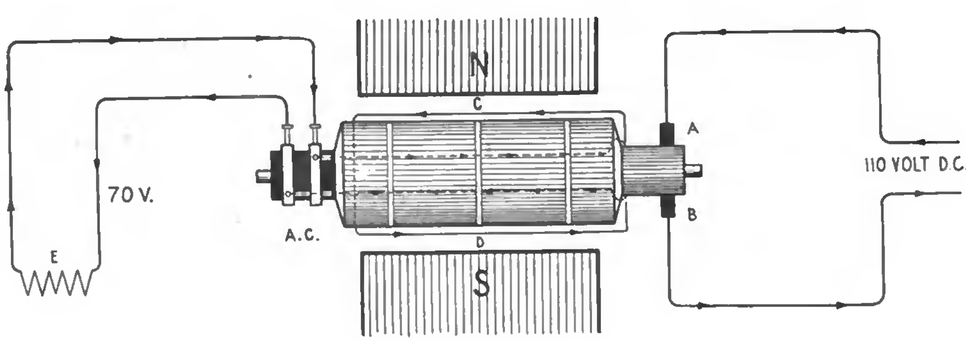


Figure 60.—Showing the general circuits of a rotary converter in which a single winding sets the armature into rotation and also generates alternating current which is collected by the collector rings on the left hand end of the shaft. If 110 volts D. C. are supplied to the motor brushes approximately 70 volts alternating current can be taken off the collector rings. If a higher voltage is desired, a small step-up transformer must be inserted at the point, E

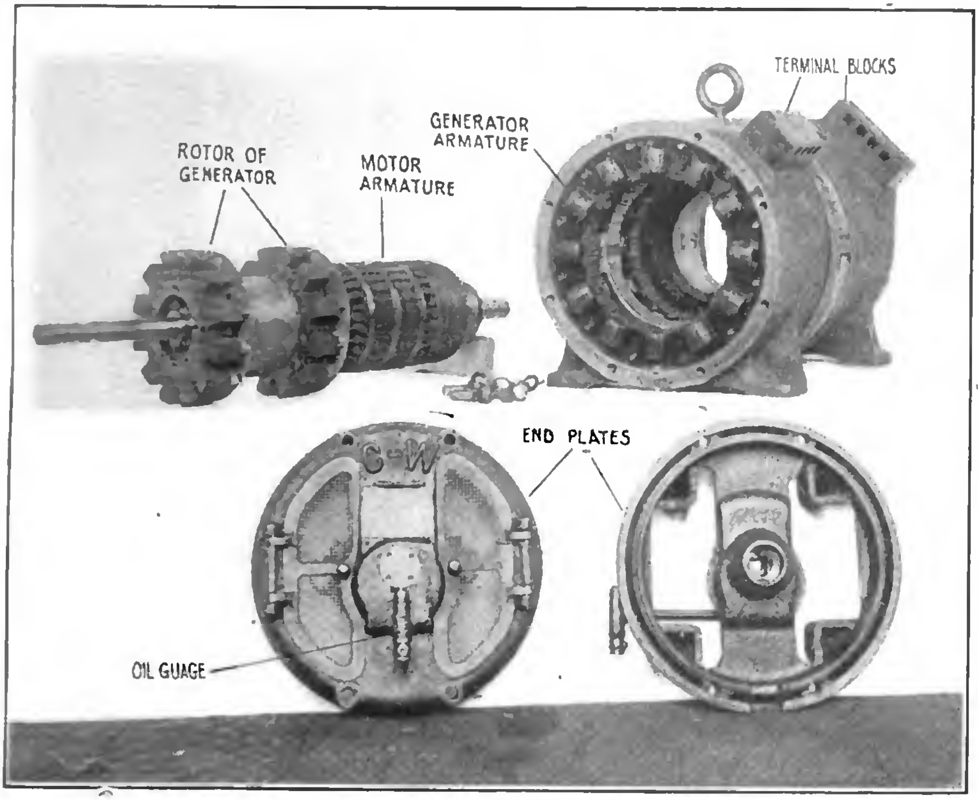
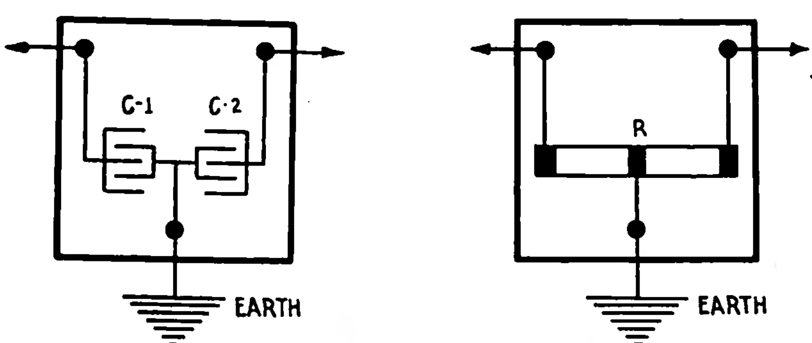


Figure 61.—Showing the general details and construction of a Crocker Wheeler ½ K. W. 500 cycle motor-generator as supplied with modern Marconi radio sets. Both the field poles and armature of the generator are stationary, the rotor being constructed of a toothed mass of iron which alternately opens and closes the magnetic circuit between the field poles and the armature coils. This machine has the same general operating characteristics as the 2 K.W. 500 cycle machine



Figures 62 and 63.—These drawings show protective condensers and a protective resistance rod, either of which may be attached to the circuits of the motor-generator to prevent burning out of the windings by electrostatic induction from the transmitting apparatus. Powerful magnetic and static fields are set up in the immediate vicinity of a radio transmitter aerial during the process of radiation, which may induce rather high voltages in the power circuits. With either of these devices the differences of potential between the windings and the frame are neutralized and the induced current is diverted to earth. The condensers generally have capacity of one microfarad each. The rod has resistance of 1,000 ohms

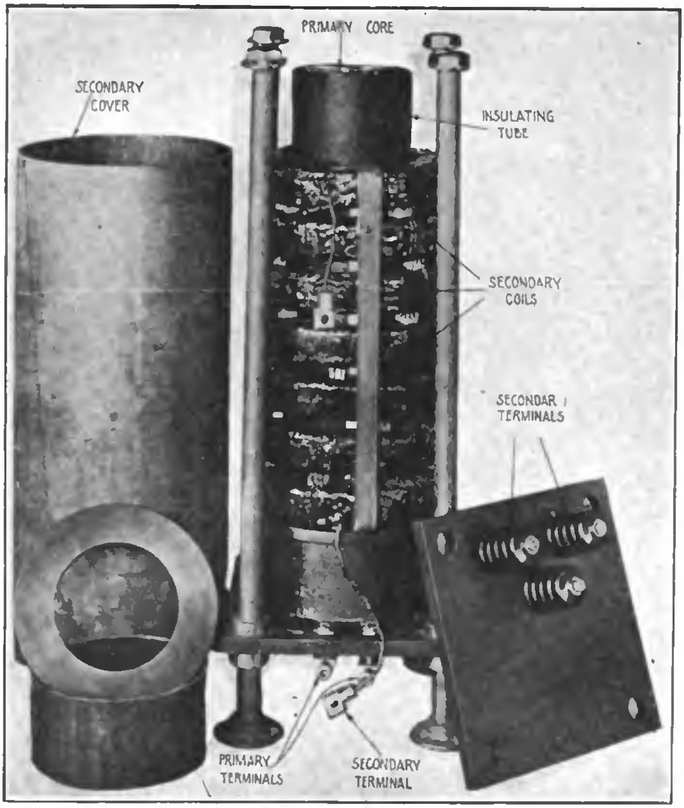


Figure 64.—Showing the general construction of the 2 K. W. 500 cycle open core transformer as developed by the American Morconi Company. The primary winding consists of a single layer of wire wound over a soft iron core made of iran strips. The secondary winding is composed of a number of sections of comparatively fine wire which are connected in series and slipped over an insulating tube placed about the primary winding. The secondary terminals are connected to a lid on the top of the transformer and are specially insulated therefrom. The primary terminals are attached to the bindino posts at the base. Dry insulation is emploved throughout.

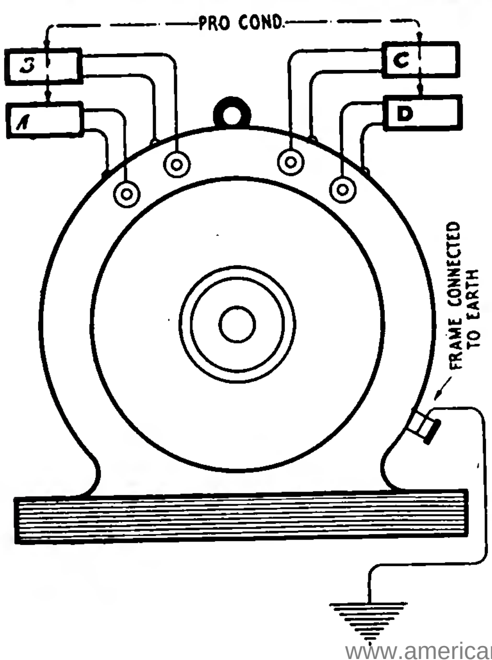


Figure 65.—Showing how protective condensers are connected to the frame of modern motor-generator sets. One terminal of condensers, A, B, C, and D is attached to the binding posts of the motor-generator, and the remoining terminals to the frome. The frame in turn is connected directly to earth. These protective condensers are shunted across the field winding and across the A. C. and D. C. armatures of a motor-generator

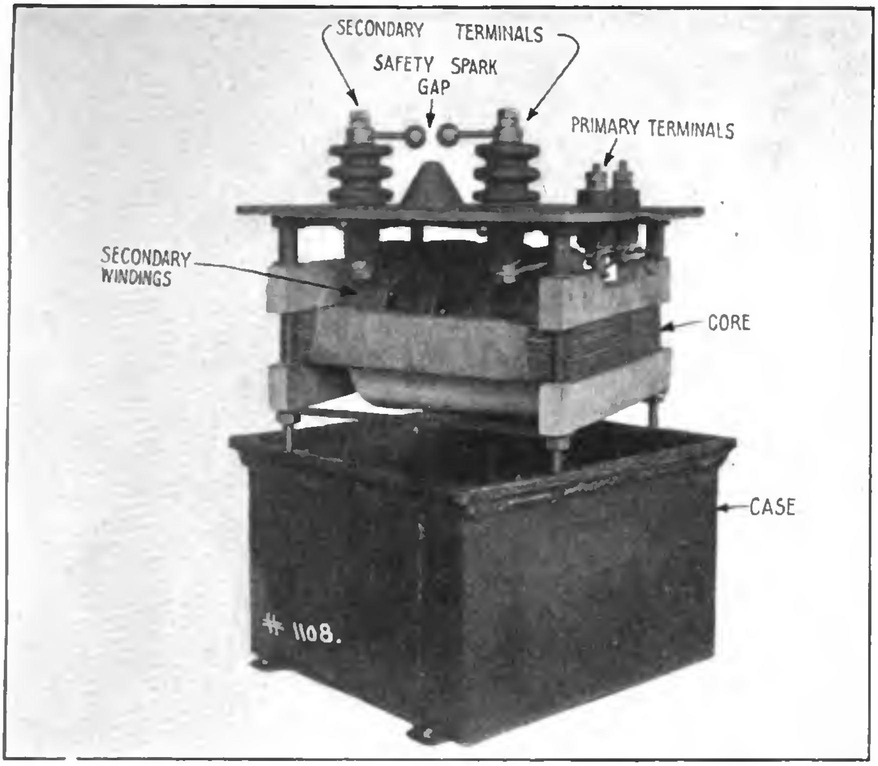


Figure 66.—Showing the construction of the Marconi 2 K.W. 500 cycle closed core transformer. The primary and secondary windings are wound on a special leg inside a rectangular iron frame. The transformer takes current at a pressure of 120 volts at the primary and delivers current at pressure of 12,500 volts at the secondary. The core is mounted on wooden blocks and the entire core and coils are immersed in a semi-liquid grease in a metal container. A safety gap is provided to prevent break-down of the secondard windings under special strain. Both this transformer and the one shown in Figure 64 are specially designed for Marconi quenched spark transmitters

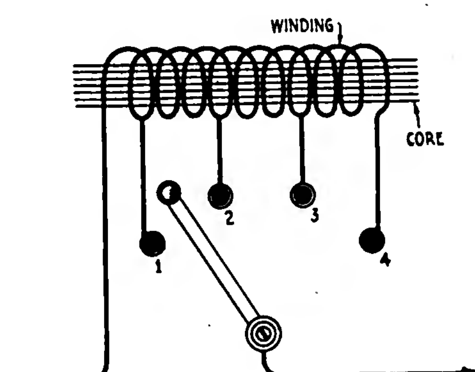
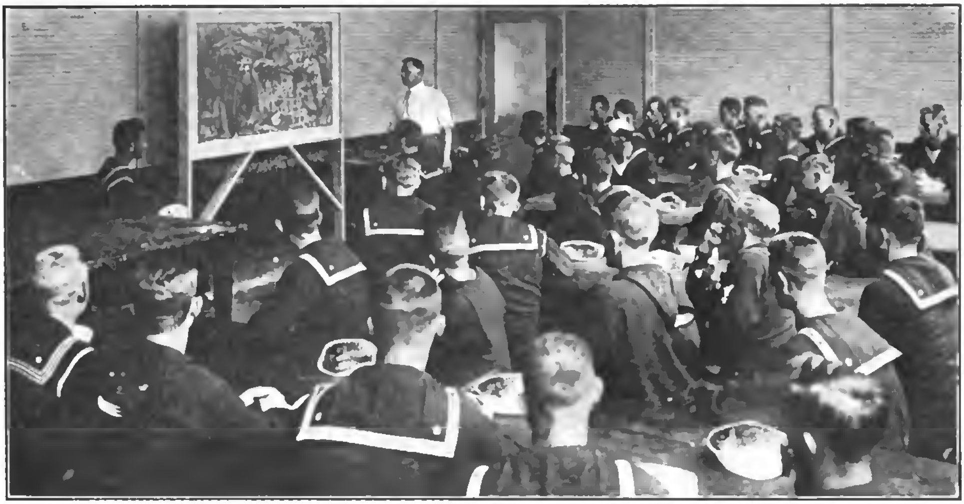


Figure 67.—Indicating the general circuits of a primary reactance coil which is connected in series with the primary windings of a transformer. This coil may be used to regulate the flow of alternating current or to place the primary and secondary circuits of a high voltage transformer in electrical resonance. The reactance of the coil can be varied in two ways—either by drawing in and out the iron core, or by placing the contact blade of the switch on the successive taps 1, 2, 3 and 4, as shown

(To be continued)



Dunwoody apprentices undergoing an oral examination

Teaching Wireless to Bluejackets in the Northwest

The Expansion of Radio Training at Dunwoody Naval Station in Minnesota

By WILLARD CONNELY, U. S. N. R. F.

"IMMEDIATE necessity for more electricians-radio," read a message recently sent by the United States Bureau of Navigation to Ensign Colby Dodge, U. S. N., commanding officer of the Dunwoody Naval Training School in Minneapolis.

Coincident with this message was issued an illuminating announcement by commander E. L. Bennett, assistant chief of the bureau. It was to the effect that the Navy Department contemplated assuming control of all the ships of the American Merchant Marine, and operating them with naval officers and enlisted men.

The intelligence of the wireless operators must be second to none. Among bluejackets high school graduates are in the minority in the ranks of the enlisted men, and those with any college training naturally are still fewer. These two classes of men, with former telegraphers, make the most progressive students of wireless. Of course cases are found where men with meagre schooling but natural aptitude for the art become proficient. However, Uncle Sam's wireless recruits are chosen from the enlisted men with a care which is probably not exceeded in any other branch of the service. When the fact is taken into consideration that some of the first line battleships in our constantly augmented Navy each require no less than thirty radio men, the extent of the task in training them can be realized, particularly as the extra burden of providing operators for the merchant ships now has to be taken into account.

So the Dunwoody Station, as the only naval school in the Northwest teaching wireless, found it necessary to increase without delay its quota of radio students. Captain William A. Moffett, U. S. N., commandant of the midwestern naval district with headquarters at Great Lakes, Ill., and Ensign Dodge hastened this expansion.

The sailors came to Dunwoody, 450 strong, early last August, just after the acceptance of the offer of the Dunwoody Institute, free, as Government quarters for the bluejackets' instruction. Nine groups of fifty men each were to learn nine different handicrafts in a four months' course of study and application. There were classes in gas-engineering, coppersmithing, blacksmithing, general electricity, cooking, baking, carpentry and machine-shop work in addition to those in wireless.

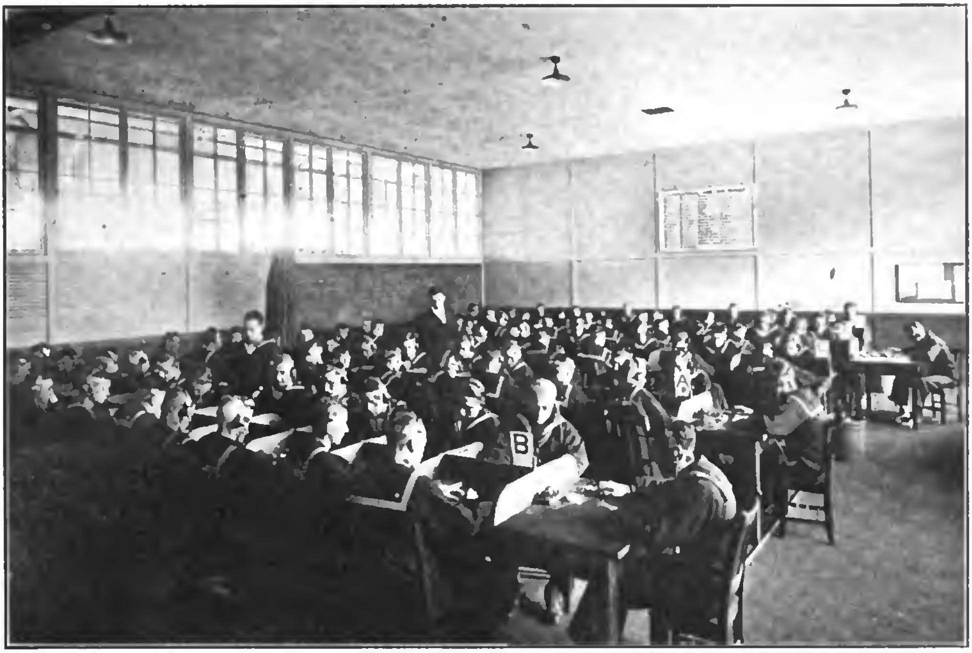
The fifty radio students then at Dunwoody Station had come from the Mare Island Navy Yard in California, where they had already undergone considerable experience in wireless. With the advantage of the additional instruction in Minne-

Wireless students at the general mess. On the left is shown Miss Anna Stanley, chief commissary steward

apolis these men became able to receive from fifteen to twenty-five words a minute, international code. Two of the men, Ross and Strachan, were copying more than thirty words. Accordingly the Bureau directed that the Mare Island contingent be transferred to the Government Radio School at Harvard University in order to receive final instruction before going to sea. Permission was granted to retain Ross and Strachan at Dunwoody as assistant instructors.

Then came from Captain Moffett's colony at Great Lakes a class of fifty, most of them new in radio, to replace the Mare Island students. These were followed in a few days by fifty more picked men, and before another week had elapsed a detachment of one hundred, as carefully chosen, arrived at Dunwoody.

Dunwoody has for the head of its radio department W. R. Davis, formerly chief electrician-radio on the U.S.S. Birmingham. When the Bureau of Navigation decreed that the wireless detachment be made the largest and most consequential at the Dunwoody Station, five more assistant instructors from the Harvard Station were detailed to aid Mr. Davis. These instructors, P. W. Ablondi,



Members of the radio class sending and receiving. Standing in the center is Instructor W. R. Davis, formerly chief electrician-radio on the U. S. S. Birmingham

B. L. Barrett, F. C. Danforth, J. Lovejoy and C. R. Woodall, were assigned to teach code and related work with Ross and Strachan. All are enlisted bluejackets, with advanced ratings.

Mr. Davis has divided the apprentices into four sections. Three of his seven assistants are detailed to the operating room and the other four are in charge of the two recitation and lecture halls.

The wireless men have lodgings at a hotel near the Institute. Reveille is at half past five o'clock in the morning. At six o'clock the assistant instructors, acting in the coordinate capacity of section leaders, assemble the men for roll-call, then march to the training school. Breakfast is served an hour later, and the daily work begins at eight o'clock. For an hour and a half the first two sections occupy the operating room for code work. This period ended, each section proceeds to a recitation hall for related studies and lectures. Sections three and four, of course, reverse the program, while the three hours' work in the afternoon are divided in the same manner. At twenty minutes to four o'clock in the afternoon the men are at liberty. It has been observed, nevertheless, that the most promising students often use the latter end of the day (until the six o'clock evening mess) to write in their log books or daily records. Two hours of outside work and study are required daily.

As the course is now arranged, a sixteen weeks' schedule has been mapped out. During all the period except the final week, operating practice and the study of radio laws take up considerable of the time. But the related work is also of prime value. For example, in the first month the men attend recitations and lectures and work in the laboratory and machine shop, receiving instruction concerning magnetism and electricity, storage batteries and alternating and direct currents. During the second thirty days Mr. Davis has scheduled instruction concerning internal combustion engines, transformers and induction coils, radio power circuits, condensers and oscillating currents, theory of radio telegraph, antennae and ground.

He proceeds during the third month with instruction in oscillating circuits, spark discharges, transmitting sets, spark systems, arc systems, wave-meters and measurements. At the end of this time the students go into the more advanced investigation of receiving circuits, receiving sets, vacuum valve hook-ups and operation, concluding with main station operation and care. The training ends in the final week with a comprehensive review and examination.

At the end of each week students are examined in sending and receiving, and are also given ten questions to answer concerning subjects taken up during that week. All students are marked weekly on four general counts: theory, practice, log book and conduct. A mark of 4. represents a perfect performance, with marks of fair and probation grading down to 2.39; the latter figure indicates inaptitude. A man displaying general deficiency is returned to the station or navy yard whence he came. From there he is usually dispatched to sea as an ordinary sailor. Such cases of failure are rare.

Promptness in keeping log books up to date is insisted upon. The book must contain a diary of deductions and compilations and sketches of instruments and materials used. Instructor Davis gives out each week a list of twenty questions to be answered in the log books, in addition to the transcription of individual notes mentioned. Questions answered in log books at the end of the fourth week of study in the Dunwoody radio classes follow:

1. How many ampere hours will be recorded by a meter through which 160 amperes have passed for three quarters of an hour?

2. Explain the difference between current strength and the quantity.

3. Which effects of the current are directly proportional to it?

4. What is the function of an insulator?

5. How does low conductivity affect insulating qualities?

6. What is the circular mil area of a wire three-sixteenth in diameter?

7. What is the square mil area of a No. 12 B & S copper wire?

8. The coils of a rheostat made of No. 8 iron wire have a resistance of ten ohms. What length of wire was required to construct this rheostat?

9. Draw a diagram of ten cells in series; also in parallel and series parallel.

10. State Ohm's law in full. How would you find resistance if E and I are known?

11. How do you find the joint resistance of unequal resistances in parallel?

12. Show a sketch of a wire carrying current marking the direction of the current, and the direction of the magnetic lines around the wire.

13. Draw a diagram showing an ammeter and voltmeter connected in circuit.

14. Explain exactly the difference between force and work.

15. What is the difference between a kilowatt and a kilowatt hour?

16. How many watts are expended in an arc lamp having a hot resistance of 4.5 ohms and requiring fifty volts?

17. How many kilowatts would a ten horse-power motor require?

18. A motor armature has a resistance of .001 ohm. How much current would flow through this armature if connected to a 220 volt supply and not allowed to rotate?

19. What would a voltmeter indicate if connected across a resistance of twenty-five ohms, and an ammeter in the circuit indicated ten amperes?

A special short course in wireless telegraphy will be offered men accepted for service in the Dunwoody Unit of the National Aerial Coast Patrol. Instruction in seaplane and torpedoplane flying is to be given on Lake Minnetonka, a few miles southwest of Minneapolis. Lieutenant-Commander John Towers of the Bureau of Operations, and Ensign Dodge of Dunwoody are now collaborating on details for this instruction. The radio course is being mapped out by Acting Director H. W. Kavel, who has general charge of the Dunwoody routine, and by Instructor Davis.

One result of the expansion of naval radio training at Dunwoody has been to increase the interest in wireless in the Northwest. Another has been to demonstrate the need for wireless operators in the Navy.

A Digest of Electrical Progress

The Relation of the Engineer to the Problems of the War and the Necessity for United Effort to End It—Accomplishments in Wire Telephony—The Use of Phantom Circuits for Increasing the Capacity of a Given Number of Lines—The Story of the Torpedo

THE ENGINEER AND THE WAR

IN a stirring inaugural address delivered before the American Institute of Electrical Engineers, E. W. Rice, Jr., President-elect, discussed the relation of the engineer to the problems of the present war He impressed upon his auditors the fact that modern warfare is wholly a problem of mechanics and engineering, and that the present conflict will only be brought to a successful termination by conducting operations along scientific lines.

Because its activities embrace all other fields of scientific progress, the speaker declared, the profession of electrical engineering is foremost among all other engineering professions. Hence, those engaged in electrical engineering were, in the present national crisis, called upon to offer a supreme sacrifice and nothing but organized and disciplined work would prove successful. Concerning this point he said:

> "No nation of loafers ever won the war. Other things being at all equal, that nation or people who are willing to work the hardest will surely win the victory. I wish to point out that the enemy we are fighting is recognized as the most industrious organization in the world. Our enemy has prepared for war for fifty years, and has been working with ever-increasing energy ever since the war was started three years ago. We made no adequate preparation during all this time, and therefore started with a fearful handicap of lost time and lost opportunities. We must not delude ourselves that our enemy is exhausted, but remember that he has the advantage of a full 'flying start.'
>
> "We must accelerate at an incredible rate if we are to get our war motor going fast enough, soon enough to catch up.
>
> "Our enemy boasts that we have started too late. We must, by the hardest work, directed with scientific skill and accuracy, organize and effectively utilize all our power of work to make his prophecy an idle boast."

It was remarked that we were called upon, as never before, to put aside personal preferences. No matter how repugnant war might be to our habits of thought, we must adopt those methods which the enemy has found to be most essential. Constructive criticism administered sparingly during this period would be helpful and would do far more than mere fault finding.

The popular mind, Mr. Rice pointed out, is apt to believe that this war will be settled by some wonderful and perchance miraculous invention, but engineers engaged in practical work realize how impractical and hopeless such a possibility is. No superman or hero would end this conflict. The united effort of thousands of men skilled in various professional lines, each contributing his bit, only would avail. Team play in our civil army at home was as essential as in our fighting army abroad.

Continuing along these lines, the speaker said:

> "I venture to suggest that we cannot all occupy desks at Washington, and it is well for us and for the country that we cannot. We can, however, put ourselves and our business in such condition as to meet whatever demand is made upon us. Only relatively few can be useful in the direct service of the Army and Navy, but there is plenty of honorable work and useful work for us to do. The most effective work for most of us will be in the shops and offices at home, and everyone who does his work loyally and well is as much a factor in our organized war as the man at the front."

The problem of this war demanding an immediate solution, he asserted, is that of shipping, but it would be successfully solved if we were content to employ the simple common-sense methods used by engineers and successful business men in the ordinary course of business. It was merely a race between ship building and ship destruction. We must also adopt the very latest methods of loading and unloading vessels in order that there might be the least delay in port. Above all, we should build a vessel that would prove most adequate in defense against attacks of the submarine, no matter what the cost of the vessel might be or how impractical it might prove after the war. He pointed out that it was also well to take into consideration whether it was worth while to continue building large dreadnoughts, battle cruisers and the like, which cannot possibly be finished for years to come. Unless our ship-building facilities were limited, our efforts should be concentrated and spent in the construction of large, high-speed cargo ships which could be built in one-half the time. This would be a great step towards solving the problem.

Proper development of the submarine should also receive its full share of attention, for we might yet have to rely upon undersea craft to convoy our vessels through the war zone.

In this crisis the selfish theories of the individual must give place to compromise and all work should be actuated by a spirit of conciliation.

THE ADVANCE OF WIRE TELEPHONY IN THE UNITED STATES

THE average engineer does not fully realize the problems which telephone specialists have encountered in the establishment of transcontinental or local telephone service. The construction of such lines is not merely a matter of stringing wires from pole to pole; technical problems of the highest order are involved, says a recent issue of the *Sibley Journal.*

In the transmission of the human voice over a wire line a complex alternating current is employed at frequencies varying from 200 to 2,000 periods per second. This energy must not only be transmitted without distortion, but there must be sufficient energy delivered at the receiving station to operate the receiver. In addition, the telephone line must be fully protected from extraneous inductive disturbances such as may be set up by nearby power or lighting circuits.

Take, for instance, the wire telephone line from New York to San Francisco. This is 3,400 miles in length and contains about 3,000,000 pounds of copper, and while difficulties were encountered in establishing the poles and wires alone, the greater problem was one of delivering sufficient energy at the receiving station to give audible response in the receiver. It is an established engineering fact that

1/1000 part of the energy put in at the transmitter must be delivered to the receiver in order to obtain successful operation, but a transcontinental line such as that mentioned would actually only deliver about 1/50,000,000,000 of the energy put in at the transmitting end unless special appliance were provided.

The first step employed to overcome the line losses of lengthy circuits was the insertion of loading coils placed every eight miles through the entire circuit. By the use of these coils the energy at the receiver was increased from 1/50,000,000,000 to about 1/1,000,000 of the energy put in at the transmitter. In order that the loss from the loading coils themselves might not attain in the aggregate an extremely large value, the design had to be very carefully calculated.

Considerable amplification of the strength of telephonic signals has been obtained by the use of electronic relays which control the current of a comparatively high voltage battery and thus amplify the signals. Telephony by means of cables over great distances has always presented a difficult problem. Great losses are occasioned by the fact that the dielectric, in order to separate the conductors underground, is other than air.

The Bell telephone system has established an underground cable between Washington and Boston, practically 500 miles in length, which required very careful calculation of the loading coils to reduce the line losses to a minimum. Without the loading coils only 1/30,000,000,000,000 of the energy sent out would be delivered at the receiver, but by extremely careful designs of the loading inductances this loss was reduced to 1/300 of the transmitted energy. A number of step-up amplifiers of the electronic type, added at proper points along the line, delivered one-tenth of the energy at the receiver, which resulted in a telephonic service of a very high order.

An interesting aspect of the transmission of telephone currents over long distances was the fact that in reality electric wave propagation is dealt with and that the length of such waves for a frequency of 800 per second is about thirteen miles. In considering this fact more in detail, it becomes evident that the receiver produces practically no reactive effect upon the transmitter.

Another ingenious adaptation of telephone lines has been the use of phantom circuits for increasing the capacity of a given number of lines. Two wires of one metallic circuit and two wires of another metallic circuit are used in pairs as one side of a given system and by gaining perfect balance, a third circuit is provided for commercial use. Each wire of a given metallic circuit also has been employed, by proper connection to earth, as one side of a telegraphic system, telephone conversation being carried on at the same time.

Power and lighting systems which may happen to be in inductive relation to telephone circuits are among the greatest sources of inductive noises. Usually, in the case of an alternating current circuit, it is found that it is not the fundamental frequency which interferes, but one of the upper harmonics.

It has been proposed in Europe to overcome the limitations of long distance wire telephony by the use of large powers at the transmitter, but experiments made by American engineers have determined that no advantage would be thus gained. As a matter of fact, a distinct disadvantage would result, and it is agreed that the present type of transmitter and receiver with properly associated apparatus fulfills all requirements.

THE TORPEDO'S STORY SELF TOLD

IT is seldom that we have a heart to heart talk with a modern torpedo. The average layman's knowledge of this destructive instrument of warfare is confined to the fact that it is self-propelled, can travel through the water at a fair rate of speed and work destruction to a million dollar cargo in a fraction of a minute.

The phantom torpedoes of conversation that can do better than sixty miles an hour; that can travel more than fifty miles in a single trip; that can cross the ocean if necessary, and are controlled in their paths by electricity or magnetism—these are set at nought in a tale told by a torpedo to Gunner's Mate Freed in a recent issue of the *Popular Magazine.*

"I am twenty-one feet in length and twenty-one inches in diameter, and ordinarily I am assembled in three parts known as the tail and after-body, the flask and the head. My tail contains the machinery which turns the propellers that force me through the water; the flask carries my fuel in the form of compressed air that sends me on my mission of destruction. I cost nine thousand dollars, and can run for ten thousand yards, or more than five miles, before my energy is used up, traveling that distance at the rate of about fifty feet per second. I am a monster made of forged nickel steel, and weigh two thousand pounds and have turbine engines which are capable of making one thousand seven hundred and sixty revolutions per minute. In my head I carry a high explosive called guncotton, which explodes upon contact. In times of peace, when I am practiced with, the guncotton is taken out of my head, and water is substituted to compensate for its weight. When I have been fired in practice, and have made my run and expended all my energy, I have lost sufficient weight to float to the surface until I am picked up, recharged, and refired."

So much for the general construction. It seems, however, that the initial trial trip of the autobiographical torpedo did not prove successful, for it is remarked that a drain plug came out of the air flask, which caused the torpedo to fill with water, sinking it to the bottom. A diver was soon detailed to locate it.

After recovery, the torpedo was once more placed in its cradle, and having been fully charged with air, was without delay again fired at a target located at a distance of 10,000 yards. A perfect hit was scored. The history of the torpedo continues:

"As I passed from the tube my starting lever was automatically thrown to the rear, thereby lifting a valve off its seat, allowing my compressed air—which previously had been packed away in my air flask—to escape through my tail, and thereby causing my machinery to run at terrific speed. As previously arranged by the naval gunners, I descended to a depth of eighteen feet, and then straightened out on my course. My course was followed as straight as a die for the whole run of ten thousand yards, not deviating two feet on either side. My machinery worked like a clock, and I knew that my run was being anxiously followed by the gunners, who were looking through binoculars from the deck of the submarine.

"At the completion of my run, I came to the surface, whereupon I discovered that I had been fired at a target at an eight-thousand-yard range, and that I had passed directly under the center of the target, making a perfect run, which is known as a 'bull's-eye.' I had a very short time to remain in the trough of the sea to wallow around, for, within a very few minutes, one of the navy's fifty-foot speed boats had caught up to me, and soon had me in tow back to the submarine."

Keeping the Governmental Eye on Amateur Stations

By a United States Radio Investigator

I SAT by a window in the Navy Yard, looking out upon the hustle and bustle that has marked Naval activities in this country since April 9th, when the Ensign summoned me.

"It is reported," he said, "that an operative radio station is located somewhere upstate, working only between one and two in the morning. Hurry home, change into plain clothes and meet Jackson in front of the Hotel Astor. He will have on a checked cap and will be in an automobile showing license number 378-174."

This was the order that sent me on an assignment which I anticipated would bring to light something else than the operations of a careless amateur. I met Jackson and we started. A slow drizzling rain set in, then we had tire trouble; so, by the time we arrived at our destination, we were in no mood to be lenient with an amateur disregarding the law, which calls for the closing and sealing of all private radio stations not engaged in Naval communication.

After locating the house, which had a hundred-foot aerial on the roof, we settled down to work. And we found—not a German spy; only a typewriter and an aerial with the leads disconnected.

A lodger, the proprietor of a restaurant, had been typing menus enough to last during the time he planned to be absent on a vacation. This accounted for the "crackling" that was heard at night. It is likely that the case would not have been reported if the aerial and masts had been down.

On another occasion I was ordered to investigate a supposed wireless plant on the roof of a three-story brownstone house in New York, dwellers nearby having spoken of "a German spy talking to the Kaiser through the air."

I visited the house, questioned several tenants, and then went to the roof. There I found an American flag floating from the top of a mast that supported an aerial, the leads of which were disconnected.

A son of one of the tenants, I learned, had installed a wireless plant before the entry of the United States into the world war. When that event occurred, the apparatus was disconnected and stored away in a trunk. The mast was left standing, however, and the aerial was never lowered. That was what started the investigation.

It is cases like these that subject the United States Radio Investigators to considerable annoyance and loss of time. Heedless amateurs use their receiving apparatus, after the aerial has been lowered, by connecting the leads to telephone wires, or by leaving up their aerial after disconnecting and storing the apparatus. Some lower their aerials and leave the apparatus set up on the operating table.

The Navy has been delegated to see that the President's orders for the confiscation of private radio apparatus are executed. The orders provide for the confiscation of such apparatus not sealed and stored away.

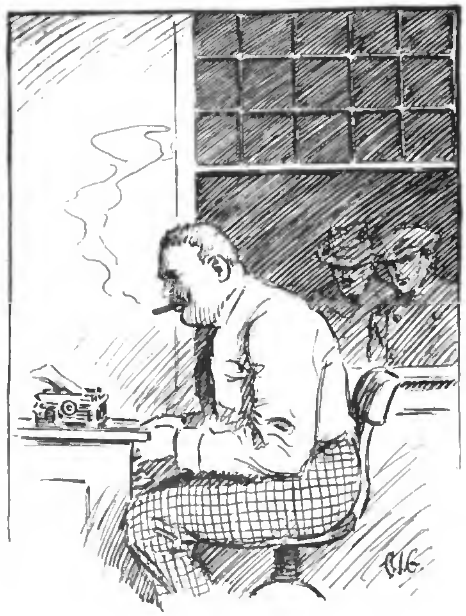
One costly set of apparatus was confiscated because the equipment was connected to a dummy antenna in a room. The owner, who had read suggestions for improving the set by using a dummy antenna inside the house, carried on experiments which he believed did not violate the law, since no energy was radiated outside.

Amateur radio stations must be dismantled. Antennae must be lowered and masts razed. All apparatus must be disconnected, sealed and stored away. Experiments involving inductance and capacity and such power and voltage as would justify terming the tests "radio telegraphic experiments" are forbidden. No aerial must be used; ground connections must not be made. In short, all the experiments usually performed by amateurs must cease.

The Government, however, does not intend to forbid doctors using induction coils for taking X-ray pictures, or physical laboratories from performing conventional induction coil and transformer experiments.

It has been pointed out that the utilization of valuable amateur equipment and the services of amateurs throughout the country are pertinent subjects for Government consideration. But the Navy has installed its own system of espionage for detecting possible operations of agents of the German Government in the United States; therefore it behooves the amateur not to retard the actual work of locating German wireless agents by causing complaints to be lodged regarding masts and aerials. Every amateur club should make sure that the President's orders are observed.

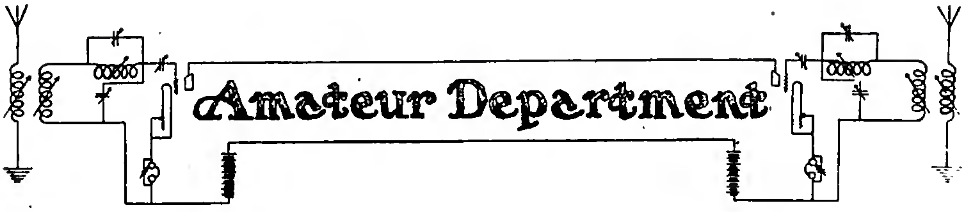
Amateurs would do well also to keep in mind the fact that now, when their stations are silenced, is an excellent time to learn the American Morse code, for good operators should know both codes. In order to secure a Commercial Extra First Grade License, for instance, one must know the American Morse. Landline telegraphy is a particularly promising field for women or for amateurs who cannot pass the physical examination necessary for enrollment in the Naval Reserve Force.



A lodger, the proprietor of a restaurant, had been typing menus

A CALL FOR TECHNICAL MEN TO SERVE AT HOME

The attention of wireless men is called to the need of men whose ages range from eighteen to forty in sundry branches of technical troops in the United States Army. Technical men who are exempt or who for any reason cannot volunteer, can yet efficiently co-operate by forming technical patriotic guilds in their several industries or home neighborhoods to look after the welfare of the men in the service and give them the opportunity of obtaining technical assistance, opinions and advice. Men skilled in any line of science, mechanical, electrical or chemical, or in building aeroplanes or ships, are wanted as technical guildsmen. Applications for literature should be made to Major J. E. Bloom, U. S. A., 266 Market Street, Newark, N. J.



A Night Signaling System

By F. E. AUSTIN

ALL methods of signaling may at present be divided into two classes, audible and visual, and the visual may also properly be separated into two classes, night and day signaling. Night signaling is performed by the operations of a single light or by the simultaneous operation of several lights. When a single light is employed, it is flashed on, and rendered invisible by operating a shutter; or if an incandescent electric lamp is employed, the circuit is opened and closed by means of a switch.

If several lamps are to be operated simultaneously, the operation can best be effected by means of switches or keys. A simple system designed for signaling a distance of three or four miles at night, using the normal unaided eye, or a distance of ten or more miles, using field glasses, will be outlined.

The apparatus consists of four white and four green incandescent lamps, arranged as shown in the accompanying drawing on a pine board about 16 feet in length and not more than 3 inches in width. The shaded circles denote the green lamps and the unshaded circles denote the clear bulbs or white lights. Tungsten filament lamps may be used, 40 watt lamps being satisfactory. The lamps may be designed for 110 volts, 220 volts or for any other pressure, depending upon the pressure of the supply mains. Ordinary 8 volt pocket lamps may be employed, and operated by primary cells if power circuits are not available.

The lamps marked 1, 3, 5 and 7 are the uncolored lamps and those marked 2, 4, 6 and 8 are the green colored lamps. These lamps are wired up as shown in the drawing to a series of small brass strips, numbered to correspond with the various lamp terminal connections. A perforated cardboard disc, D, arranged to turn about its center by a knob, H, allows certain of the brass strips to make contact with a brass strip, B, held securely in position back of the disc.

From the strip, B, one of the line wires connects with a key or switch, K. The right hand terminals of lamps marked 1 and 2 are connected with another key or some form of circuit interrupting device marked "flicker device" in the drawing.

Suppose the disc, D, is so turned that the letter, B, on it is in a vertical position, then strips 1, 4, 6 and 8 make contact, through the holes in the disc, with the brass back strip, B, and lights 1, 4, 6 and 8 will be lighted when key K is closed.

If all signals are read from the top downward, and if a white light denotes a dash, while a green light denotes a dot, it is evident that the letter B is signaled as dash, dot, dot, dot; or — . . .; or white, green, green green.

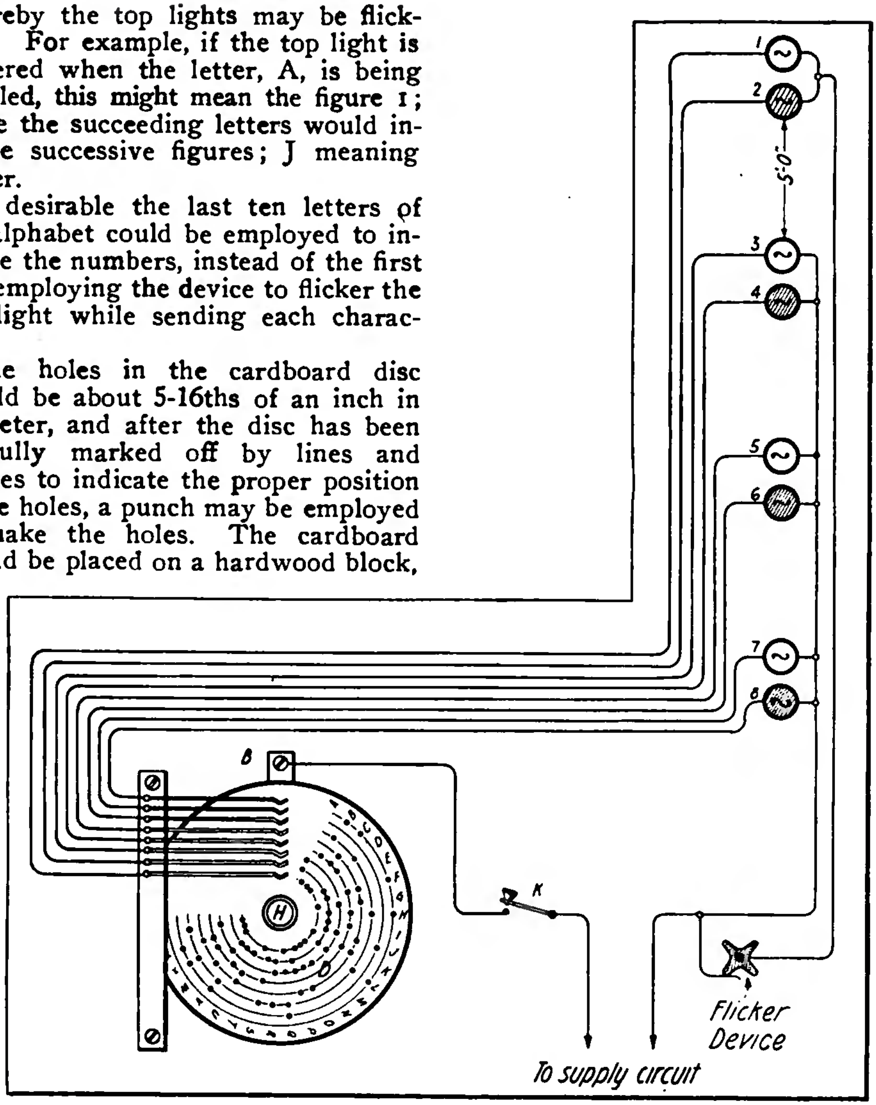
Suppose that the disc is so turned that the letter, H, is vertical or opposite the back brass strip, then the springs 2, 4, 6 and 8 make contact through the proper holes, and all four green lamps are lighted when the key, K, is closed; denoting four dots.

The cardboard disc should be about 8½ inches in diameter, and should be very carefully marked off into sectors, and these intersected by eight concentric circles. The innermost circle should be about 3¾ inches in diameter. There should be twenty-six radial lines dividing the circle into twenty-six equal sectors if the alphabet is to be employed.

These are really all the characters needed because of the arrangement whereby the top lights may be flickered. For example, if the top light is flickered when the letter, A, is being signaled, this might mean the figure 1; while the succeeding letters would indicate successive figures; J meaning cipher.

If desirable the last ten letters of the alphabet could be employed to indicate the numbers, instead of the first ten, employing the device to flicker the top light while sending each character.

The holes in the cardboard disc should be about 5-16ths of an inch in diameter, and after the disc has been carefully marked off by lines and crosses to indicate the proper position of the holes, a punch may be employed to make the holes. The cardboard should be placed on a hardwood block,



and the punch given a quick blow with a hammer in order to produce holes without rough edges. Square holes give better satisfaction than round ones, and if a square punch is not available, the round holes can be squared by use of a small sharp penknife.

The distance between each white and each green lamp should be five feet; the farther apart they are the greater the distance the signals are distinguishable. It should be noted that the top light, either a white or a green, is always employed in each signal; also that lamps 1 and 2 are never lighted at the same time; which may also be said of 3 and 4, 5 and 6, 7 and 8.

Each letter is instantly flashed at one operation of the key after the disc has been properly set, thereby considerably facilitating the reception of messages. The ordinary dot and dash code may be flashed by setting the disc for T and using the key as in ordinary telegraphy to flash the top light. Any desired code may be adopted and a disc properly stamped to send it. When one disc has been carefully made, it

(Concluded on page 176)

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

A Compact Receiving Tuner of Neat Appearance

Of the various types of receiving tuners I have witnessed I believe the one described in this article takes up the least space, for a given wave-length, of any of them. It not only has good working qualities, but it also possesses a very neat appearance. It is to be especially observed that the coupling between the primary and secondary winding is altered by turning the coils at right angles, but unlike the familiar variometer the coils do not telescope; still, the coupling will be found sufficient for the most rigid requirements. In fact, a tuner of this type has been found very efficient in connection with the vacuum valve detector.

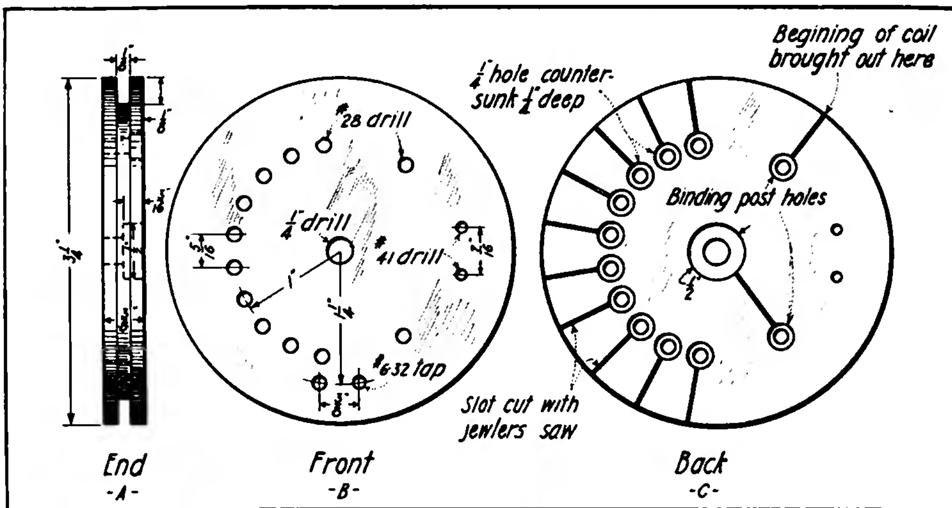


Figure 1, First Prize Article.

The primary and secondary discs shown in Figure 1 are identical in construction, with the exception of the two holes x and y in *B*. These are drilled in the primary disc only and are used for its support. They may be made of either black fibre, hard rubber, or micarta. Wood should be avoided if possible.

The primary is wound with 100 turns of No. 28 S. S. C. wire, with taps brought out every ten turns; the secondary is wound with 200 turns of No. 32 S. S. C. with taps brought out every twenty turns. When the desired number of turns, for a tap, is reached, the wire is looped, twisted, and pulled through the slots shown in *C* (Figure 1). The winding should not be placed until the final machining of the discs is completed.

The dimensions of the hinge for mounting the discs are shown in Figure 2. If this size can not be obtained, of course the holes for the hinge in Figure 1 will have to be changed accordingly. The bushings shown in Figure 2 are made slightly larger in diameter than 1/4 of an inch, and are forced in the holes. Two of each size of washer in Figure 2 must be made. For the switch blade

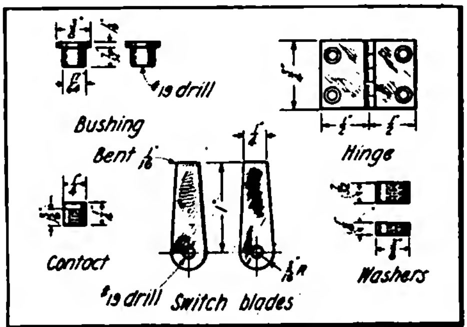


Figure 2, First Prize Article

No. 28 gauge sheet brass is very suitable. The contacts being of standard size, may be procured at any supply house. Fairly heavy escutcheon pins, with the heads cut off, should be placed at the first and last contact, to act as stop pins for the switch blades shown in Figure 4.

Figure 4 shows the method of assembling the switch, etc., and the discs mounted on the base. To bring leads out from the center of the switches, the wire may be soldered to the edge of the

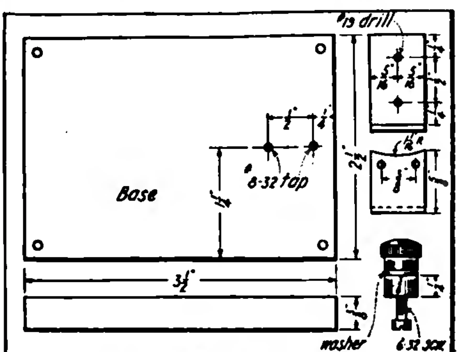


Figure 3, First Prize Article

washer under the head of the screw, then to the binding post.

The other connection comes from the beginning of the winding. All connections should be soldered.

Two pieces of book-binders cloth should be cut and glued to the inside of both discs. As this covers up the taps and screw heads, it will greatly improve the appearance of the instrument. Further improvement may be effected by stamping, by means of steel dies, the corresponding numbers opposite each contact, and filling in with white ink. As a last suggestion I may say that if the entire instrument is finished in nickel plate, the amateur will possess a piece of apparatus to be proud of.

NORMAN F. SCHMIDT, *Pennsylvania.*

SECOND PRIZE, FIVE DOLLARS

A Design for a Combination Vacuum Valve Receiving Set

I have designed a universal cabinet receiving set, the circuits of which take full advantage of the various receiving systems developed for amplification by means of the vacuum valve. This receiver can be used for short wave regenerative reception, or the bulb may be employed as a single set amplifier to a crystal de-

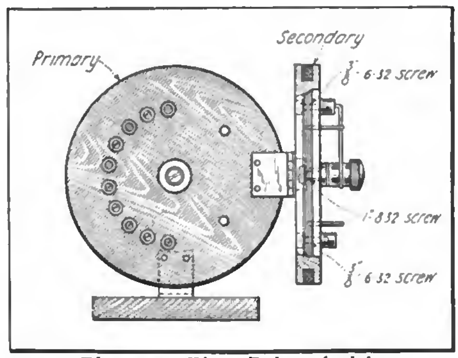


Figure 4, First Prize Article

tector. Furthermore, in order to make the change from one circuit to the other, it is only necessary to change the position of a few switches.

The general idea of assembly is shown in Figure 1, the two coils on either side of the panel being the loading coils for the secondary circuit. The position of the tubular vacuum valve bulb is clearly shown and the necessary switches for changing from one circuit to another.

The base of the instrument upon which the cabinet is placed measures 40 inches by 8 inches; the cabinet dimensions being 24 inches by 20 inches by 8 inches. Upon the projections of the base the secondary loading coils are placed in a vertical position and, if desired for purposes of appearance a top, 40 inches by 8 inches, may be placed over the cabinet.

It is to be especially noted that this cabinet does not contain any tuning apparatus other than the secondary loading coils, because the writer was well aware that the majority of amateurs prefer to employ their own make of tuner. I suggest that if the amateur proposes to incorporate an inductively coupled receiving tuner within the cabinet, that a multipoint variometer be employed, because it requires but little space. The regenerative features of the set may be placed on the top of the cabinet if desired.

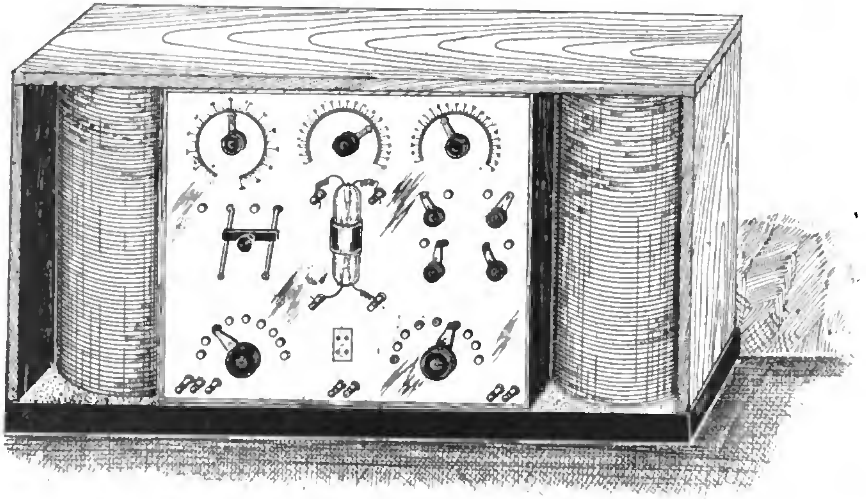


Figure 1, Second Prize Article

A complete diagram of connections is shown in Figure 2 the arrangement of circuits being in accordance with the best known practice. For instance, the majority of receiving sets now on sale have three binding posts leading to the valve elements; one leading to the grid through a small fixed condenser: one leading to the plate, and a third leading through the B battery to the filament circuit. These three binding posts are connected to posts 2, 3, and 1 respectively.

The operation of the apparatus shown in my design, is as follows:

When both the D. P. D. T. switch, D, (which is preferably of the sliding type) and the two point switch, H, are thrown to the left, the instrument is connected for regenerative working; but when both switches are thrown to the right, the instrument is connected to receive from the coupler which is connected to posts 4 and 5. If a triple pole double throw switch can be procured, the function of switches D and H may be combined. When receiving from the coupler, if switch A is thrown to the right, the instrument is connected to receive damped oscillations, but if the switch is thrown to the left, the instrument is connected to receive undamped waves. If it is desired to receive undamped waves, use is made of the loading coils, L-1 and L-2, both of which are 20 inches in length and 6 inches in diameter, wound with No. 32, S. S. C. wire, ten or more taps being taken from each.

If the instrument is to be employed as a one-step amplifier to increase the signals of another detector, such as a carborundum crystal, switch A and switch H are thrown to the right, and switch X is then closed which connects in the choking coil. When the instrument is used in conjunction with the regenerative set, the phones are connected to the regenerative terminals, but when the instrument is used otherwise, the phones are connected to posts 6 and 7.

Any three-element vacuum valve may be used. C-1 is the usual small blocking condenser. C-2 is a small variable condenser of .0025 M.F. which permits the use of short loading coils. The choke coil, or auto transformer, consists of four pounds of No. 32, S. S. C wire wound on an iron wire core 14 inches by 2 inches. The secondary of a 1-inch coil with an iron core will suffice. S is a double push switch of the miniature type which controls the A and B batteries in the cabinet.

A potentiometer and rheostat are used to vary the current. V is a coil of wire consisting of fifty-two turns of No. 32 S. S. C. wound in the same direction as the grid. It is connected in series with the A battery and may be short-circuited by switch V. This coil slipped over the bulb, sets up a magnetic field which makes the valve especially sensitive to short wave-lengths preventing in part the fading away of signals.

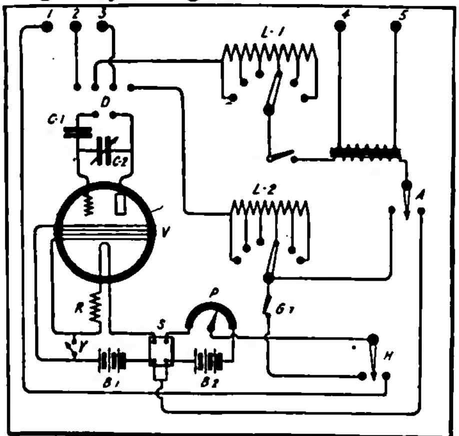


Figure 2, Second Prize Article

This instrument is not bulky and presents a very nice appearance, making a neat addition to any station. It will give excellent service irrespective of the circuit in use.

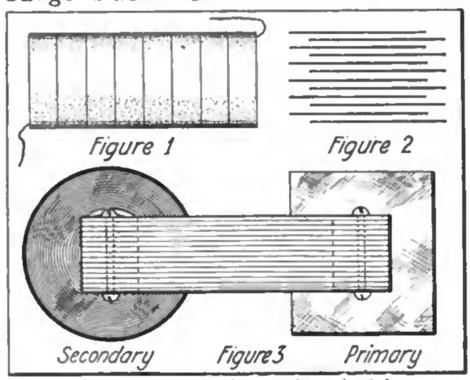
JOSEPH MORRIS, JR., *Louisiana.*

THIRD PRIZE, THREE DOLLARS

How to Make a 1/4 K. W. Step-Up Transformer

Many an experimenter has wanted a 1/4 K. W. transformer, but being unable to secure the secondary coils he is forced to give up the idea. I will therefore endeavor to show your readers how the parts of a well-known device can be used for this purpose to advantage.

First, secure two old style Heinz coil units such as used in earlier model Ford cars and carefully take them apart, taking care not to injure the secondaries, which should appear as shown in Figure 1. Next, get about 3 pounds of No. 28 Gauge black iron and cut about two-thirds of it into strips 11 inches by 7/8 of an inch, and the remaining third into strips 4½ inches by 7/8 of an inch. Next, shellac each strip and allow it to dry.



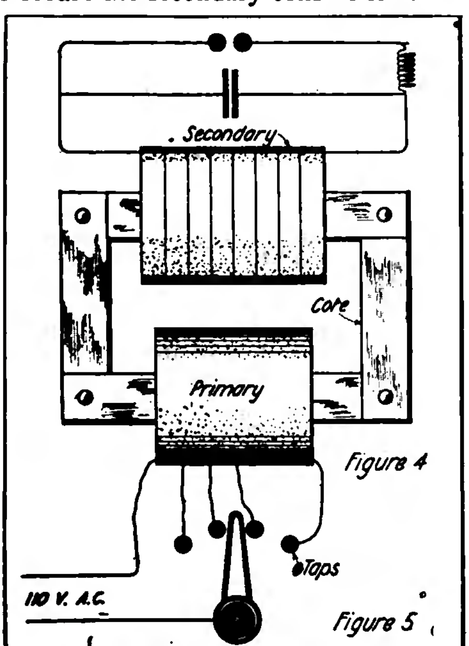
Drawings, Third Prize Article

Go to an electric store and purchase two pounds of No. 16 D. C. C. magnet wire. Assemble the primary core as in Figure 2, taking particular care to overlap the sheets. Then bind them tightly with tape or empire cloth if available. After this is completed, wind on the first layer of the primary coil and when it is completed, bind it with tape and start the second layer. When the third layer is on take a tap off of each layer. A coating of tape should be placed between each layer.

Next assemble the secondary core, following the method shown in Figure 2, but do not bind with tape. Slide on the secondaries and complete the core with smaller pieces of iron. Then assemble the transformer, as in Figures 3 and 4. This will make a very serviceable little transformer for all-around work.

Figure 5 shows the complete connections.

The transformer should now be connected to 110-volt circuit with a suitable condenser across secondary. If at first a fat spark is not produced reverse the connections between the secondary units.



Drawings, Third Prize Article

W. WAYNE ALTER, *Pennsylvania.*

The Monthly Service Bulletin
of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

Founded to promote the best interests of radio communication among wireless amateurs in America

J. ANDREW WHITE, Acting President GUGLIELMO MARCONI, President ALONZO FOGAL, JR., Secretary

Headquarters, 42 Broad St., New York

H. H. of Bottineau, North Dakota, tells us that during the time amateurs were allowed to work their apparatus, he had at his command stations within a radius of several thousand miles, the naval stations being heard with great clearness and "NAT 50 feet from the phones." FL was heard sending press to "somewhere" in the United States on about 6,000 meters. POZ was easy from four o'clock in the afternoon on into the evening.

Regarding transmission by spark coil, he remarks:

"I never attempted long distance transmitting as I only possessed a one-inch coil, but with this, sixty-two miles could easily be covered night or day, and forty-one miles using one old dry coil half spent.

"During the closing of our stations we will have to be content with repairing apparatus and studying up on matters which have been a little dim to us heretofore. And last, but not least, we should help our country in this time of need by offering our services to the Government as wireless operators whenever we may be required."

I have read with much interest, the June, July and August issues of THE WIRELESS AGE. No doubt, some of the amateurs would be glad to learn of a freak occurrence which I encountered last winter. The details of the incident follow:

Station 9 AFW of North Manchester, Ind., was operating a 1 Bull Dog coil. I had been acquainted by mail with the operator for a little over a year, but naturally, had never heard his signals.

One fine, cold, snappy night last December 9 AFW was calling an amateur a few miles away. The signals came in clear and steady, but not very loud. The wave seemed to be about 500 meters.

I immediately dropped him a card and asked if I might be mistaken in the call. I requested him to call me at eight o'clock a few mornings later.

At the time stated, I tuned to his wave, and in came 9 AFW nearly three times louder than before. He claimed to be using a one-inch Bull Dog coil on ten used dry cells—no helix, no condenser, but merely the gap hooked across the coil. I could hardly believe it, as I copied his signals through two commercial stations on 600 meters.

Later, I received a card from him stating his aerial was about 200 feet in length and 75 feet in height.

The receiving set used at my station was an audiotron set of my own construction. The distance between 9 AFW and 9 SL (myself) is a little over sixty miles.

(*Concluded on page* 174)

Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

Positively no Questions Answered by Mail.

F. G., Brooklyn, N. Y.:

You evidently have been misinformed concerning the adjustment of a transmitting set. If the open and closed oscillation circuits of a radio transmitter are independently adjusted to the wave-length of 600 meters, the radiated wave will be of this length only under the following conditions: If the closed oscillation circuit contains a spark gap which gives proper quenching, then the length of the radiated wave will be that of the adjustment of the antenna circuit. If, however, the spark gap does not quench properly, there will be an interchange of energy between the opened and closed oscillation circuits. This reaction will cause two frequencies of oscillation and the antenna will radiate two waves.

Coming back to the first part of your query with regard to the adjustment of a receiving set, it is quite possible to vary the wave-length of a secondary circuit by inductance alone as well as in one provided with a variable condenser. The necessary capacity in such circuits is found in the self-capacity of the coil and also the additional capacity which exists in the carborundum detector itself. You, of course, understand that the open and closed oscillation circuits of a radio receiving set must be tuned exactly to the same wave-length for the maximum response.

Regarding your last query: Nagaoka's formula for the calculation of inductance appears in the textbook, "Practical Wireless Telegraphy," copies of which can be purchased from the Wireless Press, Inc., 42 Broad Street, New York City.

* * *

H. E. H., Bottineau, North Dakota:

We cannot interpret the call letters you mention in your first query. The majority of them are foreign stations, the locations of which we do not know.

In regard to the calibration of a variable condenser: We are under the impression that you can have this done at the United States Bureau of Standards at a slight cost. We also believe that such concerns as the Manhattan Electrical Supply Company of New York City can arrange with some laboratory to carry out this calibration.

The resistance of a wire to radio frequencies can be determined by the following formula:

$$R = Rc\,r\sqrt{0.0058\ N}$$

Where N = the frequency of the current,
Rc = the direct current resistance of the wire,
r = the radius of the wire in centimeters.

Answer to fourth query: Yon can obtain an ammeter range, forty to 240 milliamperes, from the Roller Smith Company of New York City; any of the advertisers in this magazine selling electrical instruments will be able to supply you with such an instrument.

We have no information relative to the power of the Naval station to which you refer.

* * *

G. W. F., Seattle, Wash.:

If you had observed your Marconi 2 K.W. 500-cycle transmitting set more closely, you would have seen that the quenched gap is cooled by air-circulating blades which are attached to the disc of the rotary gap, an air duct leading from the rotary drum to the quenched gap. It is important that the quenched gap be properly cooled by external means, such as an air blast.

Answer to second query: Experiments indicate that the average commercial aerial possesses a minimum resistance when it is worked at a wave-length about twice its natural wave-length, but this is not often done in practice. In regard to the problem which you have presented: While it would undoubtedly require more inductance to raise the wave-length of the 130-meter antenna to 200 meters than the one having a natural wave-length of 190 meters, it is probable that you will obtain a greater current with the larger antenna; on the other hand, the shorter aerial will radiate the sharpest wave because of the amount of inductance which must be inserted at the base.

Answer to third query: The actual capacity of the condenser in the closed oscillation circuit of a radio transmitter is governed by the wave-length to be employed, the power, frequency and the voltage of the transformer. A compromise must generally be effected between all of these quantities.

It is not advisable to employ a large amount of inductance in the closed oscillation circuit as it will occasion unnecessary energy losses; generally a maximum value of 30,000 centimeters is employed. It is quite possible to transfer energy from the closed circuit to the open circuit with inductance of 3,000 centimeters at the primary winding.

We cannot answer your fourth query specifically because we do not know what type of vacuum valve receiving circuit you propose to use. If a regenerative circuit is employed and the apparatus is to be used at the wave-length of 200 meters as you say, the inductance of the regenerative coupler will be sufficient to tune the telephone circuit to the wave-length of 200 meters.

We cannot answer your last query specifically because we do not know the voltage of your high voltage transformer. We can, however, state precisely that the capacity of the condenser, in order that the set may be operated at the wave-length of 200 meters, should not exceed .01 microfarad and is preferably of a value of .008 microfarad.

* * *

C. W. G., Indianapolis, Ind.:

If you intend to transmit at the wave-length of 200 meters, we are inclined to believe that the antenna, 60 feet in length by 50 feet in height, consisting of four wires, will give the best results.

Whether or not it would be advisable for you to rewind the secondary winding of your high voltage transformer in order to obtain 20,000 volts is a question that can best be answered by the manufacturer. The amateur's transformer should have secondary voltage of from 15,000 to 18,000 volts, but if one goes above 20,000 volts in the design of the secondary, the radio apparatus will require extremely careful insulation and in addition such voltages may call for an abnormally long spark gap in the closed circuit which will occasion energy losses. A transformer with a secondary voltage of 8,400 is too low for a 200-meter working because it requires a condenser of such excessive capacity as to exceed the wave-length of 200 meters.

* * *

J. W. H., Wooster, Ohio:

It is impossible for us to calculate the number of turns required on the primary winding of your transformer unless we know the voltage and the frequency of the current upon which it is to be operated.

The insertion of an iron core in a coil of wire increases the energy losses due to the production of hysteresis in the iron and the production of eddy currents.

Offhand, it would seem that your secondary composed of 15,000 turns of No. 34 wire would do for a 1 K.W. transformer. The secondary voltage is apt to be rather high with a properly designed primary, somewhere in the neighborhood of 20,000 volts.

Regarding the construction of a simple galvanometer: If the voltage of the current employed is low, your galvanometer can be wound with No. 20 or 22 S.S.C. wire, but if the voltage is rather high you should use a much finer wire. The actual size of the wire depends entirely upon the purpose to which the galvanometer is to be put.

It is quite possible, as you mention in your last query, to rewind the 80-ohm bobbin which is now filled with No. 36 wire, with No. 38 or No. 40, and with certain types of crystal detectors you may obtain better results by following this plan.

* * *

H. H. R., Chicago, Ill., inquires:

Ques.—(1) Is it considered a violation of the President's executive order to construct radio apparatus?

Ans.—(1) Our understanding is that it is a distinct violation during the war.

Ques.—(2) Just what pieces of apparatus come within the scope of this regulation?

Ans.—(2) This is a matter upon which we have received no definite information, but we are under the impression that any part of the equipment which goes to make up a complete wireless telegraph set would come under the ban.

Ques.—(3) Are we to understand that amateurs are not permitted to construct, for instance, a high voltage transformer during this period?

Ans.—(3) If the high voltage transformer is to be used specifically for radio work at some future date there is no doubt that it would come within the scope of the regulations. However, you can satisfy yourself more clearly on this point by communicating with the radio communication officer in your district.

Ques.—How can an amateur employ his time most profitably during this period?

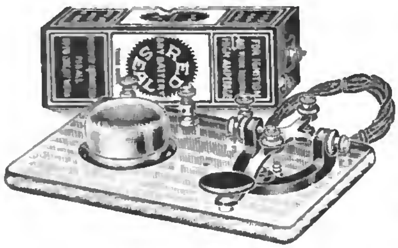
Ans.—He is now afforded an unusual opportunity to familiarize himself with the theory of wireless telegraphy and he is urged to purchase well-known textbooks upon the subject. He should also endeavor to obtain an elementary knowledge of radio engineering, as his services may in the future prove of value to the Government. Naturally, the more he knows before enlisting, the higher appointment he can obtain. It might be well for those who contemplate enlisting in the Naval Reserve to study navigation. Knowledge of gas engines, automobile driving, airplanes and airplane engines offers a highly interesting field for investigation, and the man who has leisure time on his hands will do well to follow such lines of training.

* * *

A. W., Seattle, Wash., inquires:

Ques.—(1) What substitute can I use for the test buzzer to create the signals of the continental telegraph code for practice?

Ans.—(1) Any sort of mechanical circuit interrupter would fulfill your requirements, or you could connect your receiving telephone across the armature of a motor with a 1 microfarad condenser in series. If the motor revolves at a fair speed a very clear tone will be produced, one that will equal the best high pitch buzzers. The "roundness" of the tone will depend largely upon the capacity of this condenser.



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E. C. ROBERTSON, General Salesman 1408 Prairie Ave., Houston, Texas

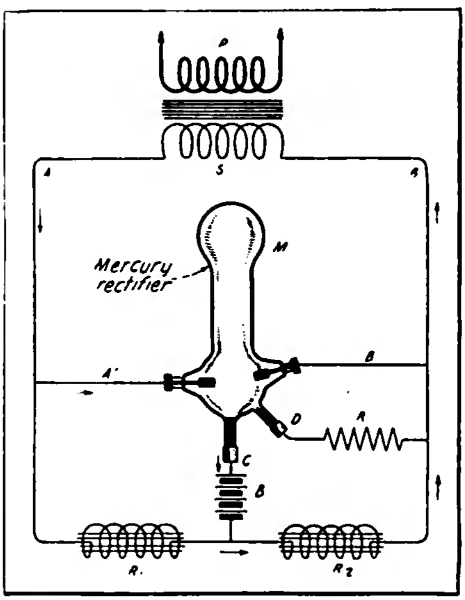
The Book That Counts

C. T. L., St. Louis, Mo., inquires:

Ques.— Please state briefly the theory of the mercury arc rectifier and give a diagram of connections showing how it is used to charge a storage battery.

Ans.—One circuit for the mercury arc rectifier is shown in the accompanying diagram. The general theory follows: First, it consists of an exhausted tube having one or more mercury electrodes to which is applied an alternating current. When current flows towards the negatve electrode or cathode, ionized vapor is produced, but if the direction ot the voltage is reversed so that the negative electrode now becomes the positive electrode, the current will not pass. The current always flows toward the cathode (or negative electrode) which is kept excited by the current itself, but unless some means is supplied to maintain the flow of current continuously toward the negative electrode, the tube would cease to operate after the first half cycle of alternating current took place.

A circuit diagram of the mercury vapor rectifier connected to a storage battery is shown in the drawing wherein it is noted finally that both alternations of a complete cycle of current flow through the battery.



In this diagram the glass bulb contains two graphite anodes, A^1 B^1, and a mercury cathode, C. A small starting electrode, D, is connected to the alternating current circuit through a resistance coil, R. By rocking the tube, an arc is formed which places the rectifier into operation. When the terminal, A, of the secondary winding, S. is positive, the arc within the bulb takes place between A^1 and C through the battery, B-1, through the reactance coil, R-2, and back to the negative side of the line, B.

When the impressed alternating current voltage falls below a value sufficient to maintain the mercury arc against the reverse voltage of the arc and the battery, B-1, the reactance coil, R-2, which has formerly been in the charging circuit now discharges, setting up a reactive current which flows in the same direction as the original current. This maintains the arc in the rectifier tube until the voltage of the alternating current has passed to zero, reversed and built up to such a value as to cause the anode, A^1, to have a sufficient potential to start an arc between it and C. The coil, R-1, now discharges, thus maintaining the arc from B′ to C until the voltage at the anode B′ has become sufficient to permit the passing of an arc from it to the anode. Current from the transformer now flows from B, through B′, through C, through R-1 back to A. Various modifications of this circuit are employed.

THE N. A. W. A. BULLETIN

(Concluded from page 168)

I have read of so many spark coil records that I think I will pass mine around for inspection.

Prior to the war, I was an amateur, residing in Iowa Falls, Ia. When war was declared, I procured a first grade commercial license and joined the Marconi operators.

But to get back to my story. One night in the latter part of March, I heard 9 ZI who was located at Eldora, twenty-two miles away, calling CQ. I was using a one-half inch spark coil of William B. Duck's manufacture, an eight-plate condenser, and small oscillation transformer. I answered him and, to my great surprise, he came right back. We conversed for half an hour. After that, I succeeded in getting him several times.

This can be verified by writing 9 ZI.

I don't claim any receiving records, although before I joined the vacuum valve users I could hear WUJ and other extreme southern stations, with phones on the table, using a crystal detector and one wire aerial.

It would be a great pleasure to hear some of my old amateur friends again, and I hope the time will soon be here when we can hear their gentle voices again. William H. Earle (9 AMH), *Texas.*

A. R. L., North Dakota:

The electrical efficiency of a dynamo is obtained by dividing the energy delivered by the sum of the power lost in the armature and in the field coils. Then if

W= the useful or available power;

W_a=the I^2 R losses in the armature;

W_f=the I^2 R losses in the field poles;

then the electrical efficiency is obtained as follows:

$$\text{Electrical efficiency} = \frac{W}{W + W_a + W_f}$$

The commercial efficiency of a dynamo is obtained by dividing the energy delivered by the dynamo by the sum of the mechanical, electrical and magnetic losses. In other words

$$\text{Commercial efficiency} = \frac{\text{output}}{\text{intake}}$$

It will be found that the commercial efficiency of a dynamo varies with the load imposed upon it, and this factor is always less than the electrical efficiency.

In the case of a motor-generator, you can observe its commercial efficiency by placing a wattmeter in the motor and in the generator circuits; by noting simultaneously the reading of the two meters under given conditions of load, the commercial efficiency of the machine will be obtained at once. The normal efficiency of the machines of the types you mention is approximately sixty-five per cent.

The electrical losses in any dynamo include the I^2 R losses in the armature field, the losses due to eddy current and hysteresis. In addition we have the mechanical loss of friction between the armature shaft and its journal bearing; also the friction of the brushes upon the commutator.

The break-down voltage of grey pressboard having a thickness of 0.35 of an inch is 8,500 volts.

* * *

G. R. B., Pittsburgh, Pa.:

You can determine the size of wire in circular mils to transmit any given horsepower any distance by the following formula, provided the voltage and the efficiency of the motor are known.

The formula is expressed as follows:

$$C.\,M. = \frac{H.\,P. \times 746 \times L \times 10.79}{E \times e \times \%M}$$

where E=the voltage required of the motor;

L=the length of the circuit in feet;

e=the voltage drop on the line;

H.P.=the horsepower of the motor;

%M=the efficiency of the motor expressed as a decimal. If you will follow out this formula you will have no difficulty in making the calculations you require.

* * *

K. R. A., Boston, Mass.:

A complete description of the Arlington station and other activities of the United States Naval Radio Telegraphic Service appear in Volume 4, No. 5 of the Proceedings of the Institute of Radio Engineers for October, 1916.

* * *

M. R. B., Springfield, Mass.:

The phenomena of electric radiation of wireless telegraph aerials are explained in simple language in detail in "Wireless Telegraphy and Telephony," by A. E. Kennelly. Copies of this publication can be obtained from the Wireless Press, Inc., 42 Broad Street, New York City.

* * *

M. R. A., Cincinnati, Ohio:

Professor Morse made his first experiments with the earth current telegraph system alongside a canal near Washington in the autumn of 1842. He laid parallel wires on either side of the canal, grounded at both ends through copper strips. On the receiving side he connected a galvanometer in series, and on the transmitting side a battery with a telegraph key. The system he employed was not "wireless" in the sense of modern day systems, because he positively did not utilize electro-magnetic waves. The current flowing in the receiver was due to the simple phenomenon of divided circuits, that is to say, a portion of the return earth current of the transmitter flowed through the copper plate and galvanometer which were located on the opposite side of the canal. The wires on either side of the canal were grounded on each end through copper plates which were immersed in the water.

* * *

T. B. L., Chattanooga, Tenn.:

You will find a complete description of the two-wheel army tractor which was driven by reins, in the May, 1917, issue of the Scientific American. It is a gasoline operated tractor, but is controlled by reins, as a horse.

* * *

A NIGHT SIGNALING SYSTEM

(Concluded from page 163)

may be used as a pattern for quickly making any number of similar discs.

For signaling between the shores of lakes, between boats or between any land stations, this system is of considerable value, and will give the amateur excellent practice in receiving messages.

Editorial Note: We advise experimenters living in the vicinity of the Atlantic and Pacific coasts not to carry on their original experiments with this device without first obtaining Government permission, as such signaling might be misconstrued and result in a spy scare. Signaling by lights is quite as interesting as signaling by radio and the suggestions given by the author may aid future members of the Naval Reserve to grasp the fundamentals of visual signaling.