July, 1918
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The WIRELESS AGE

Practical Training
Courses in
Aviation
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Special Feature
Progress of Wireless Telephony

War Training Number

JOHN BOTTOMLEY

Commercial wireless lost a pioneer from its ranks when John Bottomley, third vice-president, secretary and treasurer of the Marconi Wireless Telegraph Company of America, died in the Post Graduate Hospital, New York, on Sunday June 16th. Mr. Bottomley was in his seventy-first year.

Twenty years of ceaseless activity in the radio field are credited to the deceased, for it was in 1898 that he first met Marconi and took up the responsible task of introducing wireless telegraphy to the American world of commerce. In 1902 he became the active head of the American Marconi Company. At the time of his death he was vice-president and a director of the associated Marconi Telegraph-Cable Companies, treasurer of the Pan-American Wireless Telegraph and Telephone Company, treasurer and director of the Wireless Press and treasurer of the Marconi Institute. Mr. Bottomley had been a president of the New York Electrical Society and was an active member of the Engineers Club, vice-president of the Harlem Library, now incorporated with the Public Library, vice-president of the Harlem Dispensary and trustee of the Empire City Savings Bank.

He was born in Belfast, Ireland, in 1848, where he received his early education, later entering Queen's College. At the age of twenty-two he was placed in charge of a large exporting house, where he remained for ten years, coming to America in 1880. Here he studied law and was admitted to the Bar, being engaged in this profession up to the time when wireless claimed him.

Mr. Bottomley, who was a nephew of Lord Kelvin, the noted electrician, is survived by his wife, two sons and two daughters.

THE WIRELESS AGE

WORLD WIDE WIRELESS

An Opportunity for Patriotic Service for Stay-at-Homes

THERE are undoubtedly many men, and perhaps women too, who are intensely interested in winning the war but have not as yet found an opportunity to do their bit in the field where their efforts will produce the best results.

At the Marconi Company's factory, Aldene, N. J., which is the biggest plant of the kind in this country, great quantities and varieties of wireless apparatus are being manufactured and it is possible that a few of those who are interested in wireless and can interpret blue-prints and specifications might find desirable employment by addressing the Works Manager.

Swedish Radio Reaches Palestine

SWEDEN'S most powerful radio station, situated at Karlsborg, has been put into operation. Regular communication is now being conducted with Dutch Altengurs in Austria, and also with Tsarskoe-Selo. Wireless messages have also been exchanged with Spanish stations and with Constantinople. Word has been received that the Karlsborg station's messages have been read by a little station in Damascus, Palestine, although the Damascus station's plant is too weak to reach Karlsborg.

The masts, weighing only 25 tons each, are 684 feet high. They are insulated at four different places from the base to top and are erected with the bases embedded in black granite blocks, impregnated with paraffin. The aerials are 1,476 feet long and composed of 60 phosphor-bronze wires hung from steel tubes. The capacity of the station is increased by covering the territory between the masts with a phosphor-bronze wire netting.

Guatemala Acts to Prevent Secret Stations

LITTLE Guatemala throws in her lot with her big sister and declares that she stands by the United States. Guatemala is about as big as New York and has a population of about 2,000,000. Her action counts, as it will at least stop the establishment of German U-boat bases and wireless stations in her section of the Gulf and Pacific.

Mexican Link Established for Shipping Aid

A NEW wireless station has been established on the island of Lobos, off the cost of Tampico, largely for the purpose of affording the various petroleum companies facilities for communicating with their vessels while great distances at sea. This station is provided with some of the most powerful apparatus and will be able to communicate with the wireless stations at Mexico City, Tuxpan, Tampico, Vera Cruz, Progreso, Frontera, Mazatlan, Santa Rosalia, La Paz, Queretaro, Monterrey, Saltillo, Torreon, and by way of Havana with various stations in the United States.

War Calls Off Patent Litigation

AT the request of the Navy Department, litigation in the United States Circuit Court of Appeals in San Francisco, involving the Marconi Wireless Telegraph Company's patents has been ordered suspended for the duration of the war. At the request of Attorney Samuel Knight, representing the Marconi company, and Hiram Johnson, Jr., appearing for the Kilbourne & Clark Manufacturing Company, which Marconi charges with infringement of patents, the cases were taken from the calendar. Two days, May 22 and 23, had been set aside by the Circuit Court judges for hearing arguments in the cases. The Government now is using the Marconi patents.

Direct Communication With France by New U. S. Station

WITHIN the next few weeks the United States government will put into operation one of the most powerful wireless stations in the world. Not content with this, the government will build outside of the United States powerful wireless stations of a like capacity so that they can communicate. All of the stations will be placed under heavy guard of armed soldiers and will be surrounded by barbed wire entanglements.

The first station is being rushed to completion at Greenberry Point, on the Chesapeake Bay, across a small body of water from Annapolis and the United States Naval Academy.

Four giant towers, each 600 feet in height and situated 850 feet apart, are completed. Workmen are placing the wires and otherwise finishing off the great steel towers which will flash forth messages to the ships of the navy and to the expeditionary forces.

The new station, when completed, will cost approximately $750,000. The equipment will cost an extra $100,000, making a total cost of $850,000.

Western Railroad Operation Largely Governed by Marine Radio

TO avoid congestion at seaboard and to insure that the right cargo is at the right pier at the right time, American railroads east of Chicago virtually will be operated by wireless.

Boats returning from Europe do not announce their sailings. Their whereabouts and approximate time of docking is not known until within forty-eight hours of arrival, when it is wirelessed in. In order that docks may not be cluttered with supplies, congesting movement and delaying loading, materials will move to ports only as needed, and each shipment will be made to a definite pier of a definite port, to be loaded on a specific vessel of a certain tonnage.

For instance, "Bertha B," wirelesses on Wednesday that she will be in Friday morning. Shipping officials by wireless assign "Bertha B" to dock at a certain pier, scheduled to be clear at her time of arrival. They determine the vessel should carry 3,000 tons of shrapnel to a French port.

Orders are immediately wired shrapnel factories, where known supplies are held, to rush 3,000 tons to the proper pier of the proper port by Friday morning.

Trains to deliver this are made up and rushed through on express schedule, all passenger and ordinary freight movement being side tracked to give them right of way.

When "Bertha B" gets in she finds her cargo ready. While stevedores are working at double quick to stow her new cargo, colliers draw alongside and pour her bunkers full of coal. In half the normal time in port she is

Marconi Awarded Franklin Medal

THE final meeting, marking the ninety-fourth season of the Franklin Institute, was held in Philadelphia May 15th. Dr. Harry F. Keller, on behalf of the Committee on Science and the Arts, introduced Count V. Macchi De Cellere, who accepted the Franklin Medal awarded to Signor Guglielmo Marconi in recognition of his brilliant inception and successful development of the application of magneto-electric waves to the transmission of signals and telegrams, without the use of metallic conductors, known as wireless telegraphy, for Signor Marconi, who was unable to be present.

The Franklin Medal is awarded annually to those workers in physical science and technology, without regard to country, whose efforts, in the opinion of the Institute, have done most to advance the knowledge of physical science or its application.

Wireless Warnings of Submarine Raids Sent in Advance

CONTINUING their attacks on vessels headed for mid-Atlantic American ports, German U-boats found another victim on June 6th, when the British steamship Harpathian, 4,500 tons, was attacked and sunk 100 miles east of the Virginia Capes. All members of the crew were saved.

The sinking of the Harpathian brought the number of vessels attacked by submarines off the Atlantic coast since May 25 to fourteen so far officially identified as having been sunk or damaged and brought the total tonnage lost to 32,237 in eleven days of submarine operation. The tanker Herbert L. Pratt, of 7,200 tons, was, however, raised, so that the net loss is 25,037 tons; but the loss of life has not been heavy, and so far no transports have been touched.

Assistant Secretary of the Navy Roosevelt has disclosed the very interesting fact that he had an advance tip on the possibility of the arrival of several submarines off the American coast, that this information was of a very definite character, and was acted upon by the navy in advance. Mr. Roosevelt did not consider it wise naval policy to disclose full particulars regarding the source or detailed character of the information the Navy Department had received. Acting on it the Navy Department had begun a lookout on a more intensive scale for submarines, and had also warned vessels along the coast or approaching the coast. These warnings were sent to Porto Rican, Cuban, and other Caribbean ports, as well as to the vessels at sea and to certain port officials. Vessels had been warned by wireless several days before the U-boat raids began.

The number of schooners sunk is accounted for by the fact that without carrying receiving apparatus schooners were unable to pick up the radio warnings spread by the navy; also by the slower speed of the schooner. But that many passenger vessels and steamers were saved, and escaped vessels have been reaching American ports for a week, was probably due to the fact that they had been forewarned.

Carolina's Wireless Man Tells Experiences in Submarine Raid

ERWIN W. VOGEL, the eighteen-year-old boy who was wireless man on board the Carolina, is constructed on the plan of the hour glass in that he is wide at the shoulders, lean at the waist and amply provided with sand. There were shells banging all around the vessel when he sent her distress call out on June 2nd.

"I had been asleep," he says of his experience, " and was just dressing to go on duty Sunday evening when my assistant, Harry Werner, sent a messenger to me with word that a submarine was shelling a schooner somewhere and that he had caught the schooner's signal. To be frank about it, I was just half way into my pants. I pulled them on the rest of the way and dived on deck in my bare feet and undershirt.

"As soon as I got the cups to my ears I caught the schooner's signal over again and learned that she was the Isabel Wiley, in latitude 38:07, longitude 75:10. I sent Werner to warn the captain, and the ship's course was changed right away.

"I had a snack brought up to me and was sitting eating it and still listening in when at 5:30 a shell plopped across our bows. I squinted out and saw the sub hauled right alongside. I could hear the passengers bundling up on deck. I yelled to Werner to go find out our position from the captain or one of the officers and sent our first call out, giving our name and the fact that the Dutchmen were shooting. By the time I had sent it twice two more shells had gone whistling over us.

"It wasn't my business to figure out whether we were to be allowed to leave the vessel or whether we were to be sunk outright. My job was to send. I kept right on shooting out the distress message and yelling for somebody to give me the position.

"Presently Werner came in and said that the Dutchmen had hailed us by megaphone and said I must stop sending. I told Werner that I wasn't taking orders from any skipper but my own and to get me my orders from Capt. Barbour. He disappeared, and after I had sent the signal once or twice over again he came back with the captain behind him.

"You can stop sending, 'Sparks,' said the captain. The cups were still at my ears and I didn't hear him perfectly, so he shouted it over again, and added, 'that is an order.' Then I stood up from my chair and stepped away from the machine and the captain directed me to leave the house in case a shell might find its way in on us.

"But even after I had come out on deck a few more shells were sent sailing over the ship, I imagine, to knock out the aerials if possible. However, they cut that out by the time the decks were lined with our passengers and crew.

"It developed after we were in the boats that the shelling had been done principally to hurry us and without intent to hit us. One of the sub's officers said so. However, I had had the satisfaction of hearing from Cape May just before I quit my job and knew that they knew ashore what had happened to us.

"None of the Germans boarded the Carolina before she was sunk. All they said to us was communicated through their megaphones. When all hands were out of the Carolina the sub hove close in and poured about seven shots into her at the water line. They quit when she began to settle. It was an hour and a half by the captain's watch—he and Werner and I went away in the same boat—when the Carolina finally dived under. Her boilers blew up just before she sank and she went down by the head."

Vogel is a New Yorker and has been a wireless operator two years. His profession has had a fascination for him since he was a child and when he was a schoolboy he installed an amateur's set on the roof of his home. He studied at the Marconi Institute, graduating two years ago.

Operator Doherty Dies as Hero of the Key

MISINTERPRETATION of fog signals is believed to have been the cause of the collision between the City of Athens, the coastwise liner, and the French cruiser off Atlantic City early in the morning of May 1st, causing the loss of sixty-eight lives.

F. J. Doherty, the wireless operator, stuck to his post, vainly trying to send a call for help. Captain A. G. Forward, commander of the liner, three times ordered Doherty to leave his post and save himself, but the operator refused. He was working the key as the City of Athens sank.

Progress of Wireless Telephony*

By Elmer E. Bucher

Director of Instruction, Marconi Institute

THE vacuum tube is an unusually versatile device. Based upon Fleming's original discovery of the mobility of electrons under the influence of positive and negative charges, it is perhaps susceptible to a greater number of practical applications than any other type of oscillation detector or current amplifier heretofore devised. For example, it may be used as a detector of discontinuous waves in radio telegraphy as an amplifier of incoming radio telegraph signals, or as a self-heterodyne for the detection of continuous oscillations through the phenomenon of beats. It may also be employed to

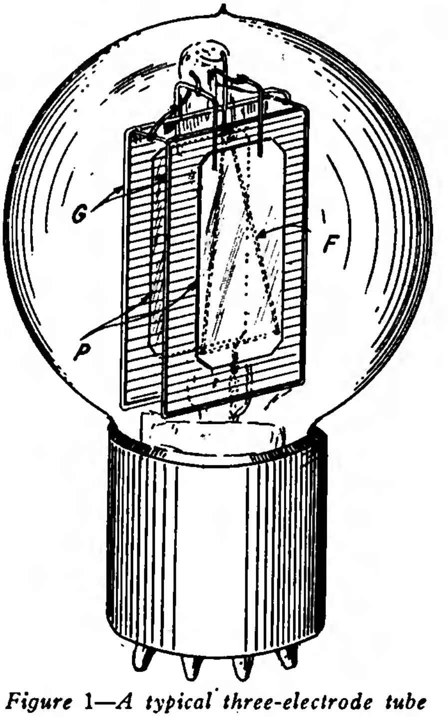


Figure 1—A typical three-electrode tube

amplify land-line telephonic signals, or by suitable connections it will amplify the output of a radio frequency alternator. The tube is in fact applicable to the amplification of a variable E. M. F. of any wave form.

One of the important applications of the tube is its use as a direct generator of radio frequency currents for either wireless telegraph or telephone communications. Not only does it constitute a generator of simple construction, but through its inherent operating characteristics it approximates an ideal modulator of radio frequency currents at high powers for radio telephony, functioning in a most direct and simple manner.

A modern vacuum tube may consist of two or three main elements—a filament and a plate or a filament, grid, and plate. Considering the three-electrode tube, the function of the filament in brief is to emit electrons, that of the plate to concentrate these electrons in a direct path to act as a carrier of local currents, and that of the grid to act as a controller of the electron cur-

* From "Vacuum Tubes in Wireless Communication," now in press.

(C) Int. Film Svce.

Communication with aircraft is graphically shown in this remarkable picture of a Serbian wireless outfit concealed in the woods. The receiving station is located at the base of the stone hut and the soldier is actively engaged in taking down a message from the aerial observer. The soldier on the extreme right is telephoning the fire corrections to the artillery while the two in the middle distance are laying out the white strips in the form of a T, as a signal to the aviator above rent. All three elements may be made of tungsten, or the filament may be of platinum, the grid of tungsten, and the plate of nickle. Other metals are often employed.

A typical three-electrode tube is shown in figure 1, where F is a triangular shaped platinum filament, G the grid made up of a number of turns of fine tungsten wire, and P a flat metallic plate of copper or nickle. The filament is incandesced by a four to six volt storage battery, and the plate is charged to a positive potential by a battery of sixty volts* or more.

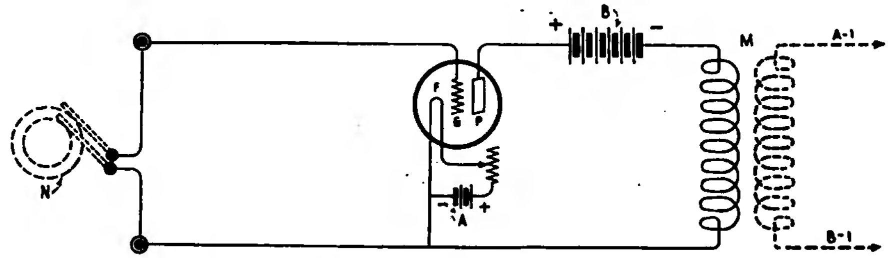


Figure 2—Diagram showing the input and output circuit of a vacuum tube

Before considering the circuits of the vacuum tube as a generator of radio frequency currents, certain problems involved in the art of wireless telephony will be discussed. In general, wireless telephone conversations are transmitted by a radio frequency wave motion termed the carrier wave. The carrier wave is modulated at an audio frequency (or speech frequency) by a microphone transmitter like that employed in land-line telephony. Any undamped wave transmitter and any type of oscillation detection giving quantitative response may be employed, provided the usual magnetic telephone is the current translator.

Consider for a moment a wireless telegraph transmitter which generates a steady wave train of continuous amplitude. If a radio receiving set containing a simple rectifier and a telephone is tuned to the transmitter, pulses of direct current in rapid succession traverse the telephone windings, but produce no sound. But if the amplitude of the radiated energy be modulated at an audio or vocal frequency by means of a microphone, the amplitude of the rectified current will be varied at a vocal frequency accordingly. Hence, the vibrations of the telephone diaphragm will follow those of the microphone diaphragm at the transmitter. The audio frequency variations occasioned by the microphone generally occur at rates from 100 to 2,000 per second, the mean average being approximately 1,000 per second. This average has been termed "mean speech" frequency.

The great problem heretofore in radio telephony has been the difficulty of modulating the powerful currents flowing in the transmitter aerial by the usual microphone, which at its best can only handle approximately one-half to one ampere of current. Owing to the imperfections of the microphone, particularly its limited current carrying capacity, a continuously operative radio telephone system was not produced until the advent of the vacuum tube.

In the earliest radio telephone systems, in order to modulate the antenna current, a number of microphones were connected in parallel and then in series with some part of the antenna system, or in special circuits associated inductively or conductively with the antenna system; but owing to the "packing" (coherence of the carbon granules) of the microphone and the difficulty of overheating, only very small powers could be employed.

Various types of high power microphones have been constructed, but they cannot be said to have satisfied the demands of modern engineering, i. e., that they be continuously operative.†

* Some tubes require only 25 volts in the plate circuit.

† The problems of wireless telephony are treated in detail in "Radio Telephony," a recently published book by Dr. A. N. Goldsmith.

Experiments have been made with the microphone connected in the field circuit of a D. C. generator supplying current to an arc generator; or in a similar way, to alter the field excitation of a radio frequency alternator. But such systems have been only partially successful because of the small current carrying capacity of the microphone and the consequent limited degree of modulation of the antenna current.

It may be stated in general that the systems of radio telephony hereto-

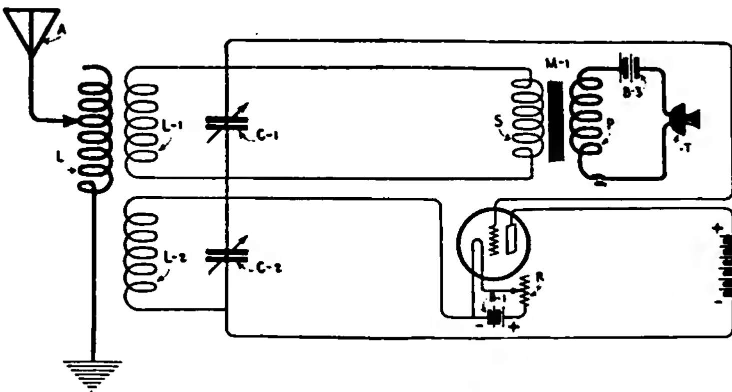


Figure 3—A simple wireless telephone circuit

fore proposed contemplated the generation of a carrier wave above the limits of audibility and the modulation of either the amplitude or the wave length at speech frequency. In some systems one or the other function is performed individually, and in others both occur to a limited degree simultaneously.

The vacuum tubes have offered a practical solution of this problem for, as already mentioned, they can be employed to generate radio frequency alternating currents of any desired frequency. And beyond this (as the grid potential—plate current characteristic—of a properly constructed valve indicates) a very slight change in the grid potential will cause a relatively large variation of the plate current. Hence, if a vacuum tube is connected up for the production of continuous oscillations, and a microphone and a battery connected inductively, conductively, or electrostatically to the grid circuit, the grid potential will rise and fall in accordance with the sound modulations of the human voice, and the amplitude of the radio frequency carrier wave will be modulated at vocal frequencies.

The three-electrode vacuum tube may be said to consist of two principal circuits, the input circuit and the output circuit. They are shown in figure 2. Connection to the filament F and the grid G constitutes the terminals of the input circuit. The terminals A-1, B-1, of the transformer M may be said to constitute the output circuit, or at least the portion of the output circuit from which the amplified energy may be withdrawn. The filament F when heated to incandescence emits electrons which are drawn to the plate P by charging it to a positive potential through the battery B. Current from the battery flows from the plate P to the filament F, and returns to the negative side of the battery.

The strength of this current is limited in two ways: first, by the electronic emission of the tube, and second, by the so-called space charge. It is found that the field of electrons between the filament F and the plate P constitutes a negative electrical charge, and when this attains a certain value, it will tend to push back the electrons given off by the filament. It has also been proven that if the grid G is charged to a negative potential by an external E. M. F. the space charge will be increased and consequently the flow of current from the battery B will be reduced. In other words, the negative charge on the grid acts to obstruct the flow of electrons from F to P. If, on the other hand, G is charged to a positive potential, the flow of electrons is accelerated, and consequently the strength of the plate current fed by the battery B increases. Hence, if an alternating E. M. F. such as that supplied by an alternator M be impressed upon the grid and filament (the input circuit) an amplified alternating current can be taken from the terminals A-1, B-1. In this case, the valve is simply employed to amplify the output of the alternator, the additional energy required for amplification being furnished by the battery B.

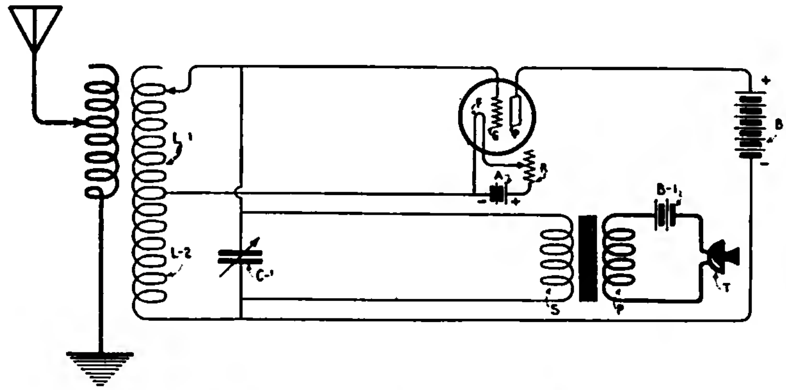


Figure 4—A suggestive circuit of same type as figure 3

It can be shown that a very small amount of energy applied to the grid circuit will release a considerably greater amount of energy in the plate circuit, and it ought to be self-evident that if the plate circuit is coupled back to the grid circuit, the alternator M can be dispensed with and the entire system set into a state of self-oscillation. This is precisely what occurs in a circuit properly devised for the use of the vacuum tube as a generator of radio frequency currents. If the input and output, or grid and plate circuits respectively, are coupled magnetically or electrostatically or in both ways simultaneously, enough energy can be fed back from the output circuit to the input circuit to keep the system in a state of self-oscillation.

The tube and its associated apparatus connected in this way is often termed a regenerative system, and the tube is sometimes termed a self-oscillator. Suggestive circuits will follow.

Simple Wireless Telephone

A diagram typifying this system of connections is shown in figure 3. Here the grid and plate circuits of a three-electrode tube are coupled magnetically at the transformer M, the grid circuit comprising the coil L-1, the condenser C-1, the grid G, and filament F; and the plate circuit the coil L-2, the condenser C-2, the battery B-2, and the filament F and plate P. The grid and plate circuits are tuned principally by the condensers C-1 and C-2, although the frequency can be changed by coils L-1 and L-2 as well. The antenna circuit is indicated at A, L, E, it being coupled to either the plate coil L-2 or the grid coil L-1. To set this system into a state of self-oscillation, either the potential of the grid circuit or the plate circuit must be suddenly changed. For example, if the E. M. F. of the battery B-2 is varied by any means whatsoever, a change of flux will occur in the coil L-2 which will induce an E. M. F. in the coil L-1, setting the circuit L-1, C-1, into oscillation at a radio frequency. The potential of the grid G will vary at a similar frequency and it will act to increase and decrease the strength of the plate current furnished by the battery B-2 at the same frequency. Since the plate circuit is tuned by L-2, C-2 to this frequency, the current in the plate circuit rises to considerable value. The entire system is now in a state of oscillation at a radio frequency which can be changed by simultaneously varying the condensers C-1 and C-2. Current can then be withdrawn from the circuits of the valve into the antenna system from which part of the energy is radiated in the form of electro-magnetic waves.

The amplitude of the radiated energy can be varied at speech frequency by means of the induction coil M-1, connected to the microphone T and the battery B-3. By proper design of the induction coil, several volts may thus be impressed upon the grid, which will cause amplified variations of the current in the plate circuit, resulting in a very great modulation of the antenna current. Valves employed for the generation of radio frequency at high

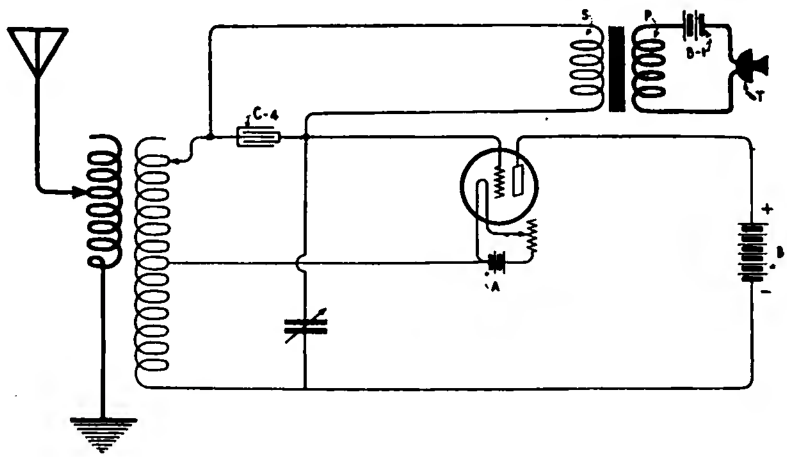


Figure 5—Method of connecting microphone and its induction coil to the grid circuit

powers may have plate potentials up to 2,000 volts or more. In order to secure the correct operating characteristic, the grid is held at from 150 to 300 or 400 volts negative potential by means of a series grid battery (not shown).

It should be understood that figure 3 is simply a suggestive circuit. It may be re-drawn as in figure 4, coils L-1 and L-2 being considered as one long coil tapped at the center to the filament. A single condenser C-1 can be used to tune the plate and grid circuits simultaneously. The microphone and its induction coil may be connected as in figure 3, or in another way as in figure 5, where a large condenser C-4 is connected across the secondary terminals of the induction coil and in series with the inductance of the grid circuit.

There are many combination circuits for wireless telephony in which the three-electrode vacuum tube may be employed in one way or the other. For example:

(1) A number of bulbs connected in parallel may generate the requisite radio frequency current and one or more additional bulbs including a microphone transmitter may be used to vary the output of the "power bulbs" by variation of their grid potential.

(2) The radio frequency current for the carrier wave may be generated by a radio frequency alternator and modulated by connecting a three-electrode valve at some effective point in the antenna system.

(3) A battery of "power" vacuum tube bulbs may be employed to amplify the output of a small radio frequency alternator and the grid potential varied at mean speech frequency by additional bulbs including in their grid circuit an induction coil and a microphone.

(4) A battery of tubes controlled by a microphone may vary the field excitation of a radio frequency alternator.

Round's Wireless Telephone System

A few examples of proposed systems will be described. The first system to employ the vacuum valve as a source of oscillations for wireless telephony was that developed by H. J. Round of Marconi's Wireless Telegraph Company, Ltd., which is shown in figure 6. It will be noted in this diagram that the grid and plate circuits of a vacuum tube are coupled at L-3 and L-4, the antenna being coupled to the grid circuit at L-1. The plate battery B-2 varying from 500 to 2,000 volts is shunted by the condenser C-2. Four

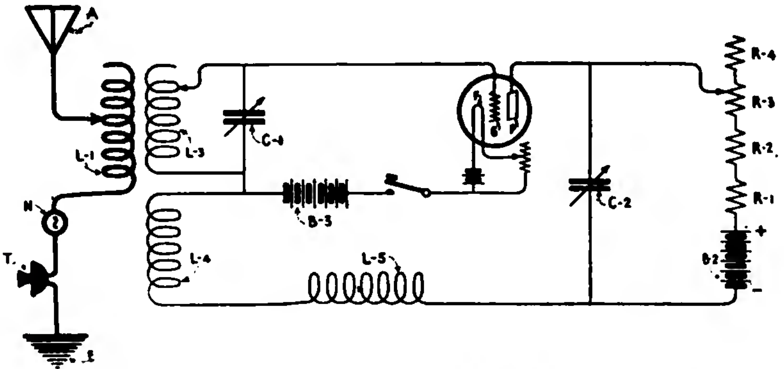


Figure 6—Circuit of first wireless telephone system to employ the vacuum valve as a generator of radio frequency currents

resistances, R-1, R-2, R3—of 500 ohms—and R-4—of 10,000 ohms—are connected in series with the plate battery.

The filament battery B-1 is an 80 ampere hour 6-volt cell, and the grid battery B-3 has a voltage of approximately 500 volts. A microphone T is connected in series with the antenna circuit as well as a small glow lamp N, which is employed to indicate conditions of resonance between the generating circuit and the antenna circuit.

The entire system is set into oscillation by opening and closing the key K connected in the grid circuit. Resonance is established by careful adjustment of condensers C-1 and C-2. By further adjustment of the reaction coupling and by tuning the antenna circuit, the small glow lamp N, will light to full brilliancy. This indicates that the antenna circuit is in a state of oscillation. When the transmitter T is spoken into, the radio frequency wave is modulated at speech frequency and response will then be secured at the receiving station. Note should be made of the fact that the microphone is connected in the circuit where it is perhaps the least effective, but later circuits developed by Round show the microphone connected to the grid circuit. With the connections of figure 6 distances up to 50 miles were readily covered.

Hund's Method of Radio Frequency Modulation

A system for controlling the carrier wave at an audio or vocal frequency suggested by August Hund, is disclosed in figure 7. In this system, the antenna oscillations are modulated at vocal frequency by a three-electrode vacuum tube. The radio frequency current for the carrier wave is generated by the vacuum tube V, the grid and plate circuits being coupled together as usual for the generation of radio frequency currents. By coupling L-2 to L-1, currents of similar frequency are induced in the antenna circuit.

The antenna system further includes the coil L-3 which may have from 6 to 15 microhenries inductance. The terminals of L-3 are connected to the plate P-1 and P-2 of the three-electrode bulb V-1.

The filament F-1 is lit to incandescence by the battery B-1 and the potential of the grid to filament varied at speech frequency by the microphone T through the iron-core in... The potential of the grid in respect to the filament can be maintained at the most satisfactory value by battery B-3 and potentiometer P. The grid normally is held at a fairly high negative potential so that no currents leak around L-3 through the valve F-1, G-1, P-1; but when the microphone T is spoken into, the valve becomes conductive at vocal frequencies; one half cycle of the carrier wave leaks through the conduction path from P-1 to F-1, and similarly the other half cycle through the conduction path from P-2 to F-1. Thus energy is withdrawn from successive cycles of the carrier wave in accordance with

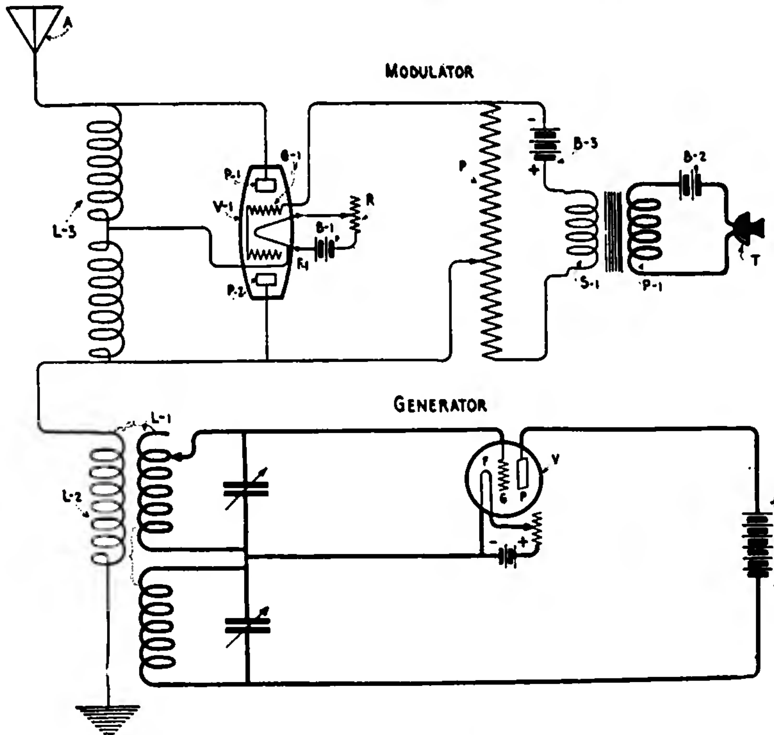


Figure 7—Hund's system for controlling the carrier wave at audio or vocal frequency

the vocal wave impressed upon the grid by the microphone T and the transformer P-1, S-1. In summary, the grid potential is modulated by the microphone, and the radio frequency currents leak from plates P-1 and P-2 to filament F-1. The antenna oscillations are damped out at speech frequency.

Obviously, two valves might be employed to secure this leakage.

Englund's Wireless Telephone System

It has been established that if the frequency of the carrier wave in wireless telephony is of constant amplitude and F cycles per second, and it is modulated at a vocal frequency f by a microphone, there will be radiated into the ether a complex wave which is made up of three component frequencies F, F-f, F + f. It is evident that the unmodulated component of the antenna current F since it does not contain the signal frequency f, need not be present in the antenna, but it may be supplied by an auxiliary source at the receiving station. Hence, if by any means the carrier frequency F can be eliminated, except as at such time that the wireless telephone transmitter is spoken into, a considerable wastage of energy is prevented, and furthermore, the carrier frequency F will not interfere with the operation of other stations in proximity.

In Englund's proposed system,* shown in figures 8 and 9, this phenomenon

* It cannot be said that systems outlined in these diagrams have attained the stage of practical commercial application. They are merely published to indicate the general trend of experimentation.

Press Ill. Svce.

The erection of wireless antennae in unexpected places is well illustrated in this view of Canadian signalmen in Flanders using a shattered tree to support an aerial of the umbrella type. The road repairs which are being made nearby and the flat nature of the country are details of interest to the Americans who are soon to experience the identical service conditions in providing radio communication for our army. Reports from France indicate that the use of the umbrella type aerial, such as is here shown, has now been definitely discarded and the horizontal, or T type, almost universally used. Most of the communication by radio being over short distances and on low wave lengths, many interesting problems are encountered and amateur experience found of particular value

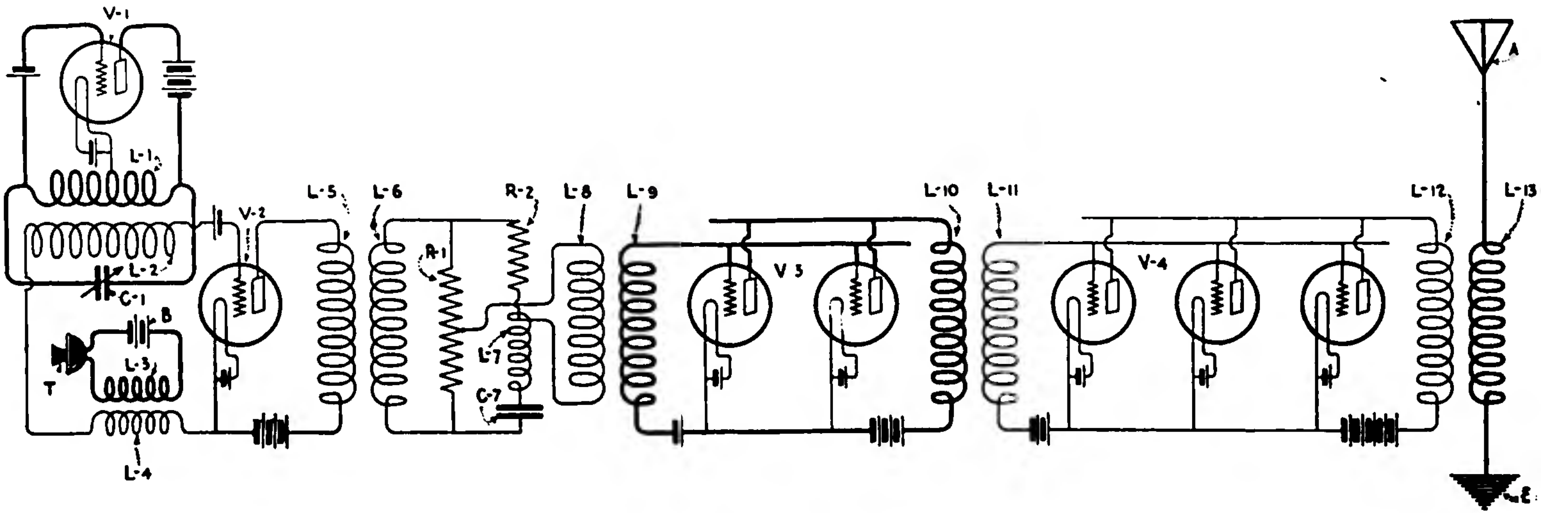


Figure 8—Fundamental circuits of a high power radiophone transmitter wherein vacuum tubes are employed to generate and to modulate radio frequency currents. The outstanding feature of this system is that the antenna does not radiate until the microphone is spoken into.

The radio frequency currents are first generated by a single three electrode tube, and then modulated by a microphone. The modulated currents are in turn amplified by a set of "amplifier" bulbs and further increased in strength by a set of "power" bulbs. The plate circuits of the latter are supplied with energy from a direct current dynamo. This system is credited to Englund.

is taken into consideration and means have been devised whereby the antenna circuit A, L-13, E, is traversed by radio frequency currents only when the transmitter "T" is spoken into. From this diagram, the student receives some hint of the fundamental circuits of a long distance wireless telephone system in which vacuum valves are employed not only to **generate the radio frequency current but to modulate it at speech frequency as well.** It is to be noted first, that the vacuum tube V-1 called the **master oscillator** has its plate and grid circuits coupled for the production of radio frequency currents through the coil L-1 and the condenser C-1, that is, the grid and plate

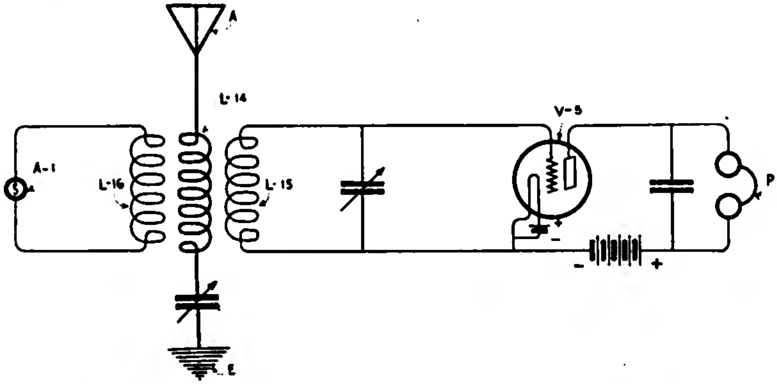


Figure 9—Radiophone receiving system for economy of energy and improved quality of received signals

circuits are coupled in such a way as to set the circuits of V-1 into oscillation. Coupled to L-1 is the secondary coil L-2 which in turn is connected to the grid and filament of another vacuum tube V-2 termed the **"modulator."**

The output circuit of the "modulator" bulb is coupled to L-6 through L-5. The circuit of L-6 in turn contains a bridge consisting of resistances R-1, R-2, inductance L-7, and condenser C-7. Tapped across this bridge is the inductance L-8 coupled to L-9, the terminals of which in turn are attached to the grid and filament (the input circuit) of a battery of tubes V-3.

By properly balancing the bridge, no current flows through L-8 at the carrier frequency F, but currents of a frequency differing from that of the carrier frequency destroy the balance according to the frequency of the vocal currents generated by the human voice. The modulated currents are then amplified by the vacuum tubes V-3 connected in parallel.

The output circuits of these bulbs are in turn coupled to the grids and filaments of the battery of **power bulbs,** V-4, of which there may be any number connected in parallel. The plate circuits of V-4 may be fed by a direct current dynamo or a large storage battery. Their output circuits are in turn connected to the antenna system at L-12 and L-13.

Beginning at the extreme left-hand part of the drawing, figure 8, a circuit will be seen containing the microphone T, a battery B, and an induction coil L-3, L-4, which is coupled to the input circuit of the **modulator bulb V-2.** The radio frequency current modulated by the microphone unbalances the bridge network above mentioned and the resulting currents are amplified through the batteries of bulbs V-3 and V-4.

The oscillator V-1, of course, can be replaced by a small radio frequency alternator. Very feeble currents flowing through microphone T can control antenna current of many kilowatts, thus greatly increasing the distances over which wireless telephony can be carried on.

Since the carrier wave of frequency F has been eliminated by this process, it must be supplied at the receiving station. The diagram, figure 9, shows a radio frequency alternator A-1 (for which may be substituted a vacuum valve connected up for the production of radio frequency oscillations) coupled inductively to the antenna system at L-16 and L-14. A vacuum valve V-5 is employed for purposes of detection. It is inductively coupled to the antenna circuit L-15.

The inventor claims that in addition to the elimination of the waste of energy by this system there is a slight improvement in the quality of received signals due to the elimination of the frequency F.

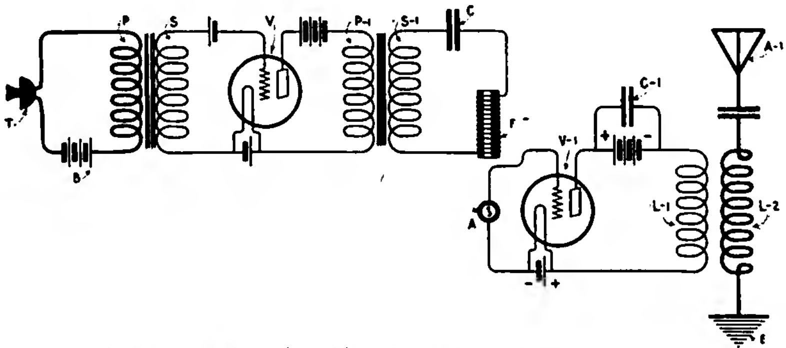


Figure 10—Radiophone transmitter in which the antenna does not radiate unless microphone operates

Carson's Proposed Wireless Telephone System

Another system has been disclosed by John Carson in figure 10, in which the antenna does not radiate except when the microphone is spoken into. It is to be noted in this diagram that the field current of a radio frequency alternator A is modulated at vocal frequencies by a mircophone T the currents of which are amplified by a vacuum tube V. The field windings F of the alternator are thus excited at speech frequency and the amplitude of the radio frequency current generated by A varied accordingly.

The complete microphone circuit includes the **transmitter T**, the **battery B**, and the **induction coil P, S.** Winding S is connected to the **grid** or **input** circuit of a three-electrode valve V, the **plate** or **output** circuit of which includes the primary winding of an induction coil P-1 coupled to the secondary winding S-1. The secondary circuit includes the condenser C and the field winding of the alternator F. The armature of the alternator A is connected to the grid or input circuit of the tube V-1 whose plate circuit C-1, L-1, may be fed with direct current from battery or direct current dynamo D. This tube, repeats and amplifies the radio frequency currents impressed upon its input circuit and the oscillations of the output circuit are transferred to the antenna through the coupling L-1 and L-2. The impedance of the circuit S-1, C, F to the vocal currents is reduced by condenser C.

In summary, the modulated currents set up by the microphone circuit T, P, B are amplified by bulb V, and a fluctuating current circulates through field winding F which varies the output of the radio frequency alternator A at a vocal frequency. A current, the reproduction of the signaling current, therefore flows in the antenna which radiates only when the microphone is in operation. The amplitude of the high frequency wave radiated from the antenna is directly proportional to the low frequency signaling wave, hence the telephone diaphragm at the receiving station is deflected at vocal frequencies.

In ordinary systems, as we have already mentioned, there is a continuous radiation in the form of an unmodulated carrier wave even when the transmitter is not spoken into. The transmission of this wave, besides involving a waste of energy, constitutes a serious bar against the operation of duplex systems.

(To be continued.)

Before We Go Overseas

The Personal Observations of an Army Non-Com on Training in the Signal Corps

By Sergeant Frank A. Rose

MY experiences on the border in the Big Bend country with the Machine Gun Company, were very interesting indeed, but in the shadow of all that is happening now, they pale into insignificance. The Signal Corps at Marfa had a small unofficial radio receiving station which was capable of receiving from Juarez, in Mexico, far to the Northwest, and San Antonio some 400 miles to the East, and from some other high powered stations. The whole Big Bend was covered with a network of single wires, as the basis of signal work in that country was a simple single wire buzzer system. The ground was so dry that the wire could be left lying on the ground with impunity, and, indeed, was so left at many points, for days at a time. Occasionally, a band of roving Mexicans would cut out a portion just for experimental purposes; but as a whole the lines of communication were in working order most of the time.

By the time the Great War is ended, when we may have to go back on the border again, it is to be expected that there will be wireless stations at every post or camp in the Big Bend, for through them lots of trouble and time, and upon many occasions, lives would be saved. An airplane patrol would spare men and horses long, weary, dusty, hot, dry rides, too, and would permit the close watching of roving bands of Mexicans with a few planes from the main posts two hours daily in the air. The Curtiss JN 4 with a 150 H. P. engine should be sufficiently speedy to make the border safe for white people, and the wireless system as used on the planes of the R. F. C. would be sufficient to enable the scouts to keep scattered ground stations informed as to conditions on the other side of the border. Troops with truck transportation could then be rushed to any needed point quickly. The same factors would enter into the detection of bands of smugglers of sheep, cattle and horses.

When I reported back from Reserve to the C. O. of my Infantry outfit at Dallas in August, my border experience immediately became useful. I was used as instructor on everything from the school of the soldier to guard duty, and was especially useful at two-arm semaphore and wig wag instruction. In September, we were moved to Camp Bowie. Until the latter part of December, I continued on the same general lines of work, managing to grab a ride in one of the JN 4s occasionally, and to keep pretty well up on wireless and aviation, which, with photography, are my hobbies. Just as my papers for examination as a cadet in the Aviation Section were completed, I was transferred to the Mobile Ordnance Repair Shop, for duty with the 111th Ammunition Train; here I acted as Supply Sergeant for a time, being relieved so I might get a chance at some of the mechanical work in the repair shop of the QMC, where our men have been working. I appeared before the Aeronautical Board O. K., but just as I was about to be called up for the physical exam, word came from Washington to discontinue all exams until further notice. That finished it, so I put in my application for a transfer to the Aviation Section as an enlisted man, with the hope that the good that I could do there while waiting for the rest of my exam would be more than I would be doing here in the shop and on the field. I am waiting for results on that now, and in case it is favorable, I expect to be assigned for duty.

However, The Wireless Age readers are more concerned with how the Signal Corps is progressing than with my personal affairs. So I'll try and tell something of the training. A few days ago the 111th Field Signal Battalion had a field meet. Major George Robinson is in command of the Bn. and he sure is developing a first class organization; they are full of pep and the meet showed that they are all taking the greatest interest in everything they go into. It took Company B about 45 minutes to set a pole, climb it, bore a hole, come down, take up the cross arm, fasten it, and get back to the earth. In opening station, establishing communication and closing station, with a distance of 300 yards to cover, a section of the wire company completed the cycle of operations in 7 min. 55 sec. Nice work, eh?

In the wireless company contest for opening and closing stations, field pack sets were opened in 150 yards, a message sent, the set taken down and closed, in about 5½ minutes, the time for setting up being 2 mins. 35 secs., and taking down 2 mins. 20 secs. Some speed, I'll say.

In the telephone station contest, one section succeeded in opening station, running 8 lines, and connecting on the other end in 100 yards in 28 seconds. In the receiving contest, Sergeant White of the outpost company took 49 words per minute for first.

Gas mask donning was an interesting stunt, inasmuch as one soldier got his on and adjusted in 5 seconds; 6 seconds is the requirement, and probably is the average. It took one signal man 1 1-3 minutes to run 100 yards, get his saddle, return and saddle up. The boys, by the way are working on horsemanship, as well as motor vehicle work.

In the motorcycle races, riding solo, there were spills galore, as the course was dished the wrong way, allowing a man to spill outwards instead of riding the saucer. One officer seemed to slide over on every circuit, but he was game and finished. The time was just over 10 minutes for 5 miles for enlisted men, and a little more for officers. In addition to these stunts, there were sack races, litter drill, mule races, tent pitching, first aid, blindfolded school of the squad, biscuit eating, cigar lighting race, wheel barrow race, broad and high jumps, dashes and tug of war; and for a wind up—a singing contest for quartettes! If that wasn't a strenuous day, it wasn't a thing.

We are close enough here to the flying fields to see all their manoeuvers, and scores of R. F. C. and American planes fly over camp every day, sometimes solo and sometimes in formation. Stunts are pulled only on occasions, but we do see some of them. The air apparently gets "bumpy" here during hot weather, as I have noticed that they do not fly as low as they did during the cold weather, and when one does come close down, he is not as steady as in the winter. We are close enough to the panhandle to get cold nights and far enough south to get hot days, and I can imagine scores of flocks of mosquitos coming up from the Trinity bottoms when it gets hotter, too.

I get the magazine all right, but a little late. As long as I get it, though, I'll not kick, as there is so much to study in it that I never get through with one in time to start right into the other. If a fellow will study all that comes in The Wireless Age, he will be a shark on all of the kindred sciences, I'll say. I find that my knowledge of wireless (for which The Wireless Age is responsible) was quite an aid in passing the mental exam for the Aviation Section. Here's hoping that I will go through the physical as well.

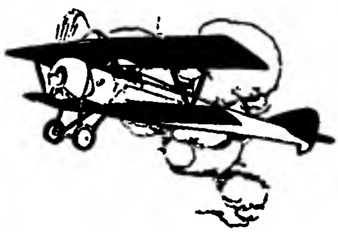
Regards to all my Wireless Age friends, and let the good work go on. The magazine's work for preparedness will help a lot more before the war is ended.

(C) Comm. Pub. Info.

The terrors of war are being realistically simulated at Camp Kearney, Cal., in the training of our soldiers. Nothing is left undone to make the conditions similar to those which the men will have to endure on the European front. The picture shows a gas attack during a midnight maneuver

How to Become an Aviator

The Twelfth 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"

FUNDAMENTALS of aviation engine theory of operation and construction of parts may now be said to have been covered in the articles of this series. It but remains to consider as types, a few of the more advanced engines, and the balance of motor instruction for the student aviator left to shop practice where actual assembly should be undertaken. The engineering factors which enter in the design of motors can be made a supplementary study, if desired, but the air pilot of wartime is not required to have the full mathematical knowledge of the laboratory expert, acquired only by painstaking study and entire concentration on that particular phase of aviation.

Due to the ever-changing refinements of design the aim has been to present the various parts as representative of the best practice, describing the function and operation and, in a brief manner, the construction. In this way the aviator learns the fundamentals, so that he is able to instantly comprehend the operation of any advanced design which he may later encounter.

A word may be said on bore and stroke ratio. While nothing fixed, definite and exact may be stated on the proper proportion of bore to stroke, it is clear that an engine with a short stroke will run at high speed smoothly but is of poor efficiency at low speeds. When the stroke is much longer than the diameter of the cylinder bore, the reverse is true. A bore of 5 inches and a stroke of 8 inches is considered a long stroke ratio, 4" x 5" a short stroke. Since both ratios have their disadvantages there is no agreement of opinion among designers; thus in seven representative types of aviation motors the following ratios are found: 4x5, 4x5½, 4x6, 4¼x5, 4⅝x5, 5x6½, 5x7. Among foreign motors the average is a stroke 1.2 times the bore dimension. The general trend in motor design is steadily leaning toward the short stroke, or high speed engine, and recent calculations make it appear that the practice of restraining piston speed to 1,000 feet per minute will be abandoned.

A few representative types of multi-cylinder engines will now be briefly considered.

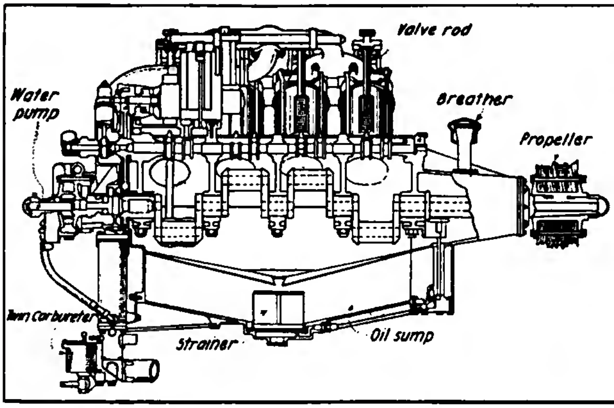


Figure 67a—Part section view of 8-cylinder V-motor

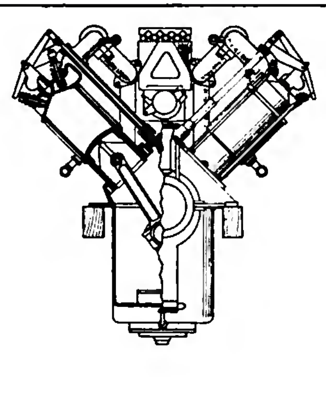


Figure 67b—Part section view of same motor from the front

V-TYPE MOTORS

The salient advantages of increasing the number of cylinders in aviation engines are, briefly, high speed with decreased vibration, flexibility and quick operation, overlapping power strokes and lighter reciprocating parts. The addition of more cylinders to the vertical type of motor is impracticable because this would require a length too great for the fuselage and a much stronger and heavier crankshaft; the best solution is therefore found in two sets of cylinders inclined inward at an angle, thus producing a motor of same length but increased power, or the V-type motor.

8-CYLINDER V-MOTOR

The standard Curtiss engine is shown in part section in figures 67a and 67b. It will be noticed that the length of the motor and crankshaft is practically the same as in a 4-cylinder engine, and the additions are merely another set of cylinders and connecting rods.

In this engine the cylinders are set at an angle of 90 degrees, or one-half the firing distance of the 4-cylinder engine. That is, in this V-type motor the power impulses occur every 90 degrees instead of 180 degrees. In the Curtiss OX, or 90 horsepower engine widely used in training machines, the cylinders have 4-inch bore and 5-inch stroke, is normally run at 1400 revolutions per minute (r. p. m.) and weighs 390 pounds complete.

The main difference between the 8 cylinder V-motor and the 4-cylinder vertical, is the arrangement of the connecting rod; it is common practice to have two rods attached to the same crank throw. This is accomplished, (a) by staggering the cylinders and having the connecting rods attached side by side to the same crankpin, or (b) the lower end of the connecting rod is forked just above the crankshaft bearing, and the rod from the cylinder opposite connected to the crankshaft bushing (at a right angle) between the fork.

The firing order is generally the same as in a 4-cylinder motor, except that the explosions occur alternately in each set of cylinders.

12-CYLINDER V-MOTOR

The development of the multi-cylinder engine to 12 cylinders responded to the demand for more power. In V form, it possesses the same advantages of arrangement and lightness of weight of the 8-cylinder, and obviously reduces vibration still further. That is, where the 8-cylinder engine has four power impulses per revolution, the 12-cylinder motor gives six explosions per revolution.

The usual practice has been to set the cylinders at 60 degree angle, but the latest design favors an angle of 45 degrees.

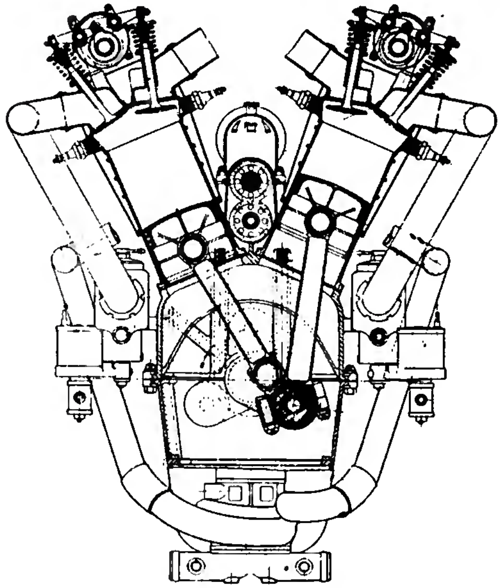


Figure 68—Cross section Renault twelve-cylinder engine, illustrating many features of advanced design

THE LIBERTY MOTOR

Details of the general construction of the Liberty motor have been given in an authorized statement issued by the War Department, extracts from which follow:

CYLINDERS

The cylinders follow the practice used in the German Mercedes, English Rolls Royce, French Lorraine Dietrich and Italian Isotta Fraschini. The cylinders are made of steel inner shells, surrounded by pressed steel water jackets. (This construction is clearly shown in figure 68, a cross section of a Renault engine). The valve cages are drop-forged welded into the cylinder head. The principal departure from European practice is in the location of the holding down flange, which is several inches above the mouth of the cylinder.

CAMSHAFT AND VALVE MECHANISM

The design of the cam and valve mechanism is based on the Mercedes, but improved for automatic lubrication without wasting oil. Figure 68 illustrates a good example of the type, which has been described in detail on page 666, May issue. The camshaft drive is of the Hall-Scott type.

ANGLE BETWEEN CYLINDERS

The included angle between cylinders of the Liberty motor is forty-five degrees, or similar to the illustration, figure 68.

The general practice in 12-cylinder engines has been to set the cylinders at sixty degrees, but by lessening the angle each row of cylinders is brought nearer the vertical and closer together, saving width and head resistance, reducing vibration and giving greater strength to the crankcase.

IGNITION

A specially designed Delco ignition system is used.

PISTONS AND CONNECTING RODS

Hall-Scott design has been followed for Liberty motor pistons; these are similar in type to those shown in the drawing above. The connecting rods are of the straddle or forked type, the fork being just above the bearing at the crankshaft end.

CRANKSHAFT AND CRANKCASE

Standard 12-cylinder engine practice is followed, except as to modifications in the oiling system.

LUBRICATION

The first system of lubrication followed the German practice of using one pump to keep the crank case empty, delivering into an outside reservoir, and another pump to force oil under pressure to the main crankshaft bearings. This lubrication system also followed the German practice in allowing the overflow in the main bearings to travel out the face of the crank cheeks to a scupper, which collected this excess for crankpin lubrication. This is very economical in the use of oil and is still the standard German practice.

The present system is similar to the first practice, except that the oil, while under pressure, is not only fed to main bearings, but through holes inside of crank cheeks to crank pins, instead of feeding these crank pins through scuppers. The difference between the two oiling systems consists of carrying oil for the crank pins through a hole inside the crank cheek, instead of up the outside face of the crank cheek.

CARBURETOR

The carburetor is a Zenith development. The compound nozzle principle of the Zenith and the constructional details were described in the May issue on pages 668 and 669.

BORE AND STROKE

The bore and stroke of the Liberty engine is 5x7 inches.

The first Liberty motor was an eight-cylinder model, delivered to the Bureau of Standards July 3, 1917. The eight-cylinder model, however, was never put into production, as advices from France indicated that demands for increased power would make the eight-cylinder model obsolete before it could be produced.

(C) Int. Film Svce.

A 20-cylinder Anzani motor, built for transatlantic flight, under examination by Y. M. C. A. student mechanics

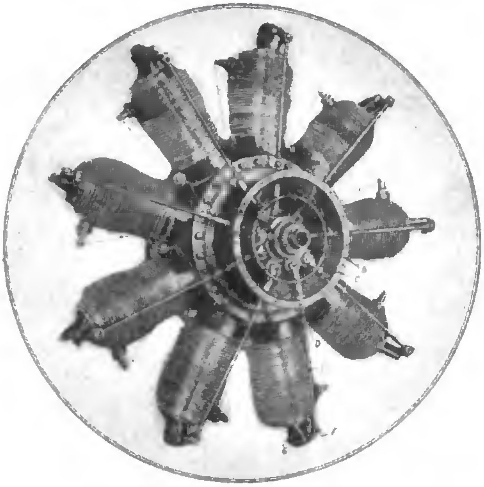


Figure 69a—General view of nine-cylinder rotary engine

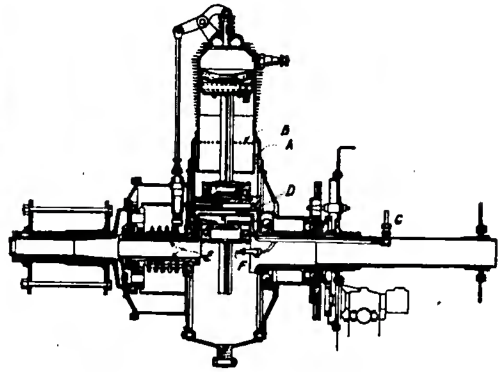


Figure 69b—Section view of rotary engine cylinder and crankcase

ROTARY ENGINES

The principal claim advocated for the rotary motors is that the design makes for light weight. It has been observed, however, that the rotating feature has little to do with this advantage, for the weight would not be perceptibly increased if the cylinders were stationary and the crankshaft revolved. Setting cylinders radially from a crankcase of a size not much larger than that which one cylinder would require is an obvious weight saving. The absence of reciprocating parts aids smooth running and the full practicability of air cooling is an added advantage. The head resistance is a disadvantage, and the loss of power (estimated at 7 per cent.) in driving the cylinders around the shaft, and the difficulty of securing high compression, further handicap this design.

GNOME ENGINE

The figures 69a and 69b show the famous Gnome engine with nine radial cylinders. The explosions occur in each alternate cylinder as the engine revolves, the odd number thus securing a uniform period of explosion. The cylinders, the construction of which is shown in section in figure 69b, are machined from solid 6-inch steel bars, 11 inches in length, weighing less than 100 pounds.

The operation of the engine is as follows:

Vaporized gasoline is forced into the crankcase through the jet F (figure 69b) entering the cylinder through the holes A, B, when the piston is at the lowest point. As the piston ascends it covers the port and the gas is compressed and fired in the usual manner. The large valve in the cylinder head is the exhaust, operated by a cam and rod. Lubricating oil enters at C on the stationary crankshaft, passing to the stationary crankpin D and flooding the bearings E. A portion of the oil which lubricates the crankpins is thrown by centrifugal force through the connecting rod tubes and in the same way oils the piston pins and cylinders. Additional lubrication of the cylinders is secured by oil which is thrown through crankcase holes.

In figure 69a the engine is shown with the crankcase cover removed, revealing the cams and gears. One of the nine holes in the crankpin, through which oil is fed to the nine cams, is indicated at A. The cam rollers, one of which is shown at B, carry oil over the surface of the cam, surplus oil feeding through the guides (C) of the valve rods, through the ball joint D and hollow rod E to the pin F. A groove on the valve lever carries the lubrication to the lever bearing G.

Other aviation engines of the rotary type include the Anzani, Le Rhone and Clerget, constructed with varying number of cylinders up to fourteen.

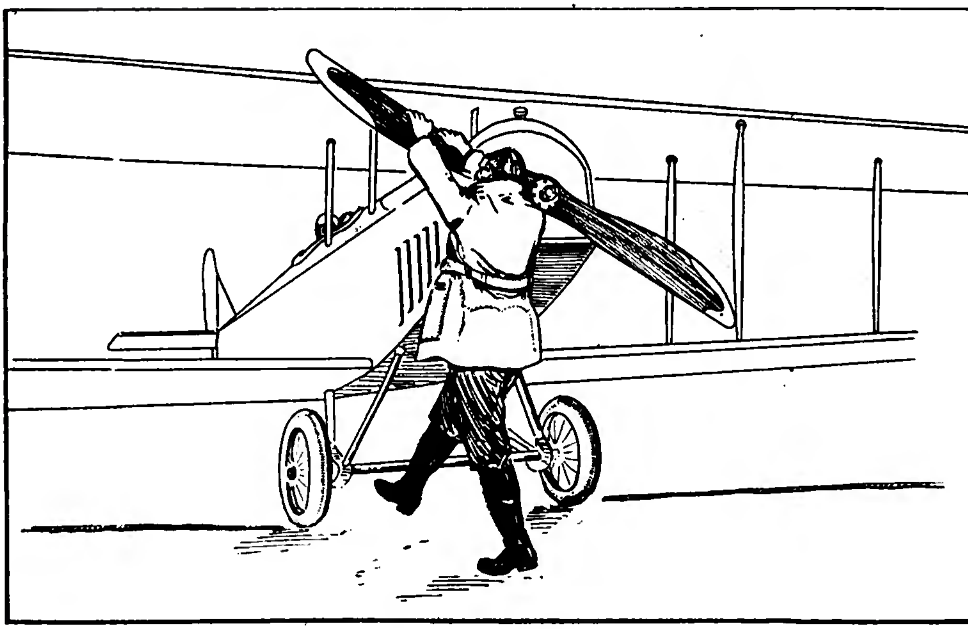


Figure 70—The proper method of swinging the propeller

STARTING THE ENGINE

PREPARATORY

The ground selected should be firm so that the foot will not slip when the propeller is swung. The blocks are then placed in front of the wheels with the cords laid toward the wing tips. A mechanician takes his place at each wing tip, grasping the bottom of the outer strut to steady the airplane when the engine is running; they pull the blocks away when the pilot signals he is ready to start. Two or more mechanicians take their places at the tail end of the fuselage to hold it down while the engine is running.

SWITCH OFF

The ignition switch must be in the "off" position before any attempt is made to swing the propeller. Many fatal accidents have resulted from carelessness on this point.

With engines of the rotary type it is often necessary to prime the cylinders by squirting gasoline through each exhaust valve. Two things are to be remembered in this connection: The squirt can must be clean and the ignition switch off.

GASOLINE ON AND AIR CLOSED

The pilot ascertains that the gasoline is on and the air intake almost closed, so the mixture may be rich for the first few explosions.

ROTATION OF PROPELLER

The propeller is swung with the ignition switch off to fill the cylinders with gas.

CONTACT

The mechanician calls "contact" at this juncture, whereupon the pilot throws the ignition switch on, and replies "contact."

SWINGING PROPELLER

The propeller is grasped as shown in figure 70. Note particularly the position of the feet. One good downward swing of the propeller is made and the mechanician immediately stands clear. If the engine fails to start the mechanician calls for "switch off" and repeats the same operation.

Once the propeller has been given its downward swing, the mechanician must stand clear immediately, as the possibility of a backfire from the engine is great and the backward swing of the propeller may result in a fatal accident. The illustration, figure 70, should be carefully studied, with particular reference to keeping the feet apart and in a position where the body will naturally swing away with the downward pull.

SIGNALS

The following procedure is standard with the Royal Flying Corps.

1. The pilot ascertains from the rigger and the mechanician that everything is correct, immediately after entering the machine.
2. Mechanician—"Switch off?"
3. Pilot—"Switch off."
4. Mechanician—"Gas on—air closed?"
5. Pilot—"Gas on—air closed."
6. The mechanician rotates the propeller to fill the cylinders with gas.
7. Mechanician—"Contact?"
8. Pilot—"Contact."
9. The mechanician swings the propeller and stands clear. The engine runs for a few minutes until the pilot is assured that the motor is in good working order.
10. Pilot waves hand from side to side.
11. Mechanicians pull blocks away from wheels.
12. Pilot looks at aviation mechanician or senior non-com, who ascertains if all is clear ahead and above for the ascent. He indicates all clear by saluting.
13. Pilot waves hand in fore and aft direction. This is the signal to start and all stand clear instantly, the mechanicians at the tail letting go immediately.

SELF STARTERS

There are two methods of cranking aviation engines by starting systems employing compressed air. One turns the crankshaft by means of an air motor and the other admits compressed air to the cylinders, forcing the piston down by pressure and thus turning the motor over. In the latter case, air for the system is supplied to a reservoir by an air pump driven by the engine and, when needed, enters the top of the cylinders in their proper firing order by means of check valves which open inward only and close by explosive pressure once the engine is running.

Developments of the electric starters familiar to all automobilists are also being employed on aviation engines. These are of the storage battery type with the current generated by the engine when running and stored for use until needed. The motor in this instance is turned over when electrical communication is made between the storage battery and the motor-generator unit, which then acts as a motor and turns the engine over by means of gearing to the crankshaft.

FUEL CONSERVATION IN FLIGHT

A final word may well be added before turning to the aspects of actual flight. When flying, the pilot must bear in mind that the maximum speed of the plane is not its most efficient flight speed, and driving the machine at full power must not become an habitual practice. The aviator soon learns by experience the range of speed of his machine and upon this knowledge must base his calculations for long flights, so his fuel may be properly conserved for the task in hand.

To illustrate, a given motor may be assumed to develop 90 H.P. at 1300 r.p.m. and consume 1-10 gal. of gasoline per horsepower hour, or 9 gallons per hour. If the gasoline tank holds 18 gallons and the speed at 1300 r.p.m. is 80 miles per hour, the duration of flight will be 2 hours, or 160 miles. If then, the number of revolutions is reduced to a point where the fuel consumption is one-half (at a speed, say, of 60 m.p.h.) the fuel will last twice as long, or 4 hours, and the distance covered will be

60 m.p.h. x 4 hrs. = 240 miles

as against 160 miles at the greater speed.

When flying at high altitudes, 10,000 feet or more, motor troubles increase. The explosive mixture changes in character, due to the decreased density of the air supplied to the carburetor. Lessened supply of air results in increased richness of mixture and, disregarding factors of motor design and construction, the amount of power obtained will vary with the changes in the proportions of the gasoline vapor. Increased air in the mixture means fuel economy, but lessened power. With a rich mixture, on the other hand, though the power curve rises, the motor and its parts overheat, delicate adjustments are thrown out and carbon deposits appear in the cylinders. The adjustment of the gas mixture is therefore of importance, the normal ratio for aviation engines being one part of gasoline to 9 to 18 parts of air.

In the thirteenth article of this series, which will appear in the August issue, the principles of general and cross-country flying will be discussed.

How the Eyes of the

Photos: British

The airplane observer is here shown in the nacelle of a pusher machine receiving his camera, preparatory to starting over the enemy lines on an observation trip

The messenger mounted on a motor cycle receives the exposed plates the minute the aviator reaches the ground and speeds with them to a dark-room mounted on a truck where they are developed

Army Record Observations

Official

The method of taking observation photographs is shown in this view of the aviator snapping the shutter of the camera fastened to the side of a tractor airplane

This view shows how the snapshots are assembled to make an accurate map of the enemy territory for staff use. The assembler uses as a guide a military outline map

Aviation News

Board to Grant Air Licenses

The board which will grant civilian licenses to operate aircraft has been announced. It includes Major-Gen. George O. Squier, chief signal officer of the army, as chairman. The other members are Col. H. H. Arnold, Signal Corps; Lieut.-Col. Claude E. Brigham, Coast Artillery; and Capt. Noble E. Irwin, Capt. T. R. Y. Blakeley and Capt. F. H. Clarke to represent the navy.

All aviators except officers of the army and navy, must obtain licenses from this board for the operation of balloons, seaplanes or aeroplanes.

❧ ❧ ❧

Signal Corps Requires Draftsmen

In a statement authorized by the Civil Service Commission, the following appears: "The Signal Corps of the Army is short of aeronautical mechanical draftsmen. The Navy has an unlimited number of places for draftsmen of various kinds and for a long list of technical workers."

❧ ❧ ❧

Major Thaw An "Ace"

Major William Thaw, commanding the Lafayette Flying Corps, is now counted among the "aces" in aviation in France, having brought down his fifth adversary and a captive balloon on the same day, April 20.

Major Thaw within a month has accounted for three opponents in aerial encounters.

A dispatch from Paris relating to the exploits of American aviators says:

"On April 20 Major Thaw, commander of the Lafayette Squadron won a splendid double victory, bringing down in turn a Drachen and a monoplane. These two victories permit him to be enrolled among the prize aviators.

"Since he assumed the command of the glorious unit, he seems to have particularly distinguished himself. Major Thaw evidently wishes to set an example, and many of his compatriots will take their places within a short time among the air champions."

❧ ❧ ❧

Speaking at the Royal Institution, Professor Pope stated that air photography for military purposes is now being done with the aid of plates sensitive to the several colors of the spectrum.

Gas Used for Testing Aero Motors

Recently the Detroit City Gas Co., an American Light and Traction Co. subsidiary, sold some $1,250,000 bonds, the proceeds to be used to finance the additional plant extensions due to the increased demand for gas in munition plants. This gas, it is learned, is being substituted for gasoline in testing airplane motors. So comprehensive is the aero motor building business that this new use for gas in Detroit has increased the daily demand 5,000,000 cubic feet.

Postmaster Patten starting Lieut. Webb on first airplane mail trip, from New York to Washington

❧ ❧ ❧

Red, White and Blue Circles on U. S. Machines

Red, white and blue circles and stripes will be the distinguishing mark of Uncle Sam's army and navy airplanes, the Signal Corps announced.

The wings of the planes will be marked with a red bullseye. The rudders will be marked with vertical red, white and blue stripes.

❧ ❧ ❧

The War Department has made a new ruling that civilian instructors will no longer be used in aviation schools and only commanding officers will do the instructing.

Signal Officers' Training Course*

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

By Major J. Andrew White
Chief Signal Officer, American Guard

FOURTEENTH ARTICLE

The Wire Company—II

FORMATION OF THE COMPANY

The habitual formations are: *The order in section column, the order in line,* and *the order in platoon column.*

The order in section column is that in which the sections of the company follow each other in the order, or the reverse order, of their numbers, from front to rear. The distance between the mounted men and carts in a section, between sections and between platoons is 2 yards.

The order in line is that in which the sections of the company are formed abreast of each other in the order, or the reverse order, of their numbers from right to left. The interval between the sections and between platoons is that which would result from the sections moving from the order in section column by the flank.

The order in platoon column is that in which the platoons of the company, each in the order in line, follow each other in the order, or the reverse order, of their numbers from front to rear. The distance between the platoons is that which would result from wheeling the platoons from the order in line to the order in platoon column.

Employment in the Field

GENERAL

The main equipment of each of the four wire sections is a two-horse reel cart carrying 5 miles of Signal Corps field wire and the buzzers and other apparatus for establishing the necessary stations. Wire can be laid out and recovered at fast gaits and stations established or discontinued in a few seconds.

Buzzer wire carriers, each with a quarter mile of buzzer wire, can be

*The articles in this series are abstracted from the complete volume, "Military Signal Corps Manual," by the same author.

used in emergency or where it is impracticable to lay the field wire. Each section carries 1½ miles of buzzer wire and 4 buzzer wire carriers.

Whenever practicable, a reserve of equipment will be kept on hand to provide for a sudden move of the headquarters or other station. For this reason the company commander must take up every opportunity to reel up wire no longer used. This can often be done as the action progresses or after a move of headquarters.

When a wire line is discontinued, every effort will be made to recover the wire, and wire or matériel will not be abandoned unless its recovery has become impracticable.

When lines are laid within the zone of fire or observation of the enemy, the men laying the lines will take advantage of cover to conceal their position and movements. Sections should not be placed in positions exposed to the enemy, nor, on the other hand, in places where it will be difficult for those for whose use the line is established to find them readily.

On the March

The position of the wire company in the column is not important unless resistance is expected. In the latter case, the company should be where sections and platoons may proceed promptly from division headquarters and lay lines to the brigades and other units as soon as they deploy. To be in a position to meet this requirement, the company should be at or near the head of the main body.

In case it is desired for tactical reasons to maintain communication between different parts of a division on the march, this service should be rendered by means of the radio sets rather than by the use of wire lines. The use of the latter on the march is more exhausting to the Signal Corps personnel and uses wire which may be urgently needed for combat lines at any moment when contact with the enemy is possible.

In Battle

When resistance is encountered and the division is deploying opportunity for the most useful and important application of the wire company is presented. The division commander or a representative will indicate by formal field order or otherwise the wire lines it is desired to establish. As soon as possible, the captain designates an initial point for the beginning of wire laying and assigns sections and platoons to suitable tasks.

The strictest economy of wire and other matériel should be observed in planning for and laying the lines to the end that same be not uselessly expended and found exhausted at a critical stage. As large a reserve as possible of wire and equipment should be assembled at a central point with which to effect replacements and meet unexpected demands. It is advantageous and most usual to play wire from a point near division headquarters outward. A principal advantage lies in the fact that the reel cart is thus placed at the end where changes of position are most frequent.

In Camp

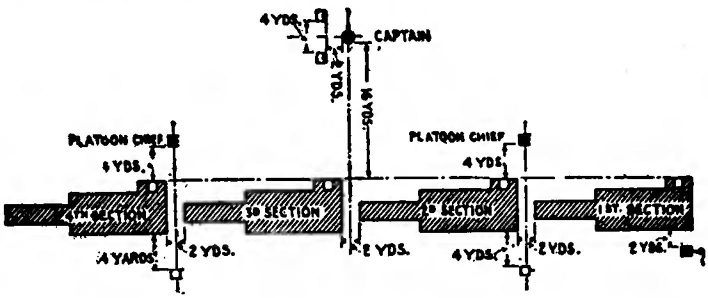
When the division goes into bivouac or camp the wire company establishes such tactical lines of information as may be indicated. These will usually be wire lines on the ground and will connect division headquarters with brigades and important outposts and observation points.

Reserve Wire Carts

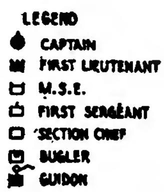
The two extra wire carts in the company carry 10 miles of field wire each, which constitutes a reserve supply for issue to subordinate units when necessary. The captain regulates the issue and use of this reserve matériel in the most judicious manner for supplementing and replacing the equipment pertaining to subordinate units. The reserve wire carts and the company instrument wagon constitute a part of the company combat train and should march in rear of the company.

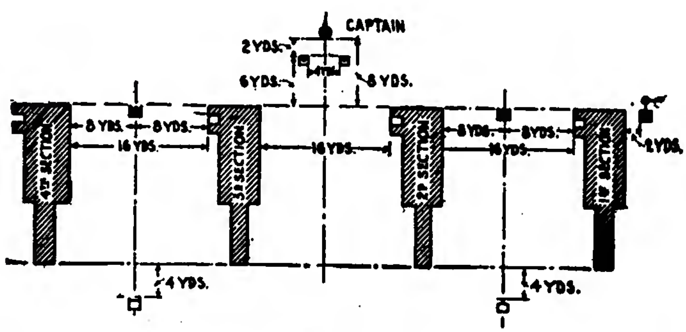
Reconnaissance

A most important preparatory measure for units of a wire company to take before actually laying indicated ground lines of information is to pro-



COMPANY IN COLUMN





COMPANY IN LINE

vide for as complete a reconnaissance as time will permit of the route to be followed in laying the wire. Such reconnaissance will be accomplished by suitable reconnoitering or scouting parties detailed from the personnel of the sections or by such detachments of the company staff as the captain may direct.

These scouting parties will examine carefully the general route to be followed in laying the wire with a view to selecting the particular route (a) which best utilizes the existing matériel and artificial cover along the route; (b) which offers the least difficult terrain to traverse; and (c) due regard being had for the above, that route which is the shortest and which involves the laying of the least possible amount of wire.

It is incumbent on the scouting party in front to *mark the route* so that uncertainty may not arise as to the direction to be followed. A marker is made to understand clearly:

(a) The route to be followed.
(b) The particular unit or units to be guided.
(c) The message, if any, to be delivered.
(d) Other directions to be carried out or the route he is to follow in order to rejoin his party.

The marker indicates the correct route, acting as guide if necessary over terrain where the route is difficult to follow, and as soon as his mission is fulfilled hastens to replace the next marker or to rejoin his detachment or detail.

By the establishment of well-understood conventions, or by the use of suitable signs, the number of markers may be reduced. Thus, it should be understood that a main traveled road is not, without indication, to be left for one that is noticeably less traveled, and that a straight road is not, without indication, to be left for one which deviates from it. By marking arrows on trees and buildings, or by other suitable signs, uncertainties of a minor nature may be removed. In important cases, however, a marker should always be left at places where a reasonable doubt may arise.

When the head of the column for which the route is being marked comes within view of a marker the latter *signals* the former, and the former acknowledges with a *countersignal.* Both signal and countersignal should be distinctive and should have been previously agreed upon. The same signal and countersignal are used throughout the detail.

The men designated for the foregoing are selected for special aptitude from the personnel of the sections and the company staff and are carefully instructed in the duties they are to perform.

It will be found advantageous to have those men of a section designated for scout duty grouped in the station squad which is last to establish its station.

Additional men are designated from time to time to receive the instruction so that substitutes may be available. Alert, cool-headed, and intelligent men should be selected for this duty; they should be good horsemen and have good eyesight and hearing.

Each scout should be provided with a good field glass, a compass, a watch, a whistle, a field message book, and a pencil.

The training of a scout should have for its object:

1. To develop his powers of observation.
2. To teach him what to look for and how to recognize it.
3. To teach him how to report intelligently and concisely.

The scout's powers of observation and description are developed first of all by simple exercises. Thus he may be required to look at a given section of terrain and describe what he sees in it.

The scout is made to appreciate the lay of the land as indicated primarily by its drainage, and secondarily by other natural features, and by the works of man. A good eye for country is thus to be acquired; the scout learns to appreciate the configuration of a terrain which may be only partially visible to him, and thus to deduce the most favorable routes for traversing it and the most probable positions for hostile occupation.

The scout must also be taught to distinguish troops of the different arms, to recognize their formations, and to familiarize himself with their usual methods of action.

The scout must be trained (a) to use field glasses; (b) to read maps; (c) to make reports, both verbal and written; (d) to make route sketches.

Signal Corps News

Radio Sergeants Needed

The country is at present in need of a large number of radio sergeants. To qualify for this rating a man should have a high school education, or equivalent. Men who have recently completed their schooling are specially wanted—those who still have their mathematics fresh in mind, have a keen ear and are eager for active service. Men in the draft age may be inducted into the service and men between the ages of 18 and 21 may be enlisted with the consent of their parents. Address Department of Enlisted Specialists, Coast Artillery School, Fortress Monroe, Va.

* * *

Expert News Photographers Needed

A number of high-grade news photographers are urgently needed by the Signal Corps. These men must have expert experience in handling of speed cameras, such as Graflex, Graphic, and also understand speeds of lenses and various makes of cameras and operation of same.

Only those men who can furnish references as to their actual experience as news photographers will receive consideration.

The men selected for this branch of the service will be sent to a school for military training. Upon completion of the training they will be promoted to grades of sergeant, first class, and will be ordered overseas in a short time.

Applicants must be citizens of the United States between the ages of 21 and 31.

All communications should be addressed to Air Division, Training Section, Photographic Branch, Washington, D. C.

* * *

250 Telephone Girls Go to France

Besides conforming to the qualifications set by the United States Signal Corps for membership in the telephone unit, which is a part of the United States Army, the operators are now required to pass a psychological examination to determine their motives for wanting to go abroad.

"Out of 7,500 applications for membership in the unit of telephone girls which has been sent to France, 250 have been selected," is the statement of Capt. Wesson, Signal Corps officer in charge of the unit. One hundred women, in the official olive-drab uniform of the Signal Corps, have been sent abroad, and 150 are awaiting orders in this country.

These girls are stationed in groups of 10 in American bases of supplies and points of embarkation, according to Capt. Wesson. They will not be nearer than 23 miles from the front.

New York State sent the greatest number of telephone operators, and California and Massachusetts tied for second place.

An officer of the Signal Corps, who is experienced in the employment of telephone operators, is in charge of the housing and general welfare of the operators in France.

* * *

The following appointments, authorized by the Secretary of War and made at the military school of aeronautics designated opposite each name, are approved.

To be second lieutenants, Aviation Section, Signal Reserve Corps:

Walter J. Abels, Camp Dick, Tex.; Allen T. Archer, Harold K. Atkinson, George E. Bell, Edward L. Bloom, Richard O. Burr, and Lawrence D. Coffing, Rockwell Field, Cal.; Eugene F. Dugger, Call Field, Tex.; Carl W. Edwards and George J. Golonsbe, Rockwell Field, Cal.; Samuel C. Harrell, Ellington Field, Tex.; Frank K. Hays, Kelly Field, Tex.; Landon Hilliard, Call Field, Tex.; Gero A. Himebaugh, Rich Field, Tex.; Simeon J. Jeffries, jr., Rockwell Field, Cal.; Swift M. Lowry, Kelly Field, Tex.; William C. Morris and William V. Morgan, Rockwell Field, Cal.; Cornelius S. O'Meara, Kelly Field, Tex.; David I. Stoddard and William C. Talbot, Rockwell Field, Cal.; Roy M. Walker, Kelly Field, Tex.; Sanford M. Warren, Fort Omaha, Nebr.

The following appointments in the Officers' Reserve Corps and National Army have been made in the office of The Adjutant General, on recommendation of General Pershing, American Expeditionary Forces, France, to March 25, 1918:

William M. Barbour, first lieutenant, Aviation Section, Signal Reserve Corps.

Sydney W. Beauclerk, first lieutenant, Aviation Section, Signal Reserve Corps.

Robert C. Bedlinger, first lieutenant, Aviation Section, Signal Reserve Corps.

Alfred E. Bennett, first lieutenant, Aviation Section, Signal Reserve Corps.

Leslie B. Cooper, first lieutenant, Aviation Section, Signal Reserve Corps.

Lester B. Cowgill, first lieutenant, Aviation Section, Signal Reserve Corps.

Edmund A. Donnan, first lieutenant, Aviation Section, Signal Reserve Corps.

Joseph F. Gill, first lieutenant, Aviation Section, Signal Reserve Corps.

British Pictorial Svce.

A signal detachment at headquarters, Kara Tepe, Mesopotamia, with the heliograph and buzzer in active use

High Power Stations

Some Features of the Long Distance Stations of the American Marconi Company

By C. H. Taylor

Engineer, Transoceanic Division, Marconi Wireless Telegraph Co.

(*Continued from June* WIRELESS AGE)

TABLES and curves can be drawn up (see figures 4 and 5) showing the relations between the coupling, the number of oscillations for various wave lengths per unit of time, and the stud velocity. The size of the studs and of the electrodes in the direction of motion can be ascertained from them.

The length of the stud at right angles to the direction of motion of the disc is determined by the current capacity of the circuit with which it is to be used, and the side electrodes are built to conform to the dimensions of the stud. The density of the current per inch of sparking surface on these studs should be kept low. From observations made under operating conditions it would appear that one can go beyond the useful maxima that disc studs will handle.

The inductances forming the secondary coil of the coupler, and the loading for the antenna circuit, are built of wire stranded in a manner similar to that described for the primary coil of the coupler. As this wire must be flexible, and as the current maximum is not so great, the amount of copper in this cable is reduced. The cable comprises a number of 7 strand cables laid around a jute core 2½ inches in diameter. Each of the wires of these 7 strand cables is insulated with a double covering of cotton, and the cables spiral around the jute core. A covering of coarse black braid binds the whole group together. Cable of this type is invariably employed in the antenna circuit between the leading-out insulator and the ground connection.

The type of antenna circuit adopted by the Marconi Company is very familiar. The illustration, figure 6, gives a very fair idea of the general arrangement. Advantage is taken of the directive properties of the inverted L type of antenna both with regard to the adjacent receiving stations, as well as to the distant receiving stations. These antennæ are set with their major axes along the line of the true direction of the distant receiving stations. The general dimensions of the circuit depend upon the wave length to be employed.

As the stations we are dealing with were designed to be operated on damped wave trains, and with tone reception, attention had to be given to the dimensions of these circuits, so that the emitted wave trains might have a low decrement, and so that the most might be made of tuning and selectivity at the distant receiving stations. A compromise had to be effected between the antagonistic claims of low decrement and radiation efficiency. The resistance losses of the various parts of the antenna circuit were brought to as low a value as possible. In order to minimise the losses in the ground portion of this circuit the usual group of earth plates were supplemented by a second group, placed under the antenna near the first row of masts, and wires were carried out from the main group of earth plates under the antenna until they reached beyond the last row of masts. These wires were distributed over the surface of the ground in a manner corresponding with the wires in the antenna. In this way the soil of the ground around the station and under the antenna was not entirely depended upon to carry the currents in this circuit. Wires were also extended from the power house, in the opposite direction to that of the antenna, in order to minimise the losses in this portion of the circuit.

As will be plainly evident, it is easily possible to make the decrement too low for the other constants of the installation. By this we mean that continuous decreasing of the decrement will bring us to a value at which the antenna circuit has just ceased emitting one wave-train when it is called upon to absorb energy for the next wave-train. A further decrease will bring us to the state in which the antenna has not completed one wave-train before the energy for the next is

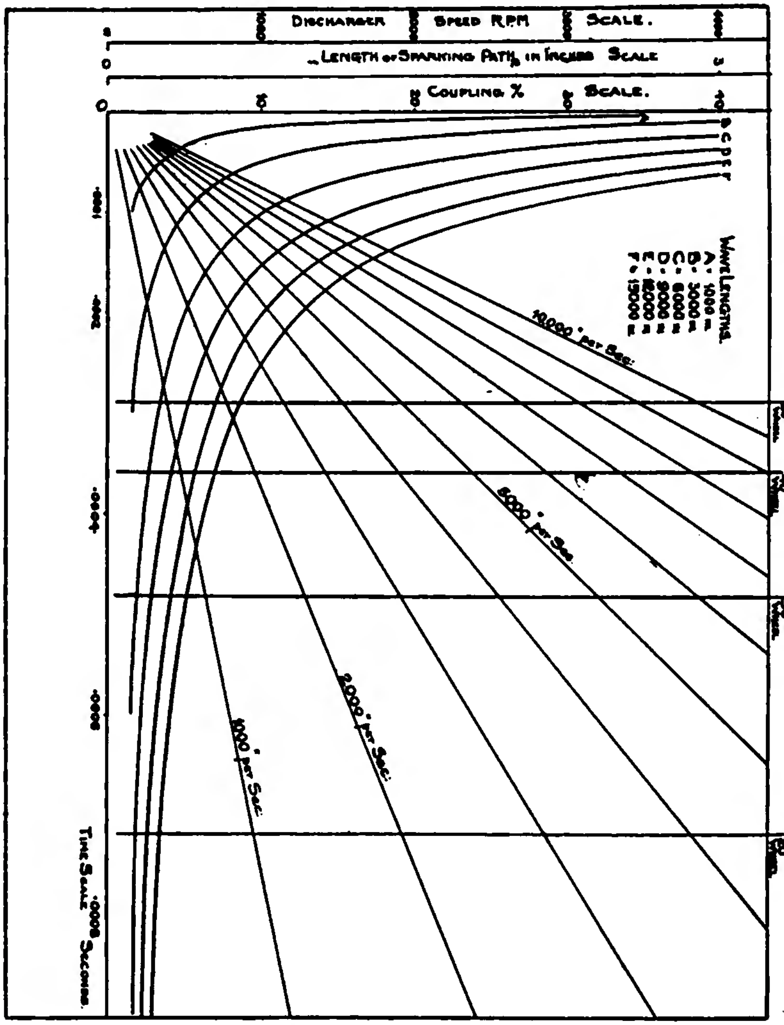


Figure 4—Sparking time, wave-length and coupling

thrust upon it. Such a decrement as this would be too low for a circuit operated as these are, unless there were complete phase harmony between successive wave-trains. As an instance of this we may point to the New Brunswick station. It has a spark frequency of 240, and may be using a wave length of 15,000 meters. Eighty of these oscillations would completely fill the time interval between two successive sparks. Now we must subtract from the complete time interval, the period required to transfer the energy from the primary to the secondary circuit, so that only sixty-eight complete oscillations in the decreasing portion of each wave-train as it left the transmitting station could be allowed. Any lessening of the decrement, that will permit of more than this number of complete oscillations after the antenna is left freely vibrating, will not be of advantage unless the successive wave trains are in correct phase with each other. On the other hand, any increase in the decrement to give a useful clearance between wave trains might involve a breach of the Government regulations. Even the effect of overlapping wave trains, when they are not in correct phase relation, may give the station an apparent decrement that is higher than the real one for the circuit.

It will thus be seen that, so far as the antenna circuit decrement at the trans-

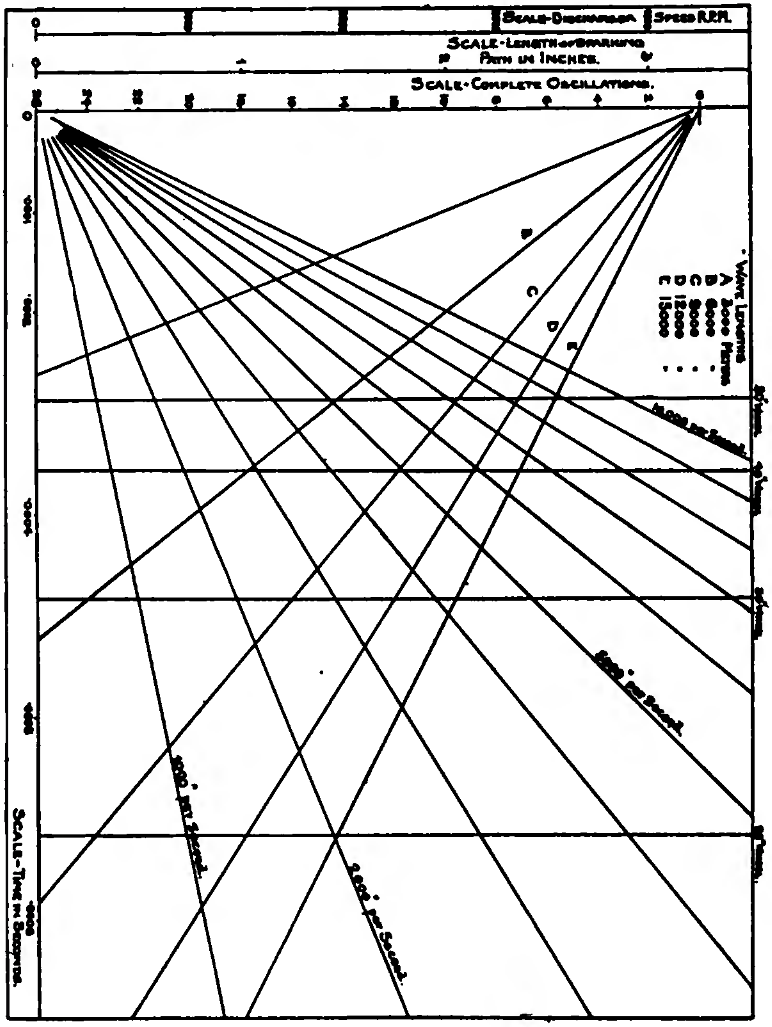


Figure 5—Sparking time, wave-length and complete oscillations

mitting station is concerned, all the demands of the receiving station are not possible of fulfillment. That station would like a very low decrement to the received wave train and a high spark frequency.

In connection with these big antennæ; and in fact, with any antenna that is to be used for continuous commercial work, the atmospheric conditions at and around the station must be taken into consideration in the design. For instance, around New York and north of that city along the Atlantic coast one must expect to experience each winter high winds, snow and sleet storms. Consequently the antenna must be designed to withstand the most adverse of these conditions. Gales can be guarded against without much extra work, but the most severe test is that arising from a combination of snow or ice sleet and wind. If the atmos-

Figure 6—Kahuku receiving station. General view of wireless link between U. S. A. and Japan, in Hawaii

pheric conditions are such as to favour the formation of ice upon the exposed wires of the aerial system; and if, after this has gone on until a cylinder of ice of appreciable diameter has been built around the wires, a wind of moderate velocity starts to blow there will be great danger that some of the antenna wires will break under the increased load. Practical experience has shown that the best method to overcome this trouble is to melt the ice as fast as it is formed. To enable this to be done the antenna wires are grouped together in pairs which run as a loop from the power house to the free end of the antenna and back to the power house, the open ends being at the power house. For normal radio work all these loops end at the power house, and are joined together to a common bus; but in case of necessity they can be cut off from the bus, and each loop (either singly or in groups) can be joined to a suitable 60 cycle circuit, and sufficient current passed through these loops to raise the temperature of each and melt the ice cylinder. At the station in New Jersey an occasion to test out this heating scheme during the early part of 1915 occurred, and it was found that it required 100 amperes per loop to do the work at a reasonable speed. When using this amount of current on wires that were very heavily coated with ice, the effect was apparent within two minutes. The coating of ice had then been melted so that it began to break away, and the loop was quite clear in seven minutes. It is needless to remark that care must be exercised that the current put into the loop is not sufficient to soften and weaken the wire. Treating the antenna wires in this manner interrupts the service for a few minutes, but avoids a possible interruption of some hours.

Another point of interest is the distribution of the current from the foot of the antenna to the grounding system. At these stations the main grounding system comprises two semicircles of metal plates sunk one on the side of the power house nearest to and one on the side opposite to the aerial system. The wires fan out to these plates from the leading out insulators, set in both of these faces of the building, and on that side which is towards the aerial system, the connections to the wires that are laid under the antenna are made over these same wires. Within the power house these two insulators are connected by a copper bus or a length of high frequency cable. At the medial point of this bus the connection to the coupling coil is made, and on either side of this junction a thermal-ammeter is inserted into the bus. In this manner we can see at a glance the values of the current flowing out of the building to each of the two sets of earth plates. These sets of plates are metallically connected together so that the complete ground plate possesses the appearance of a very short cylinder with semicircular ends. It is found that the distribution of the current is not at all equal; the larger proportion flows out on that line that leads directly toward the antenna and the smaller proportion flows out in the opposite direction. This proportion may be as high as 2 to 1 and may vary with the load.

At these long distance stations particular attention has been paid to the receiving end of the circuit. In the early days of commercial radio work the reception was invariably carried out on the same antenna as that used for transmission. This meant that the design of the antenna was treated more with a view to getting good radiation, and the reception had to take care of itself. This was not objectionable so long as very small powers were being used for transmission, but as soon as larger powers were brought into use it was found more expedient to use a separate wire for reception. Although this is an improvement, yet, since the wire is suspended from the same masts as the transmitting wires, the receiving wire is still influenced by the proximity of these other wires, and the response to the incoming signal is not so good as when the receiving wire is suspended from masts with no other antenna connected to them. This pointed the way to a complete separaton of the two functions of these stations, whenever there would be a circuit that had sufficient business to justify the increased expense. At such a station, only considerations affecting the reception of the signals would be entertained, and the antenna would be dcsigned for this separate function.

At these long distance stations this separation has been made, and in consequence each of the two functions of a radio station can be carried on simultaneously—that is to say, the transmitting station can send messages continuously, and the receiving station can receive messages continuously, during the same time over the same circuit.

Advantage was taken of the directive property of the inverted L antenna at these receiving stations. These are located, with respect to the distant and nearby transmitting stations, so that their receptivity was a maximum for the distant station and a minimum for the adjacent one. In order to annul the effect of the adjacent station a compensating antenna is added, also of the inverted L type, and so located that it has its maximum receptivity in the direction of the adjacent station and its minimum in the direction of that of the distant one. By this means the effect of the distant transmitting station can be left unimpaired while that of the adjacent station is reduced to a negligible quantity.

Since the reception is carried on at some point at a distance from the transmitting station, it is found expedient to arrange that the radio operation of the transmitting station be controlled from this same point. This is not a very hard problem. The switch keys that control the condenser circuit are operated through a polarised relay which is inserted in an ordinary land line circuit erected between the two stations. The operator at the receiving station works a land line key, and energises this relay, which, in turn, operates the switch keys and thus controls the radio transmission.

The receiver designed for these stations is of the usual type, with loose coupled circuits built with especial reference to the long waves that were to be employed at these stations. It can be used with both the crystal and the valve detector.

In addition to this, special arrangements permit of the amplification of the incoming signal, so that it could be recorded on a dictagraph cylinder. This record would be made whenever the volume of business necessitated more rapid operation than could be done by hand and ear.

For the operation of this circuit automatically there was installed Wheatstone apparatus with the necessary perforators. Signals sent at a high speed were amplified and recorded on the dictagraph cylinder and transferred from that cylinder by an operator working at a good manual speed. In this manner the circuit could be operated at a speed of from 75 to 100 words per minute.

One advantage that is gained by the separation of the receiving from the transmitting function of these stations is the ability to "break" the operator transmitting. In this there is a great saving of time, and it is found that traffic is moved forward at an appreciably higher rate of speed than when the same stations are not able to work this "break."

It has been found that these independent receiving stations possess very good receptivity, and, in consequence, were rather bothered by the usual atmospheric disturbances and by interference from stations in the vicinity, although these were using much shorter wave-lengths. Some tests were carried out on the comparative receptiveness of wires of shorter length than those proposed

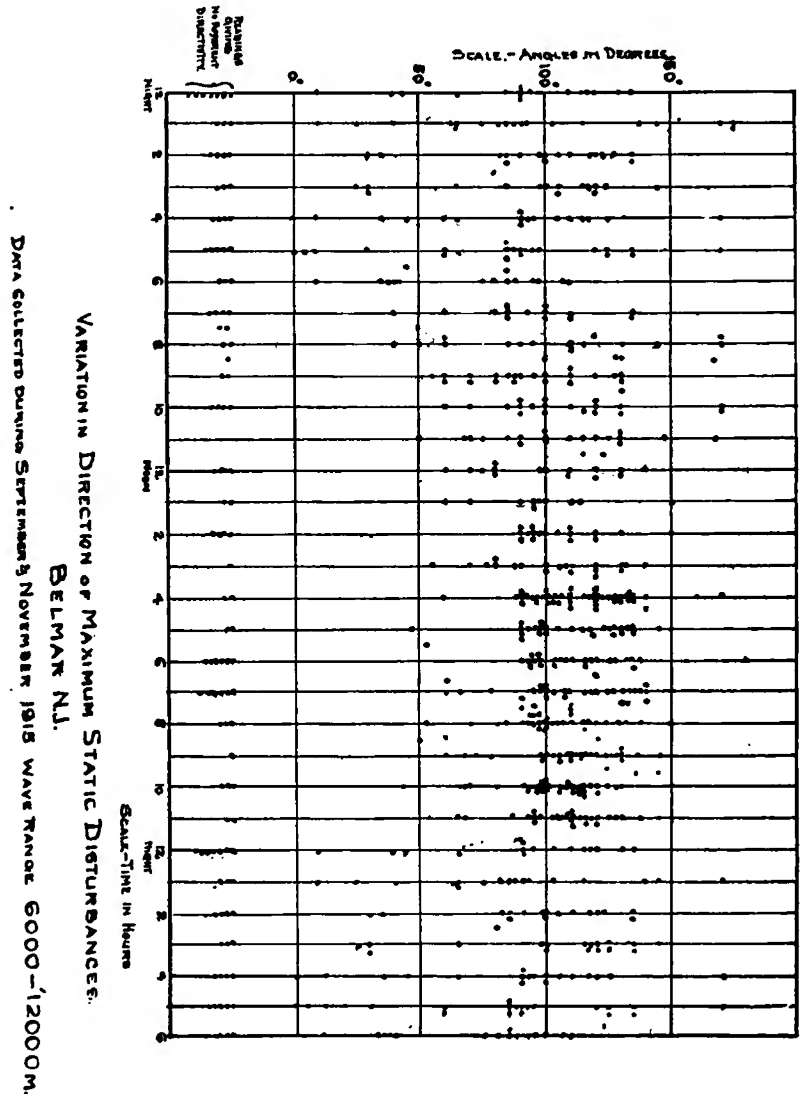


Figure 7—Radio-goniometer tests

for these stations, all wires being suspended at approximately the same height above the earth's surface. It was found that, when shorter wires were used, it was not till the natural of the antenna was increased until it was approximately equal to that of the standard long-wire antenna, did the signals on this antenna attain the same audibility as those on the long wire. Tests were also made on wires suspended fròm 50 to 30 feet above the ground; these gave signals of less audibility than the standard wire, even when the quantity of wire in each antenna was approximately the same.

(*To be continued.*)

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By Captain Fritz E. Uttmark

CHAPTER VIII.

The Earth, Its Form, Rotation and Dimensions—Mass, Weight and Gravitation—The Earth's Mass and Density

IN a science which deals with the heavenly bodies it might seem at first that the earth has no place; but certain facts relating to it are just such as we have to investigate with respect to her sister planets, are ascertained by astronomical methods, and a knowledge of them is essential as a base of operations. In fact, Astronomy, like charity, "begins at home," and it is impossible to go far in the study of the bodies which are strictly "heavenly" until one has first acquired some accurate knowledge of the dimensions and motions of the earth itself.

The astronomical facts relating to the earth are broadly these:

1. The earth is a great ball about 7920 miles in diameter.
2. It rotates on its axis once in twenty-four sidereal hours.
3. It is not exactly spherical, but is flattened at the poles, the polar diameter being nearly twenty-seven miles, or about one two hundred and ninety-fifth part, less than the equatorial.
4. It has a mean density between 5.5 and 5.6 as great as that of water, and a mass represented in tons by six with twenty-one ciphers following.
5. It is flying through space in its orbital motion around the sun with a velocity of about eighteen and a half miles a second; i. e., about seventy-five times as swiftly as an ordinary cannon-ball.

It is not necessary to dwell on the ordinary proofs of the earth's globularity. We will simply mention them.

1. It can be circumnavigated.
2. The appearance of vessels coming in from sea indicates that the surface is everywhere convex.
3. The fact that the dip of the sea horizon as seen from a given elevation, is (sensibly) the same in all directions, and at all parts of the earth, shows that the surface is approximately spherical.
4. The fact that as one goes from the equator towards the north the elevation of the pole increases in proportion to the distance from the equator proves the same thing.
5. The outline of the earth's shadow, seen upon the moon during lunar eclipses, is such as only a sphere could cast.

We may add, as to the smoothness and roundness of the earth, that if the earth be represented by an 18-inch globe, the difference between its greatest and least diameters would be only about one-sixteenth of an inch; the highest mountains would project only about one-ninetieth of an inch, and the average elevation of continents and depths of the ocean would be hardly greater on that scale than the thickness of a film of varnish. Relatively, the earth is really much smoother and rounder than most of the balls in a bowling alley.

There are various ways of determining the diameter of the earth. The best, in fact the only accurate one, is by measuring arcs of meridian, so as to ascertain the number of miles or kilometres in a degree of the earth's circumference.

There are various approximate methods, one of the simplest of which is the following:

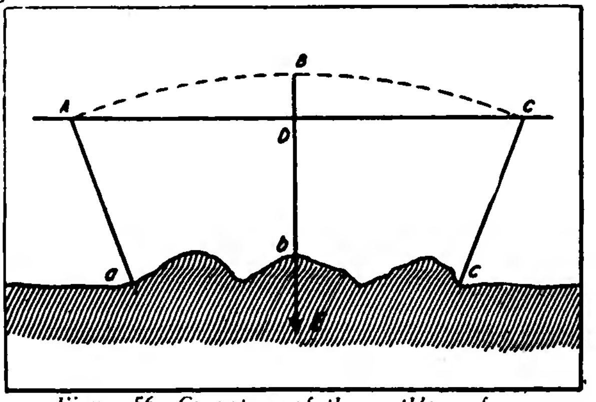


Figure 56—Curvature of the earth's surface

Erect upon a reasonably level plane three rods in line, a mile apart from each other, and cut off their tops at the same level, carefully determined with a surveyor's levelling instrument. It will then be found, on sighting across from A to C (figure 56) that the line after allowing for refraction passes about eight inches below B, the top of the middle rod.

Suppose the circle ABC completed, and that E is the point of the circumference opposite B, so that B E equals the diameter of the earth (i. e., B E = 2 R). By geometry.

$$BD : BA :: BA : BE; \text{ whence } BE = \frac{BA^2}{BD}$$

Now B A is one mile, and B D equals two-thirds of a foot, or $^1/_{7920}$ of a mile; hence B E equals

$$\frac{1^2}{\frac{1}{7920}} = 7920 \text{ miles.}$$

On account of refraction, however, the result cannot be made exact. The necessary correction is large, and varies with the thermometer and barometer; so that the actual observed length of B D instead of being 8 inches, ranges from 5 to 7 according to circumstances.

At the time of Copernicus the only argument he could adduce in favor of the earth's rotation was that the hypothesis is much more probable than the older one, that the heavens themselves revolve. All the phenomena then known would be sensibly the same on either supposition. The apparent diurnal motion of the heavenly bodies can be fully accounted for (within the limits of the observations then possible) either by supposing that the stars are actually attached to a celestial sphere which turns daily, or that the earth itself rotates upon an axis; and for a long time the latter hypothesis did not seem to most people so probable as the older and more obvious one.

A little later, after the telescope had been invented, analogy could be adduced; for with the telescope we can see that the sun, moon, and many of the planets are rotating globes. Within the present century it has become possible to adduce experimental proofs which go still further, and absolutely

Foucault's Pendulum Experiment.—Among these experimental proofs the most impressive is the pendulum experiment devised and first executed by Foucault in 1851. From the dome of the Pantheon in Paris, he hung a heavy iron ball about a foot in diameter by a wire more than 200 feet long (figure 57). A circular rail some twelve feet across, with a little ridge of sand built upon it, was placed in such a way that a pin attached to the swinging ball would just scrape the sand and leave a mark at each vibration. To put the ball in motion it was drawn aside by a cotton cord and left to come absolutely to rest; then the cord was burned off, and the pendulum started to swing in a true plane. But this plane seemed to deviate slowly towards the right, so that the pin on the pendulum-ball cut the sand-ridge in a new place at each swing, shifting at a rate which would carry the line completely around in about 32 hours, if the pendulum did not first come to rest. In fact the floor of the Pantheon was actually and visibly turning under the plane of the pendulum vibration. The experiment created great enthusiasm at the time, and has since been frequently performed.

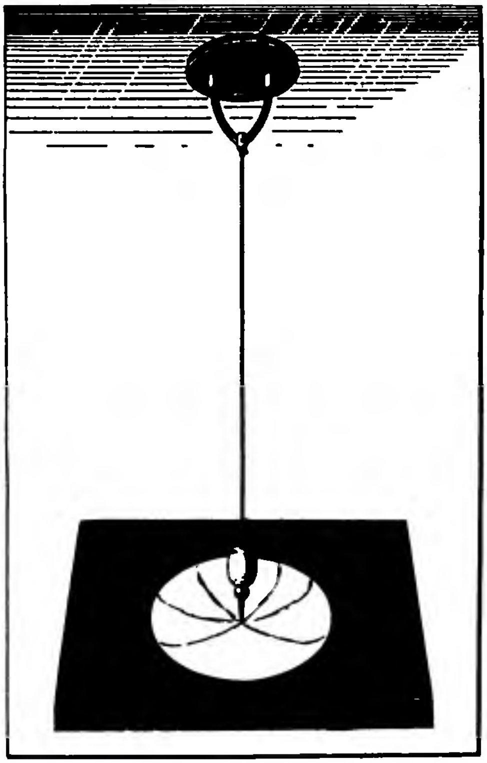


Figure 57.

Invariability of the Earth's Rotation.—It is a question of great importance whether the day ever changes its length. Theoretically, it must almost necessarily do so. The friction of the tides and the deposit of meteoric matter upon the earth both tend to retard the earth's rotation; while, on the other hand, the earth's loss of heat by radiation and the consequent shrinkage must tend to accelerate it and to shorten the day. Then geological causes act some one way and some the other. At present we can only say that the change, if any change has occurred since Astronomy became accurate, has been too small to be detected.

The day is certainly not longer or shorter by the $^1/_{100}$ part of a second than it was in the days of Ptolemy; probably it has not changed by the $^1/_{1000}$ part. The criterion is found in comparing the times at which celestial phenomena, such as eclipses, transits of Mercury, etc., have occurred during the range of astronomical history. Professor Newcomb's investigations in this line make it highly probable, however, that the length of the day has not been absolutely constant during the last 150 years.

Gravity.—What is technically called "gravity" is not simply the attraction of the earth for a body upon its surface, but the resultant of the attraction combined with this centrifugal force. It is only at the equator and at the pole that "gravity" is directed strictly towards the earth's center. Lines of level are always perpendicular to "gravity," and they are, therefore, not true circles around the earth's center. If the earth's rotation were to cease, the Mississippi River would at once have its course reversed, since the mouth of the river is several thousand feet further from the center of the earth than are its sources.

Accurate Determination of the Earth's Dimensions.—The form of the earth, instead of being spherical, is much more nearly that of an "oblate spheroid of revolution" (an orange-shaped solid) quite sensibly flattened at the poles; the polar diameter being shorter than the equatorial by about $^1/_{295}$ part. According to "Clarke's Spheroid of 1866" (which is adopted by our Coast and Geodetic Survey as the basis of all calculations) the dimensions of the earth are as follows:

Equatorial radius,	(a)	6,378,206.4 metres =	3963.307 miles
Polar radius,	(b)	6,356,583.8 metres =	3949.871 miles
		21,622.6 metres =	13.436 miles

These numbers are likely to be in error as much, perhaps, as 100 metres, and possibly somewhat more; they can hardly be 300 metres wrong.

This deviation of the earth's form from a true sphere is due simply to its rotation, and might have been cited as proving it. The centrifugal force caused by the rotation modifies the direction of gravity everywhere except at the equator and the poles so the surface necessarily takes the spheroidal form.

Methods of Determining the Earth's Form.—There are several ways of doing this; one by measurement of distances upon its surface in connection with the latitudes and longitudes of the points of observation. This gives not only the form, but the dimensions also; i. e., the size in miles or metres. Another method is by the observation of the force of gravity at various points—observations which are made by means of a pendulum apparatus of some kind, and determine only the form of the earth, but not its size.

The simplest form of the method by actual measurement is that in which we determine the length of degrees of latitude, some near the equator, and others near the poles, and still others intermediate.

If the earth were exactly spherical, the length of a degree would, of course, be everywhere the same. Since it is not, the length of a degree will be greatest where the earth is most nearly flat; i. e., near the poles; in other words, the distance between two points on the same meridian having their plumb-lines inclined to each other at an angle of one degree will be greatest where the surface is least curved.

The measurement of an "arc" involves two distinct sets of operations, one purely astronomical, the other geodetic. Having selected two terminal stations several hundred miles apart, and one of them as nearly as possible due north of the other, we must determine first the distance between them in feet or metres, and second (by astronomical observations), their difference of latitude in degrees, with the exact azimuth or bearing of the line that connects them.

The Length of a Degree of Latitude.—The geodetic and astronomical observations thus give the length of the line Ah, both in feet and in degrees, so that we immediately find the number of feet in that degree of latitude which has its middle point halfway between A and h. If the earth were spherical, the length of a degree would be everywhere the same, and the earth's diameter would be found simply by multiplying the length of one degree by 360 and dividing the product by 3.1415926.

More than twenty such arcs have been measured in different parts of the world, varying in length from 25° to 2°, and it appears clearly that the length of the degrees increases towards the pole.

At the equator,	one degree =	68.704 miles
At lat. 20°	one degree =	68.786 miles
At lat. 40°	one degree =	68.993 miles
At lat. 60°	one degree =	69.230 miles
At lat. 80°	one degree =	69.386 miles
At the pole,	one degree =	69.407 miles

The difference between the equatorial and polar degree of latitude is more than seven-tenths of a mile, or over 3,500 feet; while the probable error of measurement cannot exceed a foot or two to the degree.

(To be continued.)


Press Ill. Svce.

The Hun flag has been at half mast on this submarine since she was captured by the British, while engaged in her nefarious task of mine laying in the path of transports. Just fore and aft of the base of the conning tower may be seen the mines, lashed in cradles, as they are carried into the zone of operations. On a level with the head of the man on the "bridge," and slightly to the left, is the lower spreader of the wireless aerial, the other end of which is suspended from the mast. While this submersible is of a type smaller than those which have been operating in American waters, the view is interesting because of the daily more patent fact that a portion of the destruction to shipping in our waters has been effected by means of mines similar to those here illustrated

Navigation News

More Concrete Ships Ordered

America's first quantity output of concrete ships will be a fleet of tankers for the fuel oil trade. There will be 14 of them, aggregating 105,000 tons. Plans for these additions to the merchant marine have been announced by the concrete ship division of the Shipping Board. The concrete ship program also has been enlarged to provide for the construction of four smaller vessels, aggregating 12,500 tons, and 40 additional ones of 7,500 tons each.

✠ ✠ ✠

Fourth of July A Ship Day

July 4 will be launching day in American shipyards. Builders of the new merchant marine, from Maine along the Atlantic, Gulf and Pacific coasts to Seattle, Wash., and throughout the Great Lakes district, are asked to speed the production of ships, so as to have at least one vessel ready for launching on the anniversary of the Declaration of Independence.

If this plan, suggested by Edward N. Hurley, Chairman of the United States Shipping Board, proves a success, July 4, 1918, will be the greatest ship launching day in the history of the world. It is hoped that President Wilson will take cognizance of the event and participate in the launching ceremonies at one of the shipyards.

Chairman Hurley has sent a telegram to all the yards, asking that every effort be made to have at least one Emergency Fleet vessel ready for launching on America's natal day.

✠ ✠ ✠

300,000 Shipyard Employees

Evidence of an awakened interest in building the bridge of ships to France is manifest not only in tabulated reports showing the output of the yards for certain periods, but in reports reaching the officials of the Emergency Fleet Corporation direct from among the men in the ranks.

From the official point of view it is interesting to know that the number of shipyard employees has passed the 300,000 mark. On October 7, when the keeping of records was first begun, there were 106,900 employees according to information supplied by Meyer Bloomfield, head of the Industrial Service Section. In seven months the number of workers has been increased by nearly 200,000—to be exact, 193,000. This fact speaks for itself as to whether the workingmen of the nation have been interested by the cry for ships.

✠ ✠ ✠

Song of the Shipbuilder

We work in the oldest stuff of the world—
Water and iron and fire and air.
And the courage of men with a flag unfurled,
To build a bridge from here over there.

With a fleet of ships we'll span the sea,
To carry supplies to you in France—
Guns and food and T. N. T.—
And whatever you need for the big advance.

And what's the difference where we work—
At a bench with a hammer, or a trench at the front?
We all are needed and will not shirk;
We are done with delays! Count us in at the hunt.

And what's the difference how we fight—
With blood or money, labor or guns?
We'll keep the bridge building day and night,
Till we trestle the sea to get to the Huns.

And what's the difference where you are?
We're all on the job with a will to win;
So, boys, do your bit with your gun in the war;
We're doing our bit with the rivet machine.

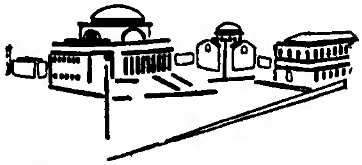
We'll keep the bridge building night and day;
We'll speed up ahead of the submarine.
We'll build to you, boys, so keep 'em at bay;
We're doing our bit with the rivet machine.

Boys, keep up your courage, we're getting to you,
Khaki or overalls, count us all in—
Knapsacks or dinner pails, we're fighting, too,
And doing our bit with the rivet machine.

In camp or the shipyard we all of us swear
That the hope ye are building will span to Berlin;
We're all of us soldiers, to do or to dare;
And we're doing our bit with the rivet machine.

LOUIS K. ANSPACHER.

Progress in Radio Science



A Generator of Sustained Oscillations

J. BETHENOD has recently perfected a powerful vacuum tube generator for undamped oscillations based upon the cathodic radiation from such substances as alkaline earthy oxide, lime, etc., or perhaps ultra-violet light.

With the apparatus shown in figure 1, the inventor claims to have produced a more powerful generator of sustained oscillations by the use of a single bulb than has heretofore been possible. He remarks that the vacuum is preferably as high as possible for satisfactory operation of the system. Referring to the diagram, a direct current generator is shown at 3, a shunt condenser at 9, the envelope or the vacuum tube at 1, two parallel plates at 4 and 4′, a cathode at 2, and 2 electrodes 5 and 5′. The coil 6, is placed in inductive relation to coil 7 which is in turn shunted by the variable condenser 8. The operation of the system follows:

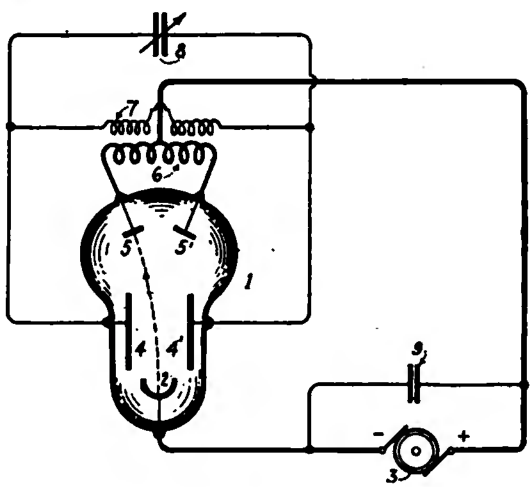


Figure 1—Powerful generator of sustained oscillations by the use of a single bulb

Because of the accelerating action of the field created by the generating dynamo 3 between the cathode 2 and the two electrodes 5 and 5′ the negative charges emitted pass between two plates 4 and 4′, which form, in a sense, the coatings of a condenser. These are connected to the ends of one winding 7 of a transformer, of which the other winding 6 has its middle point connected to the positive pole of the generating dynamo 3. Under these circumstances, the condenser formed by the plates 4 and 4′ is charged sufficiently to concentrate the cathodic beam on the anode 5′. This displacement causes a reversal of the electric field, and results finally in the cathode beam being deflected very rapidly between the anodes 5 and 5′. The continual reversal of the electro-motive force thus induced in the coil 7 may be utilized by arranging for example a condenser 8 across the terminals of the generator 3 to obviate the passage of any high-frequency current. As a protection to the generator, condenser 9 may be shunted across the terminals.

A Variable Condenser and Inductance for a Receiving Circuit

IT is desirable in such apparatus as decremeters, tuning condensers, etc., that the capacity of the condenser increase directly with the position of the movable plates.

The usual variable condenser used in tuning radio receiving apparatus consists of a set of movable plates and stationary plates of semi-circular sections. As is well known, such a condenser does not give equal increments of capacity for equal angular displacements of the plates. Several inventors have designed variable condensers of various forms in which the desired increment of capacity is obtained, but one particular construction recently evolved by F. Lowenstein to constitute the variable element of an oscillation circuit is shown in figure 2.

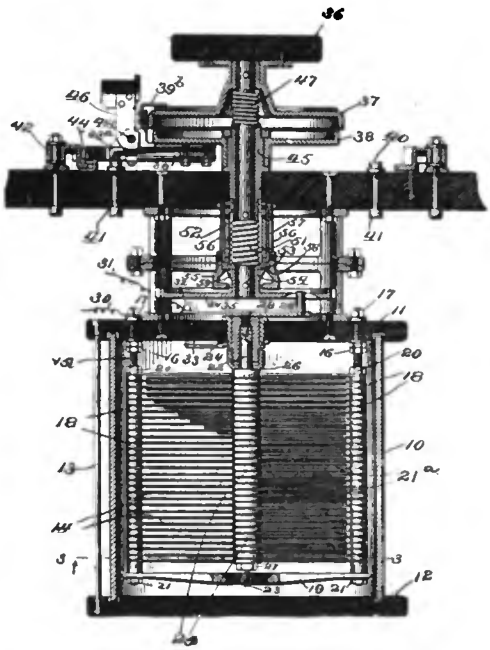


Figure 2—Vertical section of the cut off plate condenser connected mechanically to a variable inductance

In order that the same percentage change in capacity C may be produced by a given displacement of the movable plates at any point X on the characteristic or operating curve of the instrument, it is necessary that

$$\frac{C_n - C_{n-1}}{C_{n-1}} = \frac{C_{n+1} - C_n}{C_n}$$

whence

$$C_n^2 = C_{n-1} C_{n+1}$$

or

$$C_n = \sqrt{C_{n-1} C_{n+1}}$$

The variations in capacity of the condenser must therefore follow the law of geometrical progression. The equation of the characteristic can be deduced from this consideration, and may take the form

$$C = a \left(\frac{b}{a} \right)^{\frac{x}{d}}$$

where *a* and *b* are the lower and upper operating limits of the condenser capacity and *d* is the maximum displacement of the instrument.

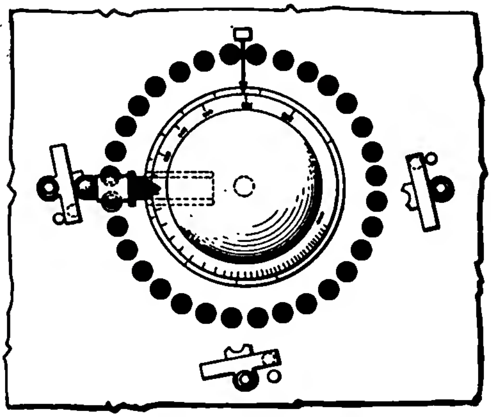


Figure 3—Plan of the apparatus shown in figure 2

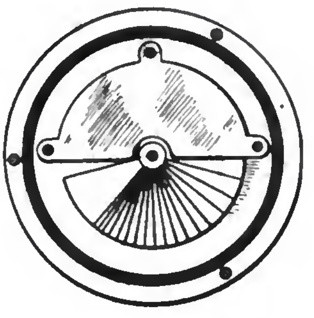


Figure 4—Transverse section of figure 2 viewed from below

An equal expression is derived from the fundamental consideration that

$$\frac{\Delta C}{C} = \text{a constant.}$$

By integrating and transforming,

$$C = pe^{nx}$$

where p and n are instrument constants, and e is the base of Napierian logarithms.

For a rotary condenser, such as is later described, the equation may be written

$$C = pe^{m\theta}$$

where θ is the angle of displacement in degrees.

From the foregoing it is evident that the active area of the movable surface of a condenser constructed in accordance with the invention, neglecting edge effects, is

$$A = qe^{m\theta}$$

In this equation the constants q and m influence the minimum and maximum capacity values and therefore the operating range of the condenser.

A condenser embodying the Lowenstein principles, giving the desired operating curve, can be made by making the superposed condenser plates semi-circular and of the same size as usual, while the movable plates are cut off at such different angles as to produce the desired logarithmic characteristic. In figure 2 is shown a vertical section of the cut off plate condenser which is connected mechanically to a variable inductance shown partly in elevation. Figure 3 is a plan of the apparatus shown in figure 2 and figure 4 is a transverse section of the line 3—3 of figure 2, viewed from below, the casing having been removed. It will be seen that the movable plates, with the exception of a few at the top of the set which are fully semi-circular are cut off at angles which are progressively graded from the top downward. As a result, the edges of the movable set of plates are arranged in step-like fashion, so that they enter successively between the stationary plates as the shaft is turned. The proportioning of the plates and their arrangement is such that the capacity of the condenser is variable substantially in accordance with the logarithmic law previously given. Futhermore, the change in capacity is much more gradual than in a condenser of other known types.

The condenser shown in figure 2 is associated with a variable inductance element, also logarithmic in character, in such a manner that both inductance and capacity may be varied together in a reciprocal relation, or each may be varied independently.

The mechanism will be briefly described, however, for the sake of clearness.

In the arrangement illustrated, the movable part of the condenser is turned by means of the crank 28, crank pin 29, crank disk 34, vertically movable shaft 35, and rubber knob 36. Attached to the shaft 35 is an upper clutch disk 37. To a lower clutch disk 38 is attached a self-inductance arm 39 carrying brush 39^a and wave length pointer 39^b, the brush being arranged to make contact successively with the contact points 40, these latter being electrically connected by means of studs 41 and suitable leads with the tapping-off points of a suitable self-inductance coil (not shown). At 42 are pivotally mounted switches, each provided with a bifurcated projecting portion 43 so disposed that one or the other of the arms of the portion always lie in the circular path traversed by actuating stud 44 carried by the self-inductance arm. As the self-inductance arm is moved in counter-clockwise direction, the self-inductance increases, the stud acting successively on the switches 42 to cut in additional sections of the inductance coil. The lower clutch disk 38 is arranged to be turned individually on a post 45 by means of a handle 46. Spring 47 surrounding the vertically movable shaft 35 is compressed between the upper end of post 45 and the upper clutch disk 37, thereby tending to maintain the clutch members out of mutual engagement. Handle 46 is here shown as pivoted at 48, whereby it may be turned down to press brush 39^a into firm contact with any of the contact points.

Both the condenser and the self-inductance can therefore be varied independently, as for example in tuning a wireless circuit. Once tuning has been accomplished, the rubber knob 36 may be pushed down to engage clutch 37-38, and turning of the knob will then cause an equal angular displacement of the capacity and of the self-inductance. The capacity scale 49 and wave length scale 50 are both carried by the upper clutch member 37. Stationary pointer 49^a indicates the capacity readings, while wave lengths are indicated by the pointer 39^b, before mentioned. In the present instance, clockwise movement of the knob, when the clutch is engaged, causes the capacity to increase and the self-inductance to decrease. To obviate the necessity of holding the knob 36 depressed during the turning of the coupled elements, a compression spring 51 is provided to keep the clutch members in engagement. This spring is confined between the lower end 52 of stationary post or sleeve 45 and washer 53, which latter rests on the hub 54 of the crank disk 34, the crank disk being secured to the vertically slidable shaft 35. The spring therefore tends to force the shaft downwardly to bring the clutch members into mutual engagement and thereby to mechanically couple the inductance and capacity elements. The spring is of sufficient strength to overcome the opposing spring 47. In the position of the parts here shown, spring 51 is prevented from depressing the upper clutch member by means of latch members 55 which are carried on leaf springs 56 secured to a sleeve 57. The leaf springs press the latch members inwardly so that their shoulders 58 may engage the under side of the washer 53. When the knob 36 is pushed down, the sloping cam surfaces 59 of the crank disk hub throw the latches 55 outwardly, thereby releasing washer 53 and the spring 51 confined thereby, the clutch being thereafter held in engagement by the spring.

Next Month

The Pan-American Wireless Project

Press Ill. Svce.

During the course of forty years' preparation for war, Fritz invested a lot of money in wireless apparatus which has had doubtful utility in service. The telescopic mast illustrated above fulfills all expectations as to quick erection, but proved an excellent mark for the practice of allied artillery. Considerations of weight and difficulties in portability made this type of mast practical only for division headquarters use, whereupon it became very useful to our gunners in aiding the shelling of Hun major generals. The outfit, as a matter of fact, was designed to accompany the high Hindenberg disciples on the march, since slightly delayed, which was to end with a joyous crackling of congratulations from Paris to Berlin.

Press Ill. Svce.

Contrary to the impression first gained of the picture, it is not that of a posed group, but represents the temporary suppression of activities by a French signal detachment at Verdun. Heavy shelling having cut off wire communication, these men were detailed to establish a signal station for daylight signaling by searchlight beam. The messenger has just delivered a dispatch, which is being read while the man with the pipe is deciphering the message which the soldier seated is writing. However, no immediate problem concerns the soldier standing near the rifles greater than solving the assembly of the "makin's" of a cigarette. Hustle and bustle are always associated with war in the popular mind and once again in this picture, as in many others from the zone of operations, the calm assurance of the fighting men makes it difficult to realize how actively engaged are the French signalists in providing continuous communication between all arms of the service and to field commanders.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE XV

By Elmer E. Bucher

Director of Instruction Marconi Institute

EDITOR'S NOTE—This is the fifteenth 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.

ERRATA

In the June issue, page 755, the three last lines of the paragraph following the title "OPERATION," should have read as follows:

termination of a wave train leaks to earth through the head telephone, impulsing the telephone diaphragm once for each group of incoming oscillations. A circuit of this kind does not possess the tuning qualities of the coupled circuits.

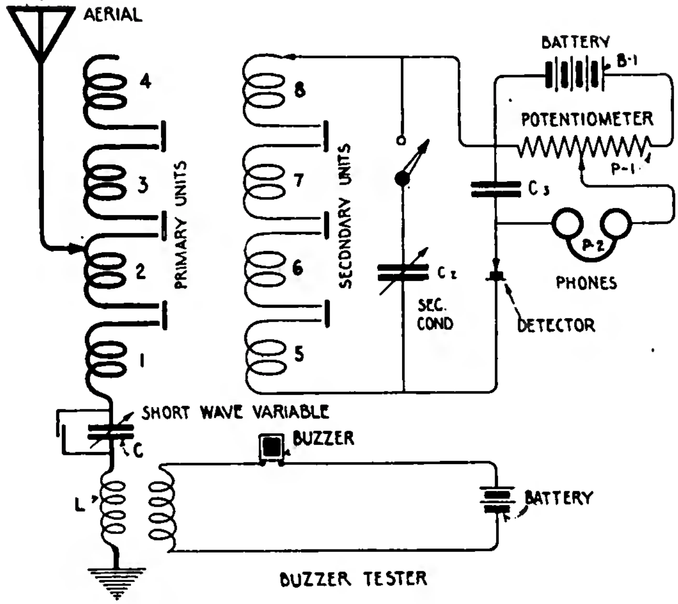


Figure 133

OBJECT OF THE DIAGRAM

To show the fundamental circuits of the type 106 receiving tuner (of the American Marconi Company) using a crystal rectifier.

DESCRIPTION OF THE DRAWING

The **primary circuit** comprises the inductance units 1, 2, 3, 4, the short wave variable condenser C, and the small coupling coil L. The **secondary circuit** embraces the inductance units 5, 6, 7, 8; the secondary shunt condenser C-2, the battery B-1, the potentiometer P-1, the telephone P-2, and the telephone condenser C-3. A buzzer **excitation system** includes the coil L-1, the buzzer B-2, and the battery B-3.

The **coupling** between the primary and secondary coils is varied by means of a gear rack controlled by a knob mounted on the front of the tuner cabinet. It has a scale marked from zero to ten.

The **inductance of the primary circuit** is varied by means of two multipoint switches, one of which operates in conjunction with a switch barrel which disconnects the unused turns of the primary winding for any particular wave length.

The four groups of the primary (1, 2, 3, 4) are cut into the circuit progressively as the wave length is increased. The aerial tuning inductance is included in the **"tens"** switch of the primary winding. The **"unit"** switch controls ten single turns of the primary coil permitting any number from one to maximum to be included in the antenna circuit. The **short wave variable condenser** is automatically short-circuited when moved slightly beyond the 180° position on the scale.

The secondary coil also is fitted with an **end turn switch** which splits the winding into three groups. The secondary variable condenser in the zero position is disconnected from the circuit, thereby eliminating the capacity effect between opposite plates when the pointer is in the so-called "zero" position of capacity.

A special wire-wound **potentiometer** is supplied, having resistance of about 450 ohms. This is adjusted by a rotary multipoint switch. The receiving **detector** is mounted on the front of the panel (see figures 134 and 135). It consists of a steel contact point mounted on an arm which is supported by a universal joint. The steel point may be placed in contact with any spot in the crystal, which is mounted in a cup underneath.

OPERATION

The primary and secondary circuits of the receiving tuner may be calibrated by a wave meter, so that the operator can pre-adjust the apparatus to any desired wave length.

The primary circuit cannot be calibrated until the apparatus is connected to an aerial because the capacity and inductance of ships' aerials differ widely. It is therefore evident that a primary winding with given dimensions will afford different wave length adjustments with different aerials.

In event that the secondary circuit is calibrated in wave lengths, the operator may select the correct inductance and capacity for the desired signal. He then places the secondary winding in partial inductive relation to the primary winding following this by varying the capacity and inductance of the antenna circuit until response is secured. The potentiometer is now re-adjusted, new points on the crystal rectifier are tried, with simultaneous variation of the coupling of the receiving transformer, until the loudest possible signals are secured.

If a scale of wave lengths for the receiving tuner is not supplied, resonance can be established with a given transmitter in the following manner:

(1) Set the secondary circuit approximately to the required wave length using large values of inductance and small values of capacity;

(2) Couple closely the secondary coil to the primary coil;

(3) Increase (or decrease) the inductance in the antenna circuit until response is obtained in the head telephone;

(4) Adjust the detector to maximum sensitiveness by the potentiometer;

(5) Adjust the detector for maximum strength of signals or until interference is eliminated;

(6) Reduce the coupling of the receiving transformer;

(7) Try other values of secondary inductance and capacity; similarly for the antenna circuit.

SPECIAL REMARKS

(1) Selectivity, that is, discrimination between interfering stations depends markedly upon the coupling of the receiving transformer. If the primary and secondary coils are coupled closely, a greater amount of energy will be extracted from the incoming oscillations than with lesser coupling. This will increase the damping. The antenna circuit will under these conditions act as an oscillation circuit whose resistance has been increased, namely, **it will respond to frequencies slightly off the fundamental frequency of the circuit.**

(2) If, on the other hand, the primary and secondary circuits are coupled **loosely,** smaller amounts of energy will be extracted from the antenna oscillations. The antenna will therefore oscillate with **greater persistence** and will only respond with freedom to waves the **frequency of which coincides with its natural frequency of oscillation.**

(3) In summary, if the two circuits are **closely coupled, broad tuning** will result, or if **loosely coupled, sharp tuning** will result. In other words, when the receiving transformer coils are loosely coupled a **small change of inductance or capacity will eliminate the signals from a given station, but when tightly coupled a much greater change of inductance or capacity will be required to eliminate the signals.**

(4) We may say in general, that an advancing wave of feeble decrement permits the primary and secondary circuits to be loosely coupled, but a highly damped wave requires these circuits to be closely coupled.

(5) If only small inductances are required at the base of the receiving aerial to establish resonance with the transmitter, sharper tuning will be secured by connecting a variable condenser in series, adding inductance until resonance with the desired wave is secured. This tends to decrease the natural decrement of the receiving antenna but generally results in a decrease in the strength of signals. The loss of signal strength, however, is more than compensated for by the degree of selectivity obtained.

(6) In general, more accurate tuning or great selectivity is secured in the secondary circuit when the shunt variable condenser is worked at small values of capacity with correspondingly large values of inductance. But if loose coupling is employed, greater values of capacity and lesser values of inductance may give increased selectivity.

(7) In summary, interference can be prevented:

(1) By employing loose couplings between the primary and secondary coil;

(2) By inserting a condenser in the antenna circuit and adding inductance until resonance is secured for a given wave length.

(8) As the transmitter operates at approximately the wave length to which the secondary circuit of the receiver is adjusted it produces strong signals, which are liable to impair the sensitiveness of the crystal. To obviate this, connections are made with the antenna switch so that when it is in the transmitting position, the terminals of the detector and secondary condenser are short-circuited. Care should be taken to

see that the antenna switch with which this receiver is to be used is constructed so as to perform the above operations. If this is done, the transmitter has very little or no effect on the sensitiveness of the crystal, and it will therefore be in a sensitive condition for receiving immediately after transmission.

Figure 134—Front view of the Marconi type 106 receiving tuner. The two switches on the front marked "Transformer Primary" vary the inductance of the primary circuit. The switch marked "units" cuts in a single turn of the primary coil at a time. The switch marked "tens" varies the primary inductance in groups of ten turns at each point of contact. The primary condenser is connected in series with the antenna circuit. The switch marked "transformer secondary" and the control handle marked "secondary condenser" control the inductance and capacity of the secondary circuits. The control handle marked "potentiometer" varies the flow of current through the detector. The switch marked "battery" turns the local battery current on and off. These terminals are connected to four dry cells in a separate box. The terminals marked "telephones" are the binding posts for connections to 2,000 ohm telephone receivers.

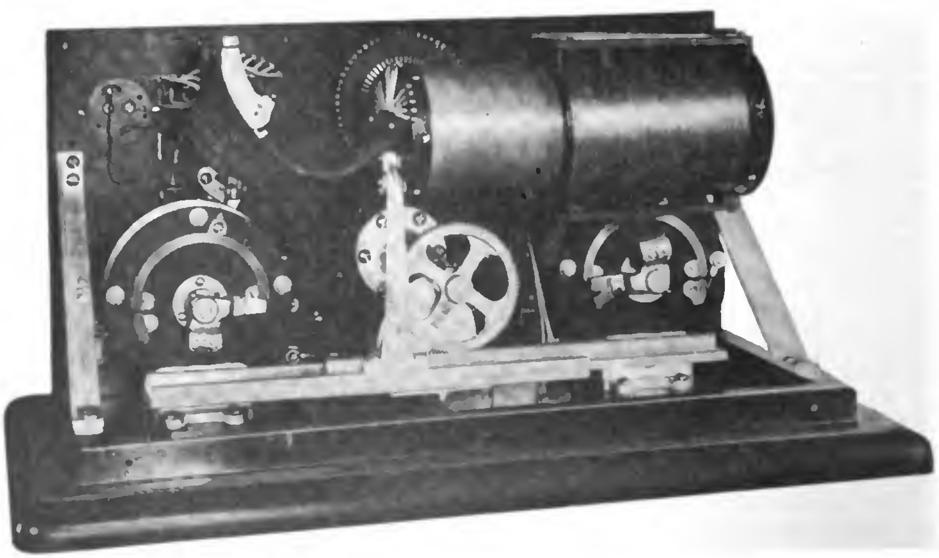


Figure 135—Rear view of the Marconi type 106 receiving tuner showing the receiving transformer, the two variable condensers, the potentiometer, and the special rack and gear for changing the coupling of the transformer.

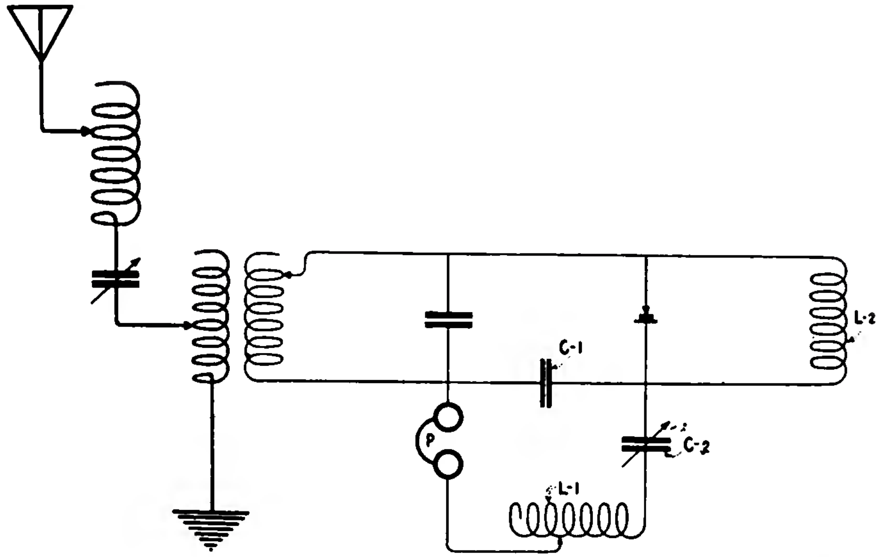


Figure 136—Showing the circuits of the group frequency tuner developed by the American Marconi Company. A fixed condenser C-1, a variable condenser C-2, the variable inductance L-1, and the telephone P constitute a circuit which is selective to audio frequencies. The receiver therefore may be tuned to the group frequency of the transmitter as well as to the incoming radio frequency current. Additional selectivity is thus afforded. The coil L-2 shunted across the detector amplifies the incoming signal considerably. The inductances L-2 are approximately 1,000 times the inductance of the secondary coil. Inductances L-1 and L-2 are approximately of the same dimensions.

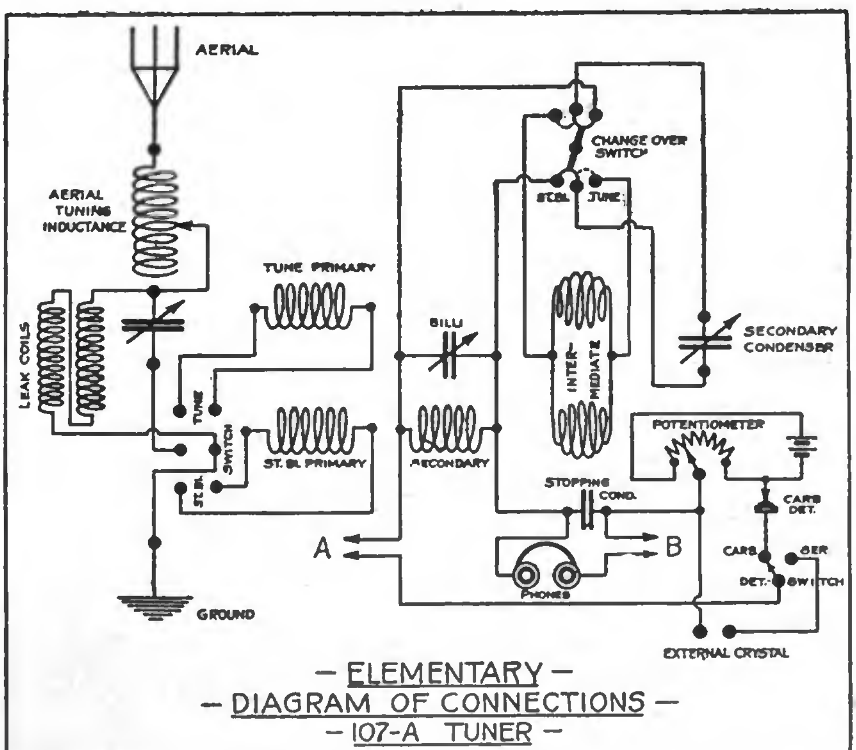


Figure 137.

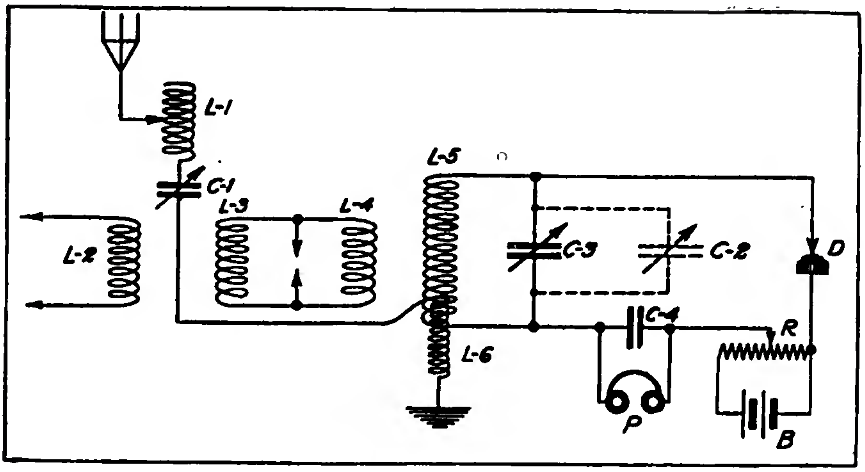


Figure 138.

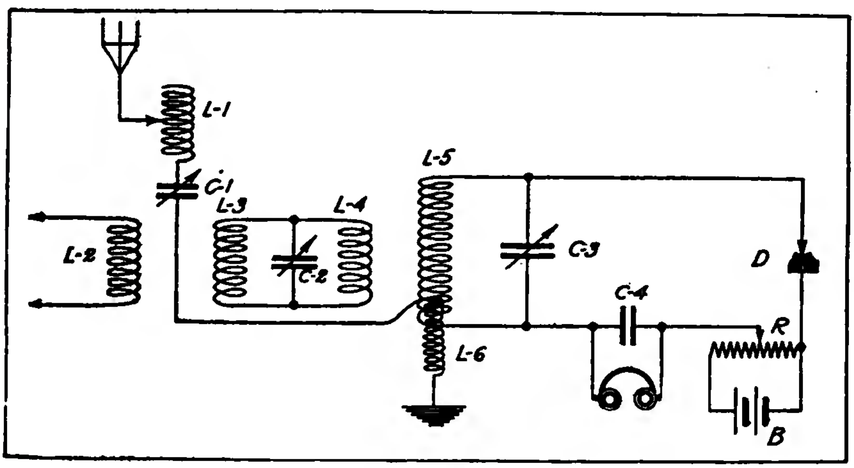


Figure 139.

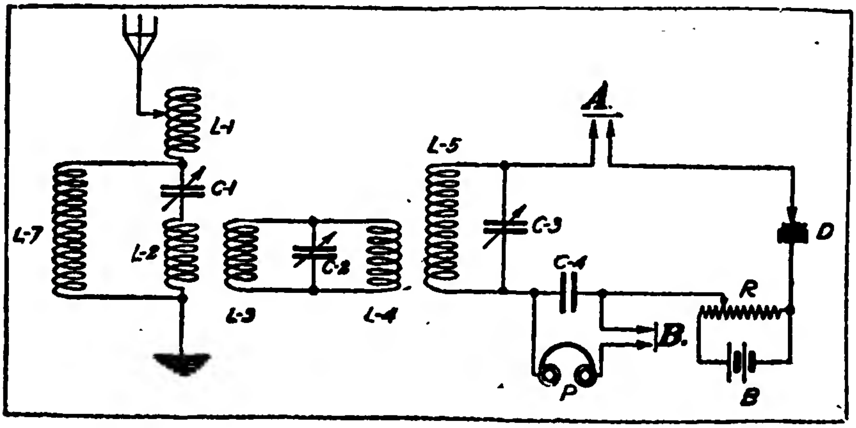


Figure 140.

OBJECT OF THE DIAGRAMS

(1) Figure 137. To indicate the complete connections of the type 107a receiving tuner of the American Marconi Company.

(2) Figure 138. To show the connections of the "stdbi" long wave adjustment of the type 107a tuner.

(3) Figure 139. To show the connections of the "stdbi" short wave adjustment of the type 107a tuner.

(4) Figure 140. To show the "tune" circuits of the type 107a tuner.

PRINCIPLE

A type of receiving tuner introduced into commercial practice about four years ago is fitted with what is termed an "INTERMEDIATE" tuning circuit which provides increased selectivity and aids in the elimination of static interference.

DESCRIPTION OF THE DRAWINGS

In figure 137 the **antenna circuit** comprises the aerial tuning inductance, the short wave variable condenser, two primary coils—one marked "tune primary," the other "stdbi primary"—and the inductive leak coils shunted around the primary circuit and the short wave condenser.

The **intermediate circuit** comprises the two windings (marked L-3, L-4 of figure 140) and a secondary condenser which can be placed in shunt to these two windings or in shunt to the billi condenser which ordinarily is connected across the secondary coil. This is effected by means of the **changeover switch** in the upper part of the drawing marked "stdbi" and "tune."

The **secondary or detector circuit** comprises the secondary coil, the shunt billi condenser (.0001 microfarad capacity) the stopping condenser, the potentiometer, batteries, carborundum detector, and a special detector switch so that either the carborundum or cerusite detectors may be employed. The telephone condenser is shunted by a telephone of about 2000 ohms resistance.

For protection from the local transmitter, the secondary circuits are opened at points A and B (figure 137) during transmission.

In figure 138 are shown the connections for the **"stdbi" long wave adjustment.** The primary coil L-6 is placed in close inductive relation to the secondary winding L-5, the primary coil L-2 and the coils L-3 and L-4 of the intermediate circuit being disconnected. The condenser which ordinarily shunts the intermediate circuit is now connected in shunt to the billi condenser C-3. This affords increased wave length adjustment.

In figure 139, the intermediate condenser C-2 is disconnected from C-3. Because of its capacity at the zero position on the scale it increases the wave length of the secondary circuit beyond the value desired. The tuner in this position is in proper adjustment for receiving **short waves with close coupling.**

In figure 140 are shown the complete "tune" circuits of the type 107a tuner, wherein the **primary, intermediate,** and **secondary circuits** complete are employed; that is, coil L-2 is placed in inductive relation to L-3, and coil L-4 in inductive relation to L-5.

OPERATION

With this tuner three possible circuits may be used. There is a **"stdbi" adjustment for (1) long and (2) short waves, and a (3) "tune" adjustment for short waves.** Connections from one to the other are made by means of the switch (figure 137) marked "change-over switch." When thrown to the right (on the actual apparatus) the primary, intermediate, and secondary circuits are in use, but when thrown to the left, the antenna coil marked "stdbi primary" is coupled directly to the secondary coil. A fixed coupling is employed. If, with the "stdbi" adjustment the condenser change-over switch is thrown to the position "stdbi," the intermediate condenser is connected in shunt to the billi-condenser across the secondary winding thereby permitting increased wave length adjustments.

With the **"stdbi" long wave adjustment** connections of figure 138 the primary winding L-2 is disconnected from the antenna circuit, and the secondary winding L-5 inductively coupled to L-6. L-6 is a fixed inductance wound tightly around the turns L-5 affording a very close coupling between the aerial and detector circuits.

It is clear that coil L-4 of the intermediate circuit is still in inductive relation to L-5, and the precaution should therefore be taken to turn the coupling knob to the zero position, for otherwise energy will be withdrawn from the detector circuit reducing the strength of the incoming signals. This absorption is more apt to take place when the intermediate condenser C-2 is connected across the inductances L-3 and L-4.

For tuning to waves up to approximately 1000 meters with "stdbi" connection, the billi-condenser only is employed. For longer wave lengths, the six-point double throw switch mounted on the top of the tuner (marked "change-over switch" in figure 137) is placed in the "stdbi" long wave position. This connection permits waves up to 3,000 meters to be recorded.

The "stdbi" short wave circuits are shown in figure 139, the only difference between them and those of figure 138 being that the condenser C-2 is connected in shunt to the intermediate circuit. The condenser C-3 is employed to tune the secondary circuit to resonance. With this connection tuning is accomplished by setting the condenser switch at "tune," and the coupling knob (of the intermediate circuit) at zero; then carefully adjusting the billi condenser. Next connect in a few points of the aerial tuning inductance and vary the capacity of the short wave condenser until response is secured.

For sharp tuning on the shorter wave lengths below 1000 meters, place the double-throw knife switch on the "tune" position. Place the condenser switch on the "tune" position. Set the coupling knob of the intermediate circuit in the neighborhood of 70° to 90°. Add two or three points at the switch of the aerial tuning inductance. Adjust carefully the intermediate condenser. Follow this by varying the capacity of the short wave condenser and of the billi condenser until the loudest response is secured. In this position all the variable elements of the complete tuner are in use.

SPECIAL REMARKS

(1) It is important to note that the type 107a tuner is fitted with four binding posts at the rear from which connections extend to the type S, SH, or I aerial change-over switch. When this switch is placed in the transmitting position, the circuits of the 107a tuner are interrupted at the points A and B (figure 140) thus breaking the circuit to the detector and the head telephones. The contacts of the antenna switch must have careful inspection from time to time, for unless they close the circuits properly, the apparatus will not function. Should these contacts be broken, a permanent jumper must be placed across the binding posts to keep the circuit closed.

(2) The "stdbi" connections are employed when the operator is awaiting a call from one of several stations not accurately tuned to the same wave length. The "tune" connections are employed during periods of excessive interference.

(3) It is essential that the polarity of the detector battery be correct for the maximum strength of signals. This can only be determined by experiment. The connections to the crystal should be reversed and the potentiometer adjusted until the loudest signals are obtained from a given station.

(4) The type 107a tuner was originally designed for use with the Fleming valve, but it is now equipped for use with the carborundum detector solely. Two connections extend out from the base of the tuner immediately under the aerial tuning inductance to permit connection to an external detector such as cerusite.

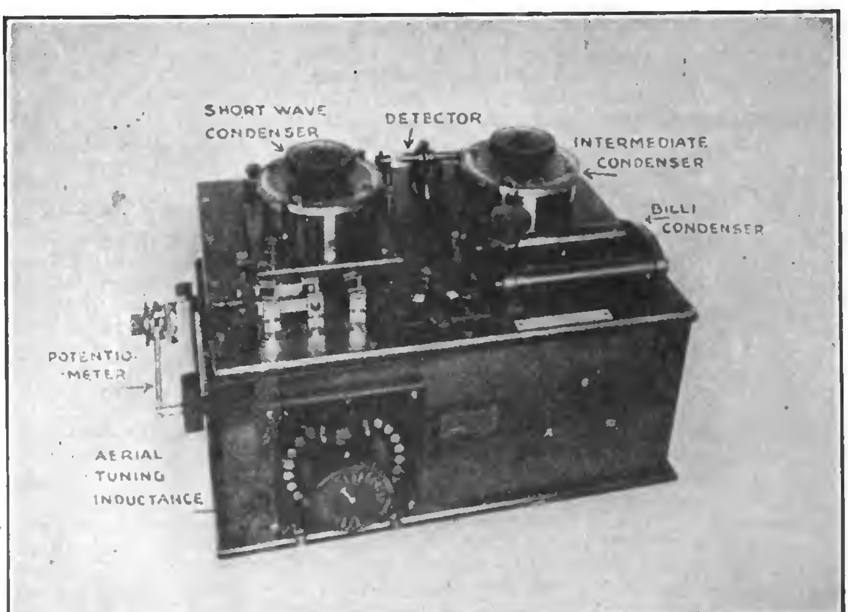


Figure 141—Showing the type 107a tuner. The photograph does not indicate the special condenser change-over switch which in practice is mounted between the short wave condenser and the intermediate condenser.

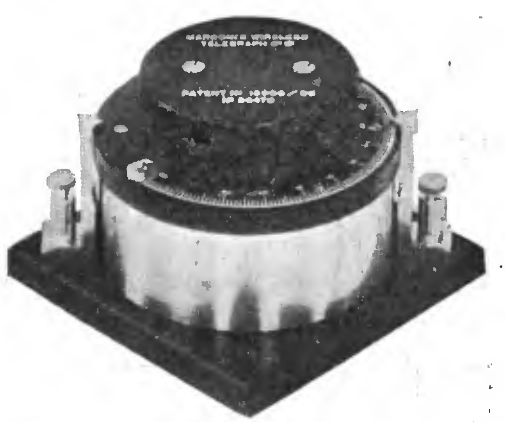


Figure 142—The Marconi disc variable condenser used in connection with the type 107a and the Fleming valve type of tuners. This condenser is of small dimensions for its capacity, which is .01 microfarad. It consists of a number of very thin steel plates separated from one another by thin sheets of hard rubber. Two semi-circular sets of stationary plates and two sets of movable plates are included in the design, thus permitting a large capacity to be obtained with a condenser of small dimensions.

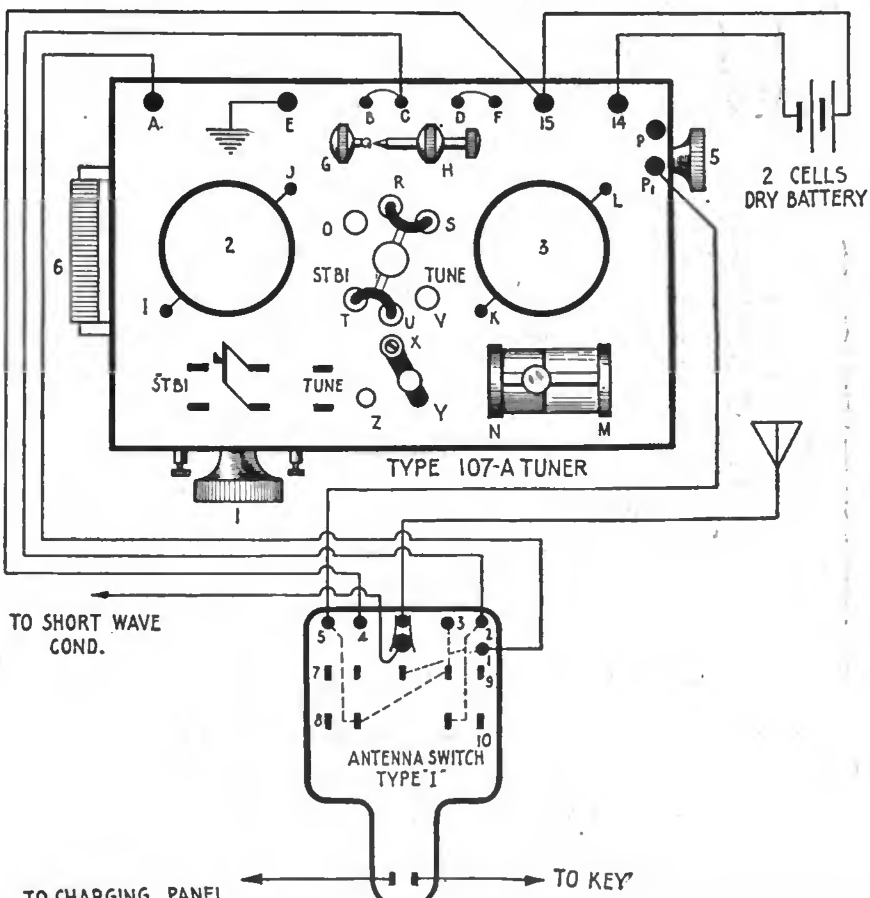
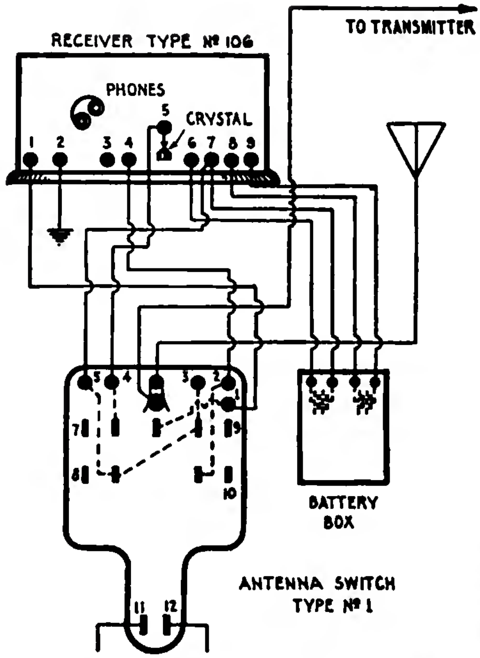


Figure 143—Showing the type I antenna change-over switch of the American Marconi Company connected to the type 107a receiving tuner. In this diagram, binding posts 2, 4, and 5, of the type I switch lead to contacts which short circuit the receiving detector and the receiving telephones during the transmitting schedule. It is to be noted that with this switch, the detector and telephone circuits are on short circuit rather than being open as in the type S switch; also the binding posts B and C, D and F, are connected together by jumpers. The other notations of this sketch are as follows: 2 is the antenna short wave condenser; 3 is the intermediate circuit condenser; NM is a billi condenser, 5 the coupling knob for the intermediate circuit; 1, the knob for the aerial tuning inductance, and 6, the potentiomcter. The condenser change-over switch is indicated by the notation RS, and TUV.



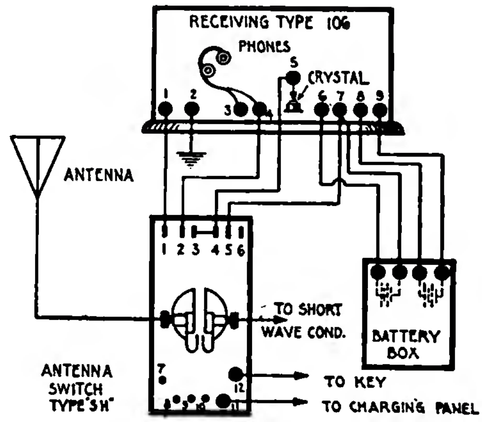


Figure 145—Showing the connections of the type SH, aerial change-over switch connected to the type 106 receiving tuner. The binding posts 1, 2, 3, 4, and 5 of the type S H, antenna switch lead to contacts which place the head telephone and detector of the type 106 tuner on short circuit. Binding posts 11 and 12 close the circuit to the primary winding of the transmitting high voltage transformer.

Figure 144—Showing the type I switch connected to the type 106 receiving tuner. The binding posts 2, 4, and 5, of the type I antenna switch short circuit the crystal detector and head telephones, during transmission. Binding post No. 1 connects to the aerial binding post No. 1 of the type 106 tuner. Contacts 11 and 12 close the circuit to the primary winding of the high voltage transformer. Binding posts 6, 7, 8 and 9 of the type 106 tuner are connected to the four binding posts of the battery box.

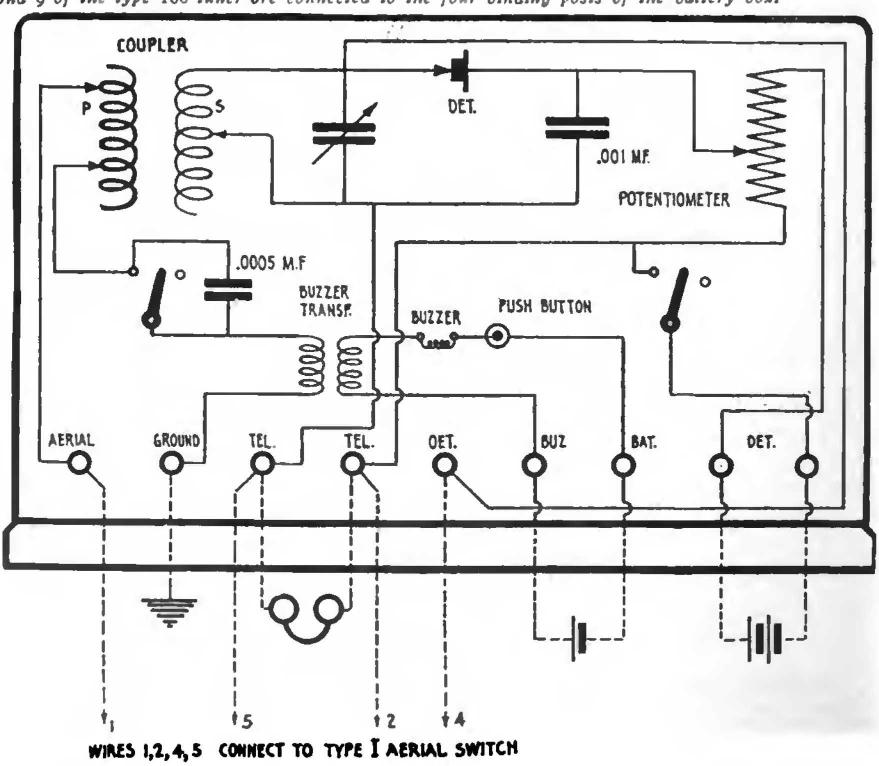


Figure 146

OBJECT OF THE DIAGRAM

To show the complete circuits of the type 112 receiving tuner (cargo ship type apparatus) of the American Marconi Company.

DESCRIPTION OF THE DRAWING

The tuner fundamentally is similar to the type 106, but it is somewhat simplified both in regard to construction and manipulation. It consists of the usual inductively coupled receiving transformer, but has **double-layer primary** and **secondary windings.** These give a maximum of inductance with a minimum of resistance for a coil of given dimensions.

The potentiometer and head telephones are connected around the condenser in series with the detector, the latter being shunted across the secondary circuit as usual. A buzzer tester is placed in inductive relation to the earth lead. The inductance of the primary winding is regulated by a "tens" switch and a "units" switch.

The inductance of the secondary winding is changed by a simple multipoint switch. The secondary shunt condenser consists of two concentric brass tubes which are telescoped by the movement of a small knob in the slot in the top of the tuner.

The coupling between the primary and secondary coils is changed by a knob sliding in the lower slot through the front of the panel.

When the knob is placed to the extreme left, the coupling is maximum; lesser degrees can be obtained by moving the knob in the opposite direction.

The series antenna condenser is thrown into the circuit by means of the switch marked "condenser-in -out." It is of fixed capacity, approximately .005 microfarad. Resonance is established by variation of the primary inductance.

The tuner is fitted with a carborundum detector, the latter being mounted immediately to the front of the panel. The local battery current for the crystal is turned on and off by the switch marked "battery-on -off." This switch always should be in the "off" position when the receiver is not in use.

OPERATION

The crystal is adjusted to sensitiveness by pressing the push button closing the circuit to the buzzer and placing the pointed contact upon various parts of the crystal until the loudest response is secured in the head telephones. Simultaneous adjustment of the potentiometer is made. In fact a different value of voltage must be applied for each new point of contact.

The complete tuner may be adjusted to incoming signals as follows:

(1) Adjust the detector by a buzzer tester;

(2) Place the coupling knob as far to the left as possible;

(3) Vary the inductance of the primary and secondary coils progressively until the desired station is heard;

(4) When signals are heard decrease the coupling;

(5) Re-tune the primary and secondary circuits using small values of capacity at the secondary condenser;

(6) Then change the coupling slightly until the loudest signals are secured or until an interfering signal is eliminated.

Figure 147—Front view of the Marconi type 112 receiving tuner showing the position of the primary and secondary inductance switches, the coupling knob, the secondary condenser knob, the carborundum rectifier, buzzer tester, and the potentiometer.

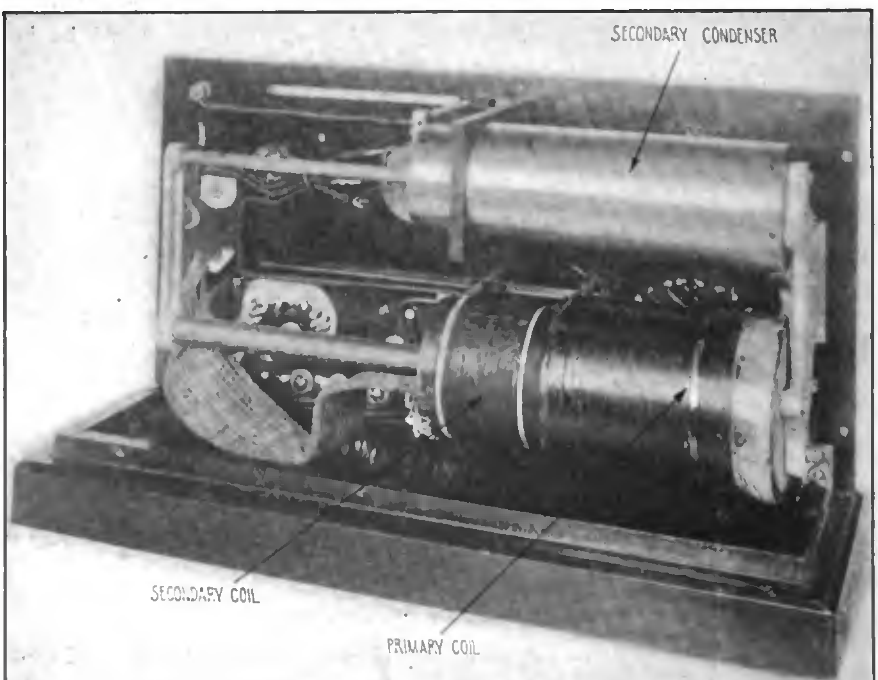


Figure 148—Rear view of the type 112 receiving tuner showing the primary and secondary inductances and the tubular secondary condenser.

Experimenters' World

FIRST PRIZE, TEN DOLLARS

"Howler" Code Practice Apparatus

DESPITE the ban put on the amateur stations by the Government for the duration of the War, code practice is more important to-day than in the past.

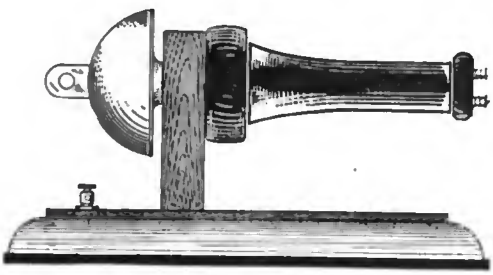


Figure 1—First prize article

Amateur operators who are not serving their country for various very good reasons are depended upon to keep alive the spirit which has aroused universal interest in radiotelegraphy. The writer suggests that the remnants of radio associations that existed before the war still continue to meet and discuss new improvements in radio apparatus, and above all spend a profitable hour in code practice.

To remove the disadvantages of the buzzer type of practice apparatus, a little device is described for producing audio frequency currents of practically constant amplitude for unlimited periods of time. It is unusually simple in construction and can be made from instruments that every "Bug" has on hand.

A glance at the photograph, figure 5, shows it to consist of a telephone transmitter and a telephone receiver mounted on a base facing each other. Constructional details are hardly necessary. Simply a base of any convenient shape or size, a wood upright with a hole cut through it, and the instruments mounted on either side of the upright, are all that is required. Figure 1 shows a side view of the completed instrument employing a single type of receiver.

Everyone is acquainted with the phenomena that takes place when the receiver of a telephone set is held up to the transmitter. A high pitched note results from the interaction of the two instruments. The two instruments are connected in series with a battery of 8 to 12 volts. It is, however, necessary to connect the receiver into the circuit in such a manner that the current from the batteries serves to strengthen and not to weaken the magnetism of the receiver poles.

The resistance of this arrangement is naturally high (in the neighborhood of 90 ohms) hence the current flowing

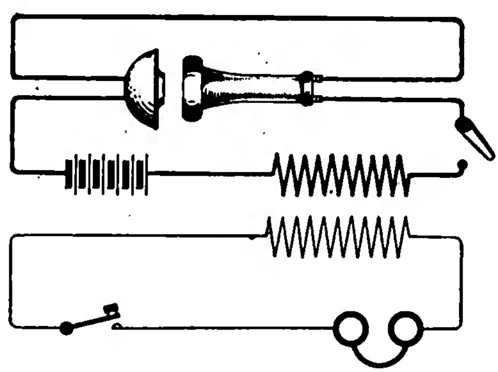


Figure 2—First prize article

is small. A set of three flashlight batteries will operate the device for months. Old dry batteries of no use for any other purpose can be employed also. The note of the instrument and the volume of sound can be varied by altering the voltage.

It is manifestly impractical to connect other apparatus in series with the instrument, or oscillator, as it is preferably called. Use is made of a standard telephone induction coil, the primary being connected in the oscillator circuit, the secondary in series with a receiver and a key as shown in figure 2. In this case the oscillator is operated constantly, the key being used to open and close the telephone circuit to produce the dots and dashes of the telegraph code. This effectively eliminates the loud click that would be heard were the circuit closed and the key in the battery circuit.

When more than one person desires to practice with the device, additional keys and receivers can be included in the circuit as illustrated in figure 3. With this circuit, the closing of any key will give a signal in all the receivers.

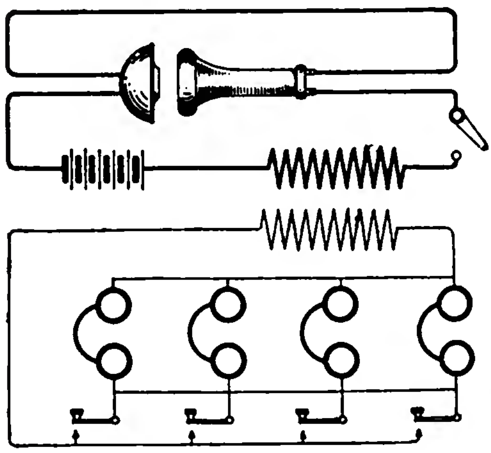


Figure 3—First prize article

We now come to another interesting possibility of the device, namely, the production of interference that is so necessary to good code practice. The only additional instruments required to make this possible are an old loose coupler and another induction coil. The wiring diagram is shown in figure 4.

It will be seen that two practice circuits intercoupled by the loose coupler L, C, are employed. In this manner the amount of interference can be varied by adjusting the coupler so that signals made in one circuit will be heard weakly in the other and thus provide interference. The use of this hook-up requires at least four persons.

From a theoretical standpoint it

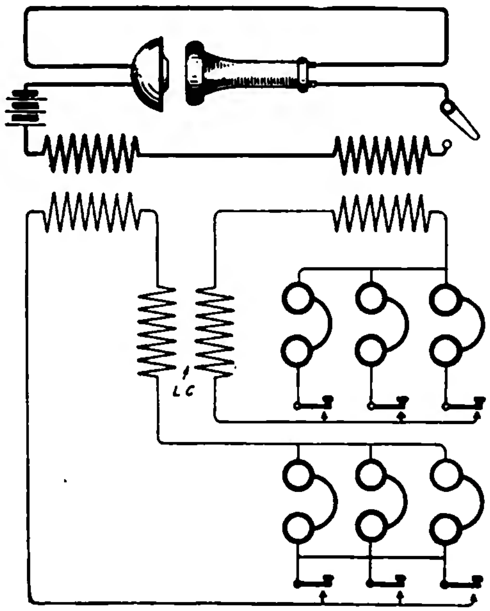


Figure 4—First prize article

might appear that the sound made while the oscillator is in operation would be annoying. As a matter of fact the reverse is true. The instrument made by the writer can hardly be heard at three feet, while it gives a clear high pitched note in the receivers. The latter may be of any resistance. When a large number are employed it might be advisable to use

Figure 5—First prize article

1000-ohm telephones, but up to six, 75-ohm telephones will operate satisfactorily. The note emitted is very musical, clear and absolutely constant without stutter or break. In fact, the device provides an ideal source of audio frequency current for code practice or other requirements in the laboratory.

THOS. W. BENSON, *Pennsylvania.*

SECOND PRIZE, FIVE DOLLARS

A Supersensitive Receiving Set

IF the Editor of this splendid magazine will allow me the space, I feel confident that I can present in full detail the best possible receiving set that an amateur can construct out of the available apparatus on the market. It should be kept in mind, however, that the construction of wireless apparatus is not permitted while we are at war.

The receiver is designed both for damped and undamped oscillations, and also has a two-step amplifier attachment that will amplify radio signals at least 150 times their original strength. The apparatus is not complicated; anybody who has had experience with undamped receivers can fully comprehend its working. For those lacking experience with the amplifier, I would recommend that they secure a copy of "How to Conduct a Radio Club," wherein its workings are described to perfection.

In figure 1, the general dimensions and construction of the cabinet are given in detail. The dimensions apply to amateurs who cannot erect an aerial in excess of 300 feet in length, and will work equally as well on an aerial of 100 feet in length. The longer the aerial the better the results, but remarkable distances have been covered with a 100-foot aerial in connection with this set.

In figure 2 the dimensions of the coils and coupler are given. The primary of the coupler may be wound on a tube 7 inches in diameter and 12 inches long, with No. 28 single silk. Switch No. 1 covers every ten turns. It has 15 taps. Switch No. 2 cuts in every 1 inch of winding and has ten taps. The secondary is wound with No. 30 single silk, and is tapped off every ½ inch. The twenty-four taps are divided between two 12 point switches, as shown in figure 1.

The coils L and L-1 are each 30

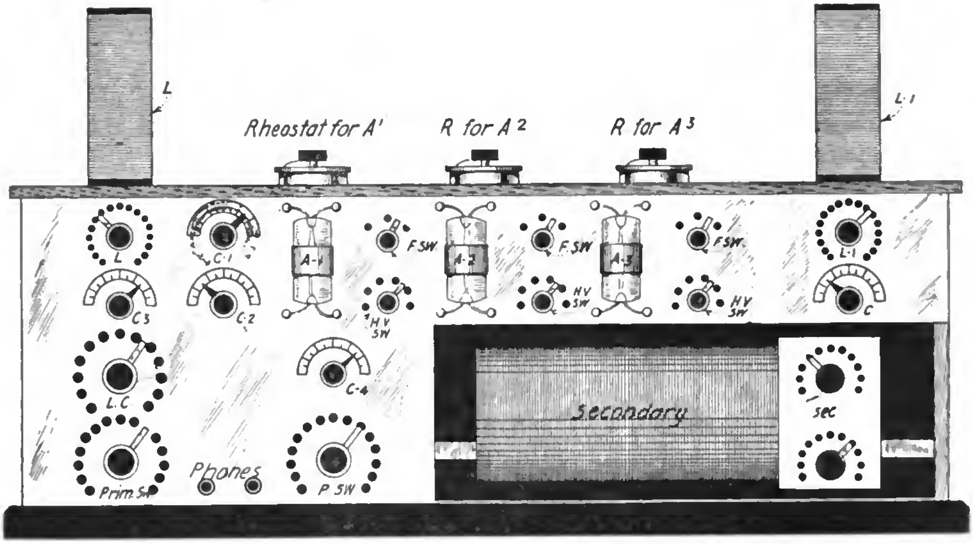


Figure 1—Second prize article

inches long and 4 inches in diameter, wound with No. 30 single silk. They are tapped every 2 inches. A tubular bulb is suitable for continuous wave reception, but good results have been obtained with the old round bulbs.

The coils L-3 and L-4 are obtained from the secondary of a ½ inch spark coil, the primary being removed and the core replaced.

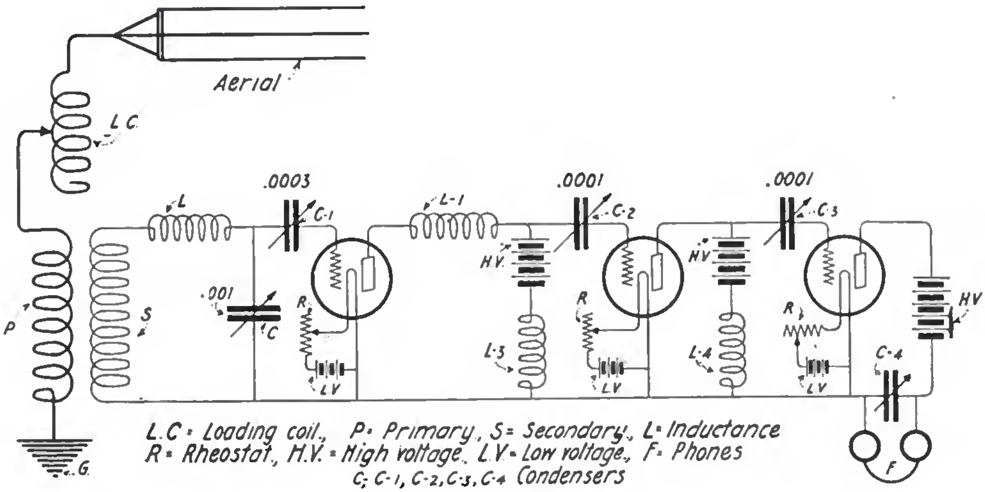


Figure 2—Second prize article

A loading coil may be inserted in series with the primary winding having the following dimensions: 4 inches in diameter and 12 inches long, wound with No. 26 single silk. No enameled wire should be used in a set of this kind, as experiments have proven it unsatisfactory for highly sensitive work.

I would recommend oak for the cabinet. This wood can be secured at nominal cost, and if it is treated with black stain, Johnson's Flemish Oak, and then rubbed down several times with wax, it fairly resembles hard rubber.

It should be mentioned also that if one does not care to use the amplifiers he should have no trouble in receiving 3,000 miles with this set under favorable conditions. With an aerial but 100 feet in length no difficulty should be experienced in receiving stations as far as 7,000 miles, under favorable conditions.

The wood required for the construction of the cabinet is as follows: The base should be 36 inches in length, 12 inches in width and ¾ inch in thickness. The same dimensions apply to the top. The front should be 12 inches in height, 34 inches in length and ½ inch in thickness; the ends 10 inches wide, 12 inches in height and ½ inch in thickness, and the secondary front 4 inches wide, 6 inches in height and ¼ inch in thickness.

Charles R. Doty, *New York.*

THIRD PRIZE, THREE DOLLARS

The Construction Of An Amateur Telephone Cabinet

SOME time ago I made the telephone cabinet here described for a short telephone line, most of the materials for which can be found in any experimenter's shop. The drawing gives the dimensions of the cabinet except for

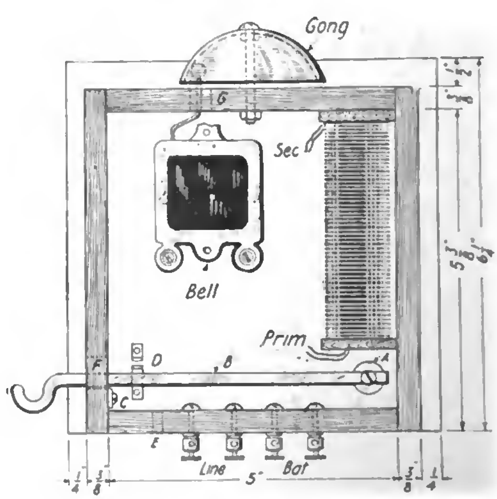


Figure 1—Third prize article

the width of the side pieces. They are each 2 inches wide. The wood for the top piece of the cabinet (figure 2) is of ¼ inch wood. One 2½ inch gong is mounted on the cabinet, as shown, and the clapper arm of the bell passes through a ¼ inch hole G. I used an ordinary door bell and broke off the

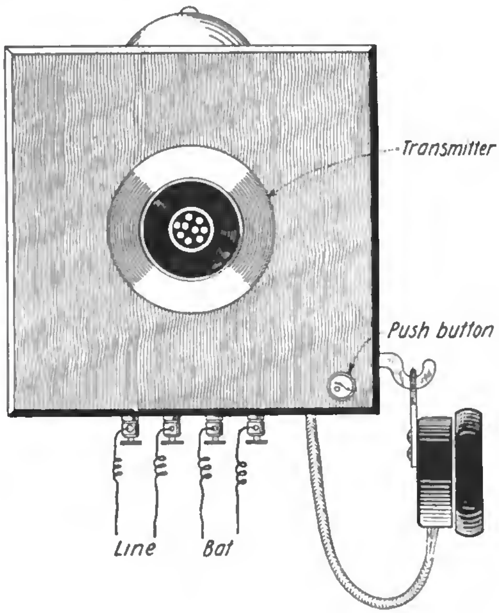


Figure 2—Third prize article

piece which originally supported the gong.

The induction coil is made by covering a small bundle of iron wires with a layer of paper, then winding on two layers of No. 26 S. C. C. wire for the primary. A layer of paper comes next and then four layers of wire for the secondary.

The arm B, figure 1, to support the receiver, is a three-sixteenth inch brass or iron rod, bent as shown and flattened at one end for the threaded hole to take a $^6/_{32}$ pivot screw. This is supported by a piece of ½ inch brass rod about 1 inch long; A, which has a hole bored through its length, threaded by a $^6/_{32}$ tap. It is held to the back board by a screw and also enters this hole. At the left of the box is a slot F, about ¼ inch wide by ½ inch long, for the lever to play in. Under the slot is a piece of brass, C, which serves as a stop and also as a contact to cut the telephones and the secondary of the induction coil out of the line circuit when the lever is down.

The function of the automatic switch, D, is to close the circuit to the primary of the induction coil when the lever is up for talking. It is made by fastening two strips of spring brass to the back board so that, when the lever is up, the brass fuses are in contact. The lever must be insulated from the

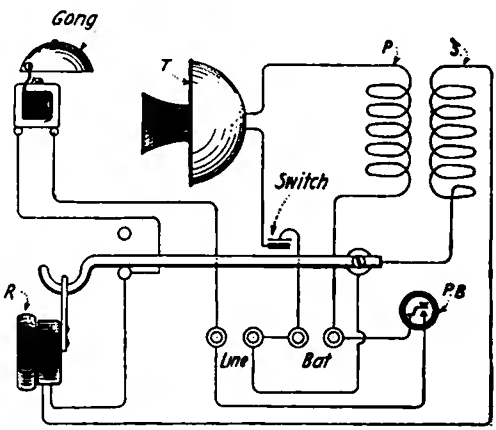


Figure 3—Third prize article

brass strips by tape or some other insulating material.

A ¼-inch hole E is made in the bottom of the box for the receiver cord to pass through. The binding posts are placed about 1 inch apart. A rubber band pulls the lever up when the receiver is removed. A wire spring would prove more satisfactory.

The transmitter and push button are mounted on the front of the cabinet, as in figure 2.

This set is at present being used on a line about 300 feet long. It works perfectly with a 6-volt storage battery. To call, the receiver is lifted from the hook and the button pressed. The buzzing in the receiver when the button is pressed tells if the bell on the other end of the line is working. The connections are shown in figure 3. The connections between the two middle binding posts are a part of the calling circuit.

JOHN B. MOORE, *New York.*

The Monthly Service Bulletin of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

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

"I NOTE in the April number of THE WIRELESS AGE queries department," writes John M. Clayton, Little Rock, Arkansas, "some one asks the greatest distance which has been covered over land by an amateur, and your reply that you think 1,400 miles is the record. For quite a while I have been collecting data of four record stations and the following extract from quite a voluminous amount of information may interest you.

"9ZN at Chicago has worked with a station (7EQ) at Baker City, Oregon, about 1,500 miles. 9ZN worked on 425 meters, and 7EQ on 200. This, I believe, is the record for actual talking. 9ZN has been heard by 6EA at Los Angeles. 9EP at Kansas City, Missouri has been heard by 6DM at noon several times. 8NH at St. Mary's, Ohio, and 8AEZ at Lima, Ohio, have both been heard by 6DM at Phoenix, Arizona. 2PM has heard 9ZF; 2PM is at New York City and 9ZF is at Denver. 5BB at Franklinton, La., has worked with 9XM at Grand Forks, N. D. 9ABD at Jefferson City, Mo., has been heard on both coasts, as have also 9ZK, 9EP and 9JW.

"I would suggest that those of the amateurs who have been left behind can do great service by voluntarily teaching code work at nights to men eligible to the draft.

"With another amateur in the city, I have been teaching code every night for the past two months to a class of about fifty drafted men at the local Y. M. C. A. Already fourteen of them have successfully passed the radio requirements for the Navy and Marines and have left."

Young oiler in the Naval Reserve force was "over-rated" and was directed to appear before a board and "show cause as to why he should not be busted down so low that he'd have to reach up to touch bottom." (This is a true one.) Examination took place and consisted of the following questions and answers, or rather we should say "answers and questions," for the *answers* rank first, as the questions are not near as good as the answers. ("Let 'er go!");

Q. "What does an oiler do?"

A. "He oils."

Q. "Do you know anything about oiling?"

A. "Nope."

Q. "How came you, then, to be an oiler?"

A. "Met a guy who made me an oiler."

Q. "If you had a boat with an 80-h. p. engine in it and you received orders to get underway, what would you do?"

A. "I'd prime her, crank her and go."

Q. "What if it wouldn't go?"

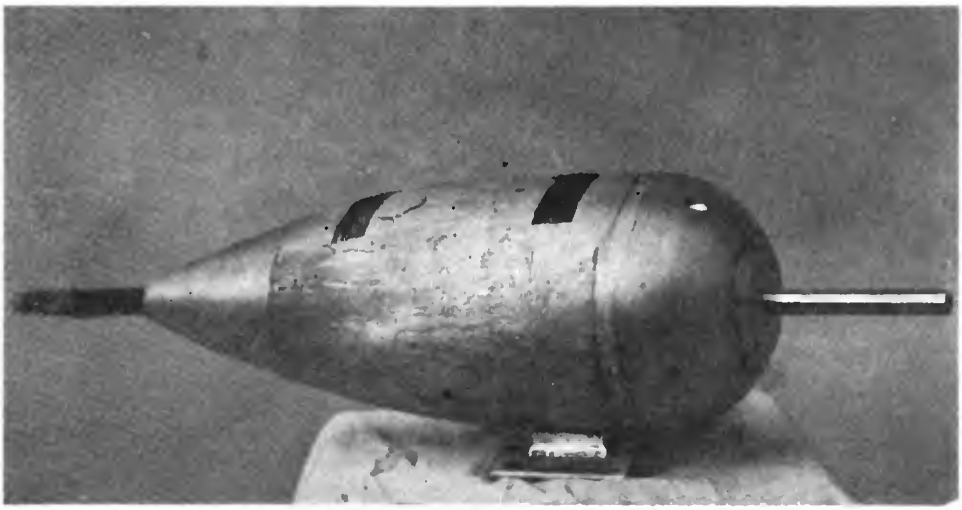
A. "I'd crank her again."

Q. "What if it wouldn't go then?"

A. "Well, this engine I'm thinking about WOULD go."—*Our Navy.*

A Novel Generator for Airplane Wireless

THE accompanying illustration shows a unique electric generator for airplane radio sets, developed by a manufacturer at Stamford, Conn. The dynamo is a combination of two direct current generators mounted in a torpedo-shaped shell. One of the generators delivers low voltage for lighting the filament of the vacuum tube wireless receiver. The other generator supplies 1200 to 1500 volts for wireless transmission. Both armatures are mounted on the same shaft and supported at each end by ball bearings. The outfit is intended to be driven by a small propellor and to be used as energy source for transmitting and receiving wireless telephone messages on aeroplanes in military service.



Airplane wireless generator

The Construction of a One-Inch Spark Coil

THE amateur about to begin his elementary experiments in radio is seldom in a position to purchase an expensive wireless telegraph transmitter. Of course I am aware that the experimenter is not permitted to construct wireless apparatus until after the War, but for beginners who would care to construct a simple one-inch spark coil for transmitting over a distance of a few miles by wireless I submit the general details of construction. It is assumed that the experimenter is familiar with the general design of induction coils. I found that a coil of the dimensions to be described will transmit approximately ten miles and can be constructed at a cost of $2.75.

The materials required are as follows:

1 lb. No. 34 enameled magnet wire.
¼ lb. No. 16 D. C. C. magnet wire.
1 core 8 in. in length by 1 in. in diameter.
2 lbs. paraffine.
1 vibrator for 1 in. coil.
4 binding posts.
1 lb. tinfoil.
2 pieces oak 4 in. by 8 in. by ¼ in.
2 pieces oak 4½ in. by 8½ in. by ¼ in.
2 pieces oak 4 in. by 4 in by ¼ in.

The core is made of a bundle of No. 22 soft iron wire, cut into pieces 8 in. in length. After the wire has been cut it is placed into a 1 in. pipe heated to red heat. After this process has been gone over twice the core should be removed and taped. It is often found that a core can be bought cheaper than it can be made.

The primary wire consists of two layers of No. 16 D. C. C. magnet wire wound around the core. It should be wound with twenty layers of paraffined paper and immersed in melted paraffine.

The secondary winding consists of 1 lb. of No. 34 enameled magnet wire wound in five pies 1 in. in thickness. After each pie has been wound it should be carefully removed and soaked in melted paraffine. When all the pies have been wound they should be connected so that their E. M. F.'s will not oppose. Paraffine blotting paper should be placed between each pie and the whole coil should be boiled in paraffine for thirty minutes.

The vibrator condenser is made of 80 sheets of tinfoil 7 in. by 3½ in. and 80 sheets of paper 7½ in. by 4 in. These are piled up alternatively. The ends of the tinfoil should project out about 1 in. The condenser also is soaked in melted paraffine.

After the coil is completed it should be assembled in a wooden cabinet. The wood may be of any kind, but oak is preferable.

Six dry cells connected in series should give a one-inch spark.

Maurice Lee.

Hydrogen Gas As Fuel

HYDROGEN was successfully used as a fuel for an automobile in a test conducted at The Hague, Holland, for the purpose of determining its value as a substitute for existing fuels. The test, conducted by the manager of a large taxicab company and Henri Meyer, editor of the Dutch motor journal, "Het Motorrywiel," of Arnheim, Holland, showed that hydrogen can be used without any of the annoyances and irregularities of operation which might ordinarily be supposed would result, such as misfiring and backfiring. The car used in the test was a Spyker taxicab.

The hydrogen was contained in a steel tank six feet long. This tank held 4600 liters (about 162 cubic feet) compressed to 160 atmospheres, which was sufficient to operate the vehicle for sixteen miles. The gas was fed from the tank through a reduction valve which brought the pressure practically to atmospheric, the feed then being through a three millimeter jet which fed directly into the carbureter mixing chamber. At the start of the test the spark advance was reduced somewhat, but after changes in the mixture were made the spark was carried at full advance without difficulty.

Some of the Good Things in Store for You

In the August issue of The Wireless Age you will find one of the most interesting articles that has appeared in many months. It will tell about Pan-American Wireless developments.

You will learn about the erection of new Radio Stations now under construction which when completed will promote closer relations between us and our Southern neighbors.

An interesting and instructive article for visual code communication by Lieut. Col. *B. O. Lenoir,* U. S. A., will appear in the August issue. This article should prove of intense interest to all Signal Corps men.

These specials will appear in addition to the regular monthly instruction courses in Aviation, Navigation, Signal Corps work and War Time Wireless.

The Wireless Age *is on sale after the 15th of each month on the principal newsstands throughout the country at 20 cents per copy or mailed to any address for* $2.00 *per year payable in advance.*

A Convenient Telephone

THE accompanying illustration shows a most convenient form of telephone receiver and transmitter. Telephone service is made better and simpler because unnecessary physical exertion is eliminated.

In the early days of the telephone considerable gymnastic efforts, both of muscle and brain, was usually neces-

Convenient telephone

sary for a successful conversation. Each succeeding improvement of the telephone brings the talking parties nearer together in the easiest way.

The stand of this telephone has a heavy, pressed steel cradle, convenient and practical, measuring in height 7 inches and in length 10¼ inches.

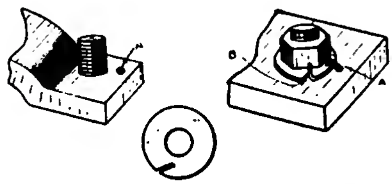
With this telephone equipment, the right or left hand is always free for writing. For instance, when one wishes to telephone from any position, standing, sitting or reclining, he can grasp the 'phone and immediately begin to talk. There is no need of holding a desk telephone in one hand and a receiver in another and no need of balancing a portable telephone on an arm chair and straining one's neck, or of leaning awkwardly over inkwells and papers on the desk in a distracting way, to complete the connection.

The receiver shell, the handle, the transmitter and the mouthpiece are of heavy bakelite, which is indestructible in ordinary telephone service. It is a duplicate of "foreign types" and has been in service in Europe for a number of years, where it takes preference over any other form.

A Simple Lock Nut.

CHARLES H. WILLEY, in a recent issue of the *Electrical Review*, tells us how to make a simple lock nut. He says:

"We were troubled with the nuts loosening up on some of our machinery, due to vibration, or other reasons.



Improvised washer used as a lock nut

As no lock nut could be used, and it was not feasible to pin the nuts, we had to use some sort of locking device. The lock washer shown was used.

"These sketches are quite clear, but it may be well to say that the hole A should be as generous as reasonable for receiving the lip. Any ordinary washer can be used. The lip B is cut in with a hack saw before applying the washer. This is turned up as shown, and with a punch or drift, the lip A is impressed into the hole."

A Full Wave Magnetic Rectifier

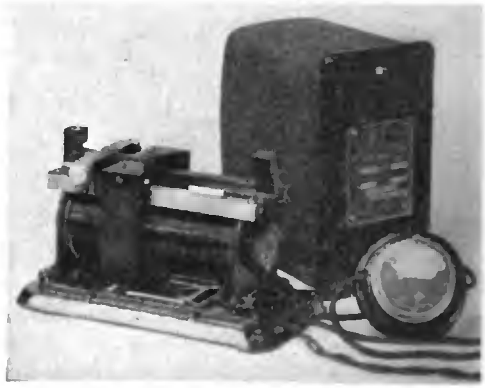
THE accompanying illustration shows a full wave magnetic rectifier for charging storage batteries.

A battery, if not kept fully charged, rapidly deteriorates on account of the hardening of the plates.

It is well known that most light and power current is alternating, and cannot be used to charge batteries. It is the purpose of the rectifier to change alternating current to direct current.

The line voltage is reduced to the proper charging voltage by a special transformer. Both the positive and negative halves of the alternating current wave are rectified into a steady uni-directional charging current which makes the cost of charging so low that the rectifier quickly pays for itself.

This device saves times, money and trouble, and it makes every lamp socket a charging station. It takes only a minute to screw the plug on the end of wire into a lamp socket and connect the other two wires to the battery. The battery of an automobile can thus be charged in a few hours without removal from the car—and at no more expense than in burning a 100-watt lamp for the same length of time. A complete charge for the aver-



Magnetic wave rectifier

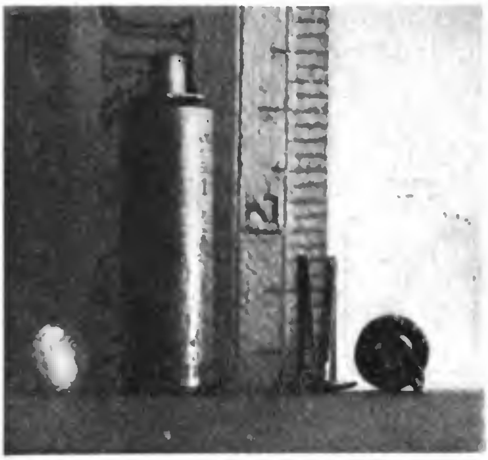
age starting and lighting battery costs about 6 cents, which is at the rate of ½ cent an hour to operate.

The charge starts at a high rate, from 10 to 15 amperes, bringing the temperature of the battery up to normal working condition. This reduces the time required for charging, and as the charge nears completion the rate gradually reduces itself owing to the rise of the battery E. M. F. This results in what is known as the "Tapered charge." The "Tapered charge" is impossible with any charging means which operates at a fixed low rate, but is automatically taken care of by the rectifier.

It is of interest to note that the rectifier is self-starting and not affected by line failures. If the line current is turned off the battery cannot discharge through the rectifier. When the current is turned on the rectifier starts itself; thus night charging is safe and saves time. One form of this device measuring 5 by 7 by 9 inches and having a weight of 14 pounds will charge a 6-volt battery or two or more 6-volt batteries connected in multiple at an average rate of 10 to 15 amperes. It will fully charge the average starting and lighting automobile battery over night.

An Economical Contact Point

PRACTICALLY every experimenter has a desire to lessen the strain on the pocket-book. One of the obstacles to the fulfillment of this desire rests in the construction of any electrical or radio apparatus using contact points. The present cost of such points runs from two cents for midget points to six cents and more for large sized points. This cost is the basis for the



Rivets used for contact points

use of cartridge shells, which, however, have the disadvantge of presenting neither a good surface for soldering leads nor a means of keeping them from falling out of switch panels. A still better point than that obtained from a cartridge shell, and one that is not generally known is the brass rivet (used in Ford magnetos) which can be obtained at any licensed Ford Service Station at a cost of five cents per dozen. The photograph shows several of the rivets one-half inch in length, having five-sixteenths inch heads and five-thiity-second inch shanks. They should be placed in five-thirty-second inch holes spaced at least three-eighths inch between centers. The points are placed in the holes and the lips of the shank spread by hammering either upon a large spike placed with its point between the lips or upon a special tocl such as shown in the illustration. The leads are then most conveniently soldered to the interior of the lips. Ford rivets have another advantage in the fact that they may be used on any material over 1/16 of an inch thick and will remain in adjustment.

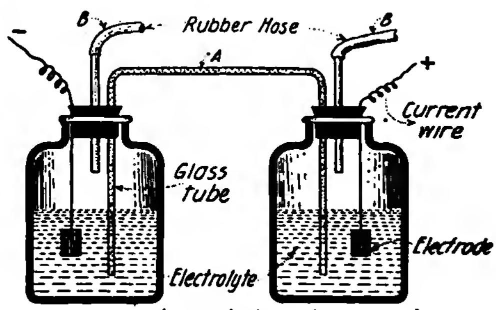
ALAN C. ROCKWOOD.

Electrolysis Apparatus.

THE object of this apparatus is to collect the products of the electrolysis separately and without any mixing.

The materials required are: Two bottles and two hole stoppers, glass tubing and electrodes.

The electrolyte fills the tube A when air is blown in through one of the



A novel electrolysis apparatus

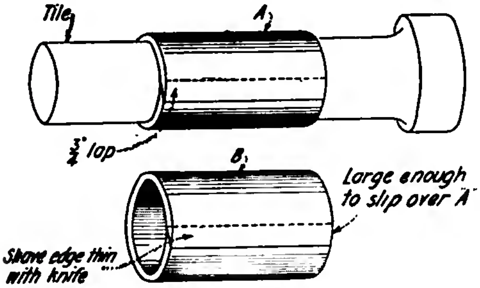
tubes B, and electric communication established. The wires holding the electrodes are held between the bottle neck and the stopper.

The rate of current flow can be lessened by partly closing one of the delivery tubes B, the pressure forcing the liquid out and diminishing the surface of contact of the electrode. The gases evolved (if any) can be obtained at any pressure by closing the rubber tubes with stop clamps.

HENRY KLAUS.

A Method of Making Cardboard Tubes For Tuning Coils

THE preliminary step in the construction of card-board tubes is to secure a piece of tile or something circular of the correct dimensions and wind it with pasteboard, as shown in the accompanying drawing. It is important to get it the right length and wide enough to insure a three-quarter inch lap. The edges are next shaved down with a knife (so that there will be no hump) and glued. Another piece of pasteboard is made in the same way to fit rather loosely over the one on the tile. It is then slipped off and a paste of flour and water smeared on the inside of the tube. The larger one must be slipped on immediately as the paste



Method of constructing cardboard tubes for tuning coils

causes the tube to expand. After standing a few hours the tubes contract again and fit snugly about the form. They may now be immersed in melted paraffine and finally covered with shellac. These are as solid as the ones which are purchased. I have used them for loose couplers and coils of various sorts.

HENRY KLAUS.

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.

M. F. B., Sunbury-on-Thames, Middlesex, Eng., inquires:

Ques.—(1) With a simple regenerative three-element vacuum bulb circuit (single bulb) such as described on page 124 of "How to Conduct a Radio Club" would it be possible to receive Arlington time signals at a range of 3,000 miles across open sea and with a ship's aerial 250 feet long and 125 feet high?

Ans.—(1) Signals should be received at a distance of 3,000 miles at night time provided the regenerative coupler is carefully constructed and the correct polarity obtained between the primary and secondary winding of the regenerative transformer.

Ques.—(2) What is the relative ratio of audibility between the three-element vacuum bulb and the crystal detector?

Ans.—(2) As a regenerative system the tube will give amplifications up to at least

100 to 150 times as compared to a simple crystal rectifier. For weak signals, the amplification factor is considerably in excess of this.

* * *

H. P. M., Royse City, Texas:

We do not fully understand your query No. 1. Do you desire to know if automatic senders are employed in wireless telegraphy? If so, it may be said that they have been used to some extent in trans-Atlantic experimental work and in commercial work. It is contemplated to employ automatic transmitters exclusively in the near future. The most favored form of automatic transmitter is the Wheatstone, the signals being first perforated on tape and fed through the machine at speeds up to 100 words per minute.

It is impossible for us to trace down the stations from which you heard signals in pre-War times.

The aerial you describe had a natural wave length of approximately 160 meters. We presume that this aerial has been taken down in accordance with Government orders.

* * *

G. G. S., Fitchburg, Mass.:

We have carefully scrutinized your diagram of connections for charging storage cells and were unable to ascertain why your carbon lamps should burn out, in view of the fact that you have two 110-volt lamps connected in series to 220 volt mains. Perhaps the potential of the line at times exceeds 220 volts. There is nothing in the diagram to indicate why these lamps burn out, because in the particular circuit you have shown the amount of current flowing is governed by the lamps and not by the storage cells. The fact that the generator is cut off, leaving the motors connected to the line, would have nothing to do with the burning out of the lamps, because the voltage of the storage cells is insufficient in this circuit to light the lamps to even partial brilliancy. We have no suggestions to offer.

* * *

V. E. E., Pennsgrove, N. J.:

Ques.—(1) If the area of metallic coatings of a condenser be doubled and the thickness of the dielectric halved, how will its capacity be affected?

Ans.—(1) It will be increased by 4.

Ques.—(2) Will you oblige me by explaining why its capacity will be thus affected, in the answer given to No. 1?

Ans.—(2) This can be determined from the formula:

$$C=0.0885\ K\ \frac{S}{T}\ \text{microfarads}$$

where S=the surface area of one plate
T=thickness of the dielectric.

It is self-evident that if S is doubled, and T is reduced one-half, the capacity will be increased four times.

A. B., New Orleans, La.:

Like your co-worker, A. L. D., you will have to readjust yourself to the new conditions encountered in the working of modern wireless telegraph apparatus. Practically all modern sets are fitted with wave-length changing switches, whereby the transmitting operator can make an instant change merely by throwing the handle of the switch.

The computation you desire on the calculations of the natural wave length of an aerial from its dimensions is laborious. A good explanation of Professor Howe's formula appears in the book entitled "The Calculation and Measurement of Inductance and Capacity," by W. H. Nottage, copies of which can be purchased from Wireless Press, Inc., 25 Elm street, New York City.

We are unable to give you details of the airplane apparatus you mention. War safety measures forbid us to speak on this point. After the war, complete descriptions of the apparatus such as is being employed in the Army and Navy will be available. We have no exact data on the range of airplane transmitting apparatus, nor have the reports of tests made by the Government been made public; but you can rest assured that the equipment is operative and that some remarkable results in communication have been obtained.

A comprehensive statement of the subject mentioned in your last query will shortly be published by the Wireless Press. Details will appear later in the advertising columns.

John Hays Hammond's radio control apparatus for torpedoes is fully described in a recent patent issued by the U. S. Patent Office. The circuits are too complicated to be gone over in detail in these columns. The subject is also treated in "Radio-dynamics" by Benjamin Meissner, copies of which can be purchased from Wireless Press, Inc., 25 Elm street, New York City.

The construction of a decremeter applicable to amateur needs is fully covered in the book, "How to Conduct a Radio Club."

A Hint for the Amateur Workshop

If you wish to measure a circular rod and have no calipers, use a monkey wrench and then measure the distance between the jaws. You can use this in the same way as you would a micrometer, but of course it will not be so accurate.

If you are in need of a chisel and have none, grind the teeth off of a flat file and grind an edge on it. This will make an excellent chisel. I speak from experience.

ERWIN F. GRAY.