May, 1919

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The WIRELESS AGE

Volume 6

Number 8

Radio Instruction Which Prepares the Men Who Go Down to the Sea in Ships

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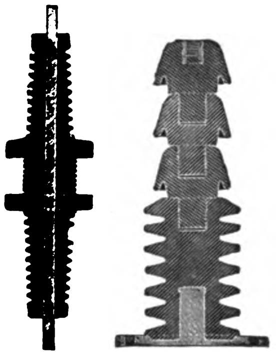

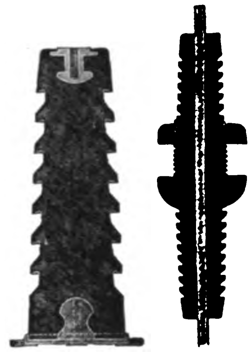

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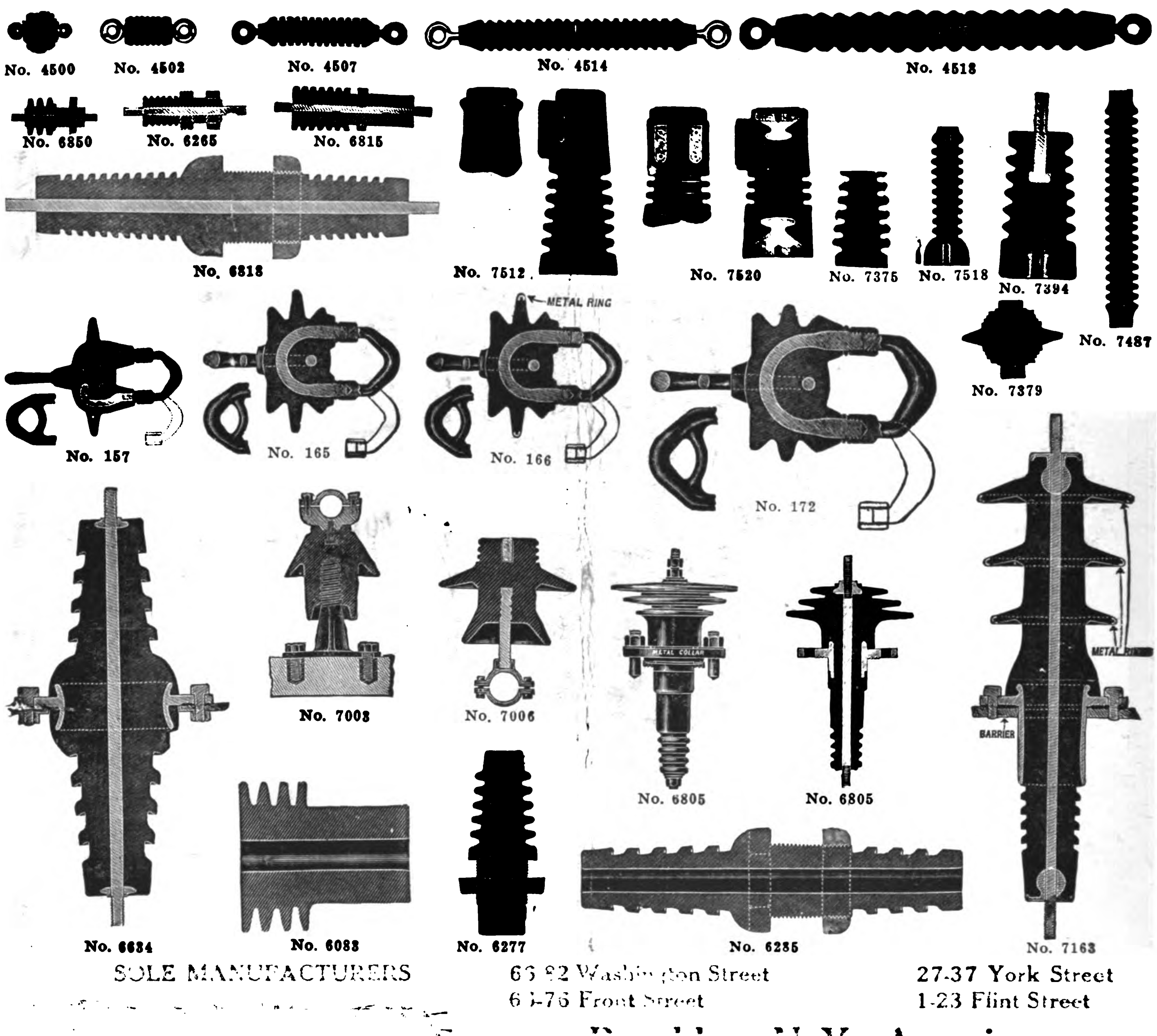

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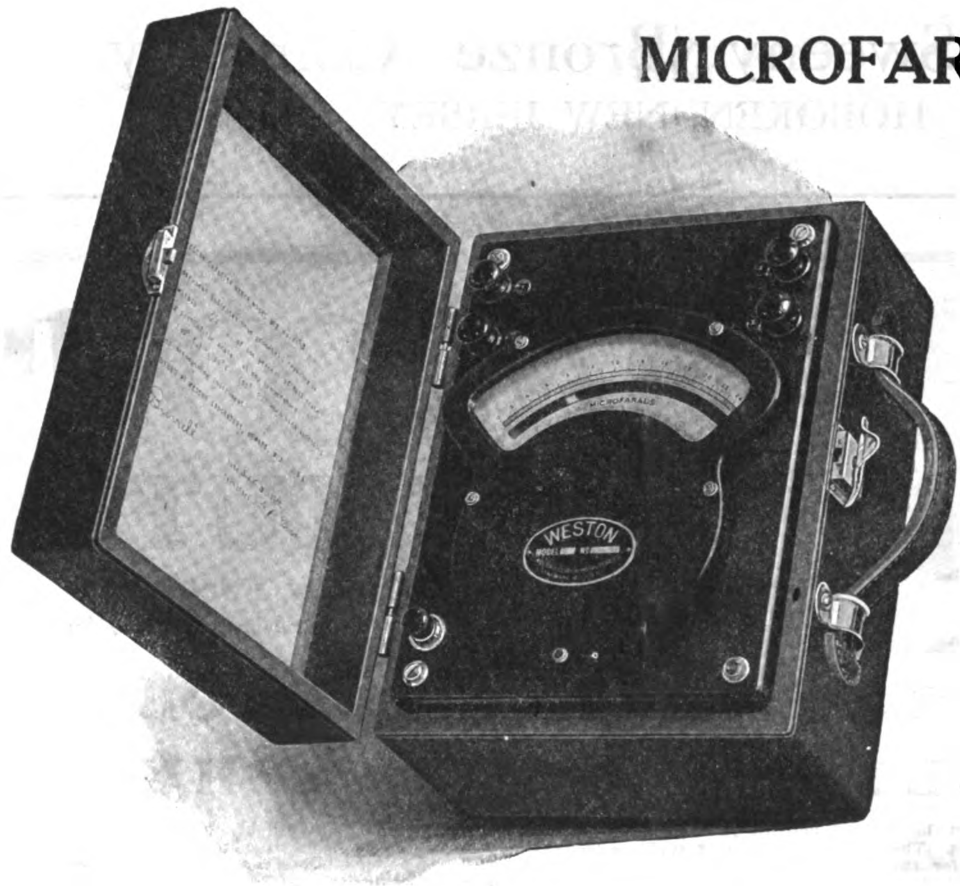

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The Wireless Age

Edited by J. ANDREW WHITE — E. E. BUCHER, Technical Editor

Vol. 6 — Contents for May, 1919 — No. 8

Index of Equipment

RENEWALS—When subscription expires, find a renewal blank enclosed. Return with remittance promptly.

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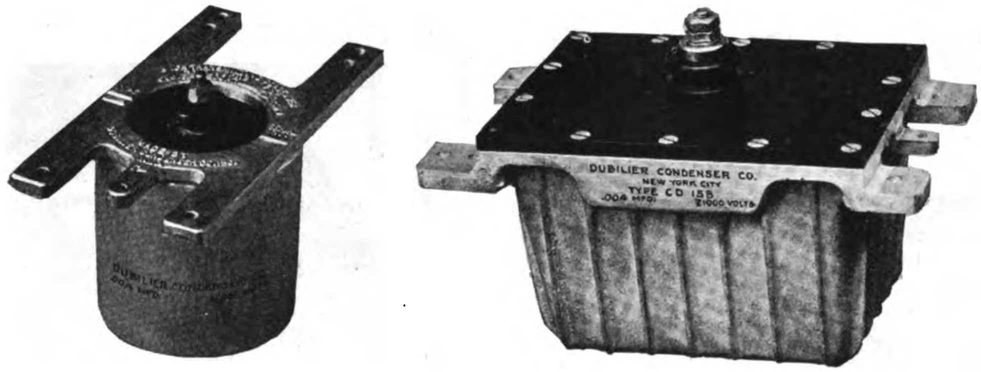
Published Monthly by WIRELESS PRESS, INC. 25 Elm Street, New York

Edward J. Nally, Pres. Charles J. Ross, Vice-Pres.
David Sarnoff, Secy. George S. De Sousa, Treas.
Alonzo Fogal, Jr., Business Manager.

Yearly Subscriptions in U. S., $2.00
Outside U. S., $2.48; Single Copies, 20 cents
Entered as second class matter October 9, 1913, Post Office at New York, N. Y., under the Act of March 3, 1879

GREAT BRITAIN, Marconi House, Strand, London — AUSTRALIA, 97 Clarence St., Sydney, N. S. W.



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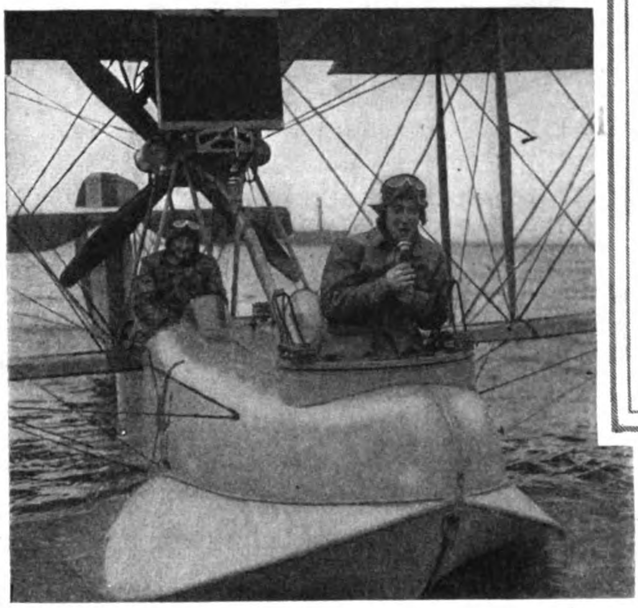
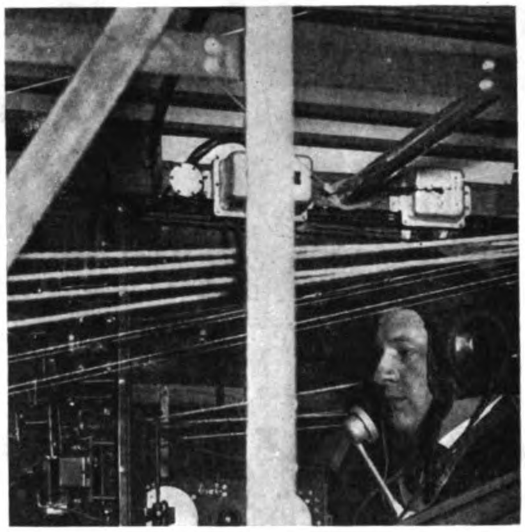




To the left: Gunner H. Leaver at the wireless phone on one of the craft of the aerial coast patrol, which in peace time is employed in locating vessels in distress or in response to any coast alarm

Above: A close-up view of the U. S. Navy's latest flying boat, F-5-L, showing the radiophone installation and the operator

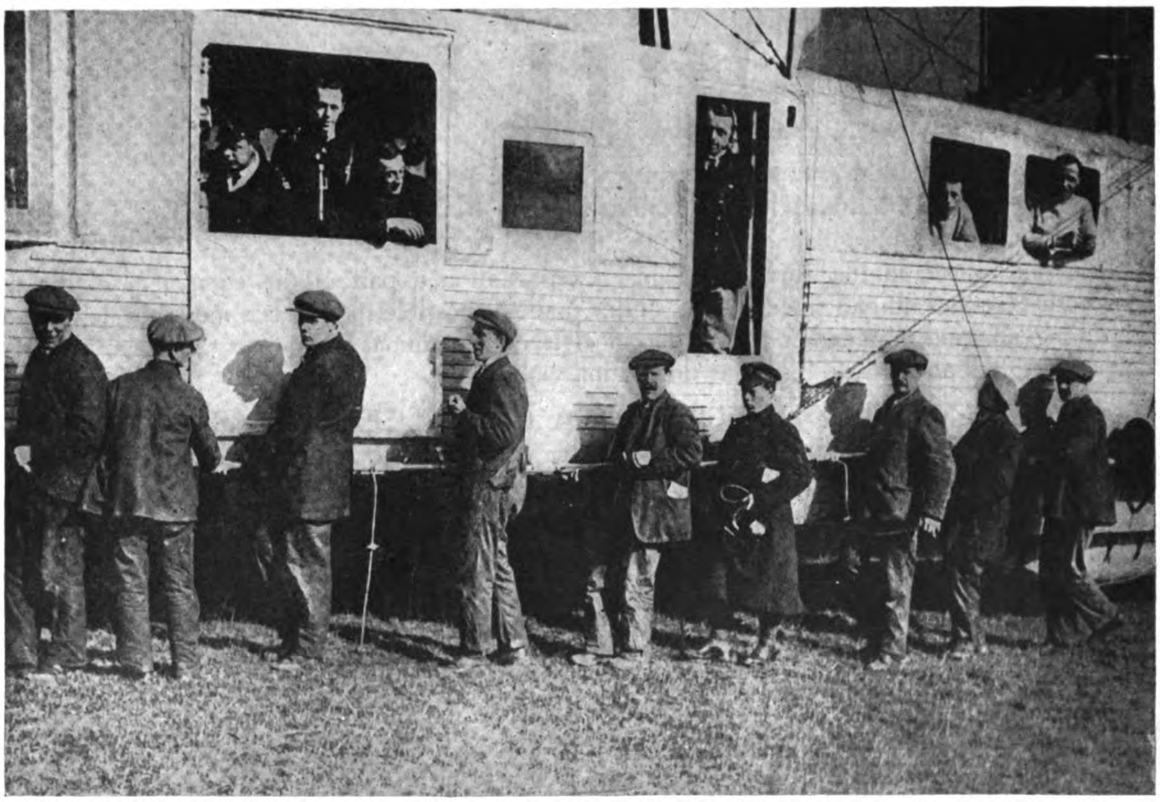


Photo: Intl Film

Launching the world's greatest airship in England; the operator may be seen at the door of the wireless cabin on the right

Vol. 6. No. 8. May, 1919

THE WIRELESS AGE

WORLD WIDE WIRELESS

Wireless Carries Voice Across the Atlantic

ROBERT WELLES RITCHIE, correspondent, was the first to make public the announcement that the human voice traversed the Atlantic at 7 o'clock on the morning of March 19.

After many months of preliminary experiments in long-distance telephony, a Marconi engineer in a wireless hut at Clifden, Ireland, at that hour, called "Glace Bay."

Instantly the answer came.

"Glace Bay talking."

From that moment on, continuously, Clifden communicated with Nova Scotia, the voices carrying strong and clear all day.

There were no sentimental speeches about the marvel of God's work, but the technical engineers talked about improvements of the system which thus carries man's voice across the Atlantic as readily as between New York and Hoboken.

"Our experiment was a complete success," said General Manager Bradfield, of the English Marconi Company. "Transmission was absolutely instantaneous, and the voices were as clear as over the telephone. After the first messages were exchanged, conditions were so perfect that our engineers continued their conversations all day, saving the delay of writing their comments and recommendations regarding improvements. I am sorry I am unable to give a detailed account at this time."

London first heard the news when Godfrey Isaacs, managing director of Marconi's Wireless Telegraph Co., Ltd., made the simple announcement at a dinner of the American Chamber of Commerce:

"Today we made experimental tests of wireless telephony between Ireland and Nova Scotia. They were completely successful. I look forward to the time, in the near future, when you gentlemen can talk to your home office as easily as with any London address."

Later, according to Mr. Ritchie, Marconi himself observed:

"Within three months you, from your hotel room in London, will be able to call any New York telephone number and get it inside of fifteen minutes, and then talk for three minutes for five dollars."

Though detailed information regarding wireless telephoning between Ireland and Canada is withheld for the present by the Marconi Company, the transatlantic wireless telephone promises to be an astonishing success and that the first efforts to talk through the air were much more successful than the first attempts at wireless telegraphing.

The establishment of a regular system of commercial wireless telephony from New York to London is believed to be now merely a question of time, and before long Sydney, Australia, and the furthest parts of the earth will be placed on the aerial exchange.

On March 20 the U. S. Navy Department also announced that one-way wireless telephone conversations were held between the Naval Radio Station at New Brunswick, N. J., and the American transport George Washington throughout her voyage from New York to Brest.

The messages were sent from the station at New Brunswick, erected by the American Marconi Company before the war, but which was taken over by the Government and has since been under naval operation.

The George Washington received wireless telephone messages and replied to them by wireless telegraph, not having a radiophone apparatus for sending messages over long distances. One of the messages sent by wireless telephone to the George Washington was from Secretary Daniels. President Wilson listened to the wireless words of Mr. Daniels but was unable to reply vocally.

The new messenger boy
—*O. S. Williams in the N. Y. Journal*

British Record in Technical Development Criticized in London

AN EDITORIAL in the London Electrician credits American inventiveness with many of the advances in wireless and takes England to task for her lack of contribution to the art on a scale of equality with other nations. In opposing control of radio by the British Government, the editorial observes:

"In view of the immense volume of progress in all branches of technology with which the private investigator must be credited, it would seem that great harm would result from hasty decisions to debar him from wireless telegraphy. No amount of liberty for established firms could compensate for the extinction of the independent worker; in fact, his extinction would assist these firms to become great monopolies.

"Our national record in wireless telegraphy, apart from the finanacial side, is a sorry one. None of the new ideas that have revolutionized the subject during the past seven years can be regarded as having their origin or full development in this country. The conception of beat-reception is American. The three-electrode thermionic relay is American. The method of generating oscillations by aid of three-electrode relays was invented (probably independently) in Germany and the United States. The control of large high-frequency currents by magnetic relays is likewise of German and American origin. The multiplication of frequency by aid of the properties of iron is French, Italian and German. The success in high-frequency generation by alternators is American, French and German. Even the design of the valves which we used by

Wireless possibilities!
—Fay King in the N. Y. Journal

tens of thousands in the war is not native; we have been the humble copyists of the French in this, and, according to some accounts, second rate in that capacity. The theory of the operation of the circuits is mainly due to French and Italian perspicacity. Nearly all amplifier design and development is French and American. Our main successes in this subject during the war have been in the improvement in detail of wireless telegraph apparatus, and in this we may probably be credited with having done exceedingly well; but the fact remains that no novelties of the first order of importance arose in the work done in this country."

Photographic Recording Method to Speed Up Wireless Transmission

WIRELESS messages can be received and recorded at greater speed, as a result of a new photographic device now being used at the naval station at Otter Cliffs, near Bar Harbor, Me. Although the instrument is not immune from the effects of static "strays," it has successfully recorded messages at high speed regardless of strong static interferences that, without its aid, would have baffled the receiving operator. It is said that this machine has frequently recorded at the rate of 400 words per minute and, on one occasion, 600 words.

Up to this time the most rapid method of recording radio signals has been by dictaphone, but the phonographic method has never yet approached the rate of 600 words per minute, so the new instrument has hung up a new speed record.

Speedy sending and receiving can condense the traffic; a greater volume can be sent with a minimum number of stations. When it is remembered that a pair of wireless stations—one in Europe and one here—can easily cost $2,000,000, the item of keeping down overhead charges by rapid sending will be easily appreciated.

Expert operators have been known to receive thirty-five words per minute for a short time under perfect conditions, but average reception has been fifteen to twenty words per minute, or 1,000 words per hour.

The photographic recorder in operation at Bar Harbor has repeatedly recorded regular traffic schedules ranging from 1,000 to 7,000 words without interruption, and at a speed of forty to fifty-five words per minute every word is perfect and easily and quickly read. It is used supplementary to the ordinary type of receiving set.

The mechanism is based on comparatively simple electrical engineering principles. A lightweight mirror "flutters" in electro-magnetic tune with the minute electric impulses coming from the receiving antenna. The duration and extent of the mirror's oscillations vary according to the dot, dash, or silence of the sending station. This mirror reflects a beam of light on the moving sensitized tape. This tape, propelled by an electric motor progresses up and down through the vertical pipes which contain the developing and fixing chemicals. Automatically the tape enters the developing fluid and then the hypo fixing bath; then it is washed in running water and is dried by electric heat assisted by forced draft—all invisibly effected inside this single machine. Like the tape from a stock-ticker, the message pours out into a basket. In rapid receiving there is an average of one word for every inch of tape. The receiving operators can read the record at a speed of 50 to 100 words per minute.

The time to record, develop, fix, wash, and dry the tape is from two to four minutes. The rolls of tape are 1,000 feet long and a continuous message of 10,000 words can be recorded without reloading the machine.

Submarine Jazzes for Airship by Radiophone

OUT of the depths the strains of a popular tune were wafted through the air to the radio telephone apparatus at the Aeronautical Exposition in Madison Square Garden, New York, on the afternoon of March 7.

The lively tune came as a striking contrast to a conversation that had just been completed with the naval airship, L. S. B., flying over the city, navigated by Captain Noble E. Irwin, director of naval aviation.

A large crowd had gathered around the radio space at the Garden, attracted by the novelty of listening to a man talking aboard an airship floating in space three miles away.

In the airship Gunner Lever was telling the crowd in Madison Square Garden the interesting points the airship was passing, when a gruff voice impinged itself upon the oratorical tones of the aerial gunner. "Say," it said, "when are you fellows going to get through? This is the Submarine 249, in the North River, off Twenty-third Street. We are tired of listening to that voice. We are going to give you a tune for a change."

Then, to the astounded spectators the loud speaking telephone, which was being used for the demonstration, reproduced the newest dance music with all the flourishes of Lieutenant Europe's famous jazz band.

Predicts Business Conducted with South America by Radiophone

BUSINESS men of America soon may be placing and taking orders in South American ports by wireless telephone, Edward N. Hurley, chairman of the Shipping Board, told a conference of the Pan-American Union on March 14.

Outlining preparations that are being made to put new shipping in the South American trade, Mr. Hurley foresaw the time when business men of New York would be sitting back quietly in their offices talking with their clients in Buenos Ayres, Rio Janeiro and Valparaiso by wireless telephone as easily as one calls up a neighbor in New York.

Twenty-two 12,000 ton vessels are being constructed for the South American trade, Mr. Hurley said. They will be equipped as comfortably as the finest ocean going palaces which ply in the Atlantic. An additional twenty-two vessels of smaller tonnage are being built for the same trade.

Wireless Service to Holland Required by Cable Interruption

THE British Administrator announced early in March, through the Commercial Cable Company, that owing to the interruption of several wires in the cables to Holland an auxiliary wireless service has been provided pending completion of repairs. Messages intended for transmission by wireless, the announcement added, should be marked by senders "via wireless," and these words should be included in the service instructions. The rate is the same as by cable.

Wireless Guide for Transocean Fliers

LONDON advices relative to transatlantic flight state that at least one of the airplanes that will compete for the transatlantic flight prize will be navigated from wireless information, supplied every half-hour or so by British Air Ministry officials. The pilot will send out an inquiry, and from the direction from which his message is received wireless stations will calculate his exact position. This will be relayed by wireless to the pilot in a few minutes.

The British "Directional" wireless apparatus has been developed during the war, and the Air Ministry claims its instruments are far in advance of those of any other nation.

"Listening at their instruments in shore stations," said an English wireless officer, "hundreds of miles from the spot where an airplane is battling its way across the ocean, our operators will hear a short, prearranged code from the navigator at every coast station.

"Possibly a number of battleships will record the messages and instruments now perfected will point out in each instance the exact direction of the airplane.

"There will be a hasty conference between the stations, and within five minutes the navigator will be able to mark on his map exactly what his position was when he sent his inquiry.

"Fitted with 'directional' wireless and a good compass the airplane will be able to steer through fog or clouds without getting more than a trifling distance off its course."

Canada also promises close co-operation so that aviators engaged in the transatlantic flights will never lose touch with their friends on shore. Friendly voices will advise them and their progress or difficulties en route will be reported in their own words and heard in their own voices by eager watchers. The Marconi wireless telephone will make this possible, says an announcement given out by Thomas Robb, of the Canadian Company. The flight will be made direct from the west coast of Ireland to Newfoundland. There are thirty Marconi stations on the west coast of Ireland and Scotland and an equal number around the central works at Gaspe Bay.

"We have the situation thoroughly in hand now," said Mr. Robb. "We have taken every precaution, so the risk to the aviators will be considerably modified. Through steamships on the ocean and land stations we will be in touch with them all the way.

"The airplane will have the wireless telephone and telegraph sets. The ship will have the wireless telegraph sets, enabling the aviators to receive news as to fog and weather and also be told where their exact landing place is. Newfoundland is a splendid wireless base, and the government there is co-operating with us."

Photographic device for printing wireless messages on tape with a speed of 400 words a minute

Method of Overcoming German Jamming Disclosed

POWERFUL German wireless installations were used to drown out messages among the Allies as part of a deliberate policy. How our navy, on entering the war, overcame this interference was described by E. F. W. Alexanderson at the April meeting of the Institute of Radio Engineers. An abstract of his paper appears elsewhere in this issue.

Dr. Alexanderson described his device as a "barrage receiver," which permits an operator to turn a deaf ear, electrically as well as literally, to all messages which may come through the ether except that particular message which he desires to hear. The invention was kept secret until the end of the war at the request of the army and navy. It has been demonstrated successfully and is now in navy use.

"The object of this development," said Alexanderson, "was to provide means for neutralizing the overwhelming intensity of the transmitted signal so as to make the receiving set sensitive to the faint impulses of the distant signal. Popularly speaking, the correspondent equivalent in sound waves would be to have an ear which could be so adjusted that a person could stand close to a steam whistle without hearing the whistle, but at the same time listen to a person speaking from a distance of a few hundred feet."

Bogota to Have Powerful Marconi Station

ANOTHER COMMUNICATION link with South America has been announced by the State Department at Washington. Marconi's Wireless Telegraph Company, Ltd., of London, the report states, has concluded a contract with the Colombian Government for the erection of a powerful wireless station at Bogota.

Millionaire's Ranch to Use Wireless and Airplane

J. PIERPONT MORGAN has engaged Erhardt Schmitt of Ansonia, Conn., to pilot the manager of his 250-mile tract of wheat fields at Hardin, Mont., in an airplane. Thus Mr. Morgan solves the problem of getting speedily to any part of the ranch. It is believed Schmitt will be the first man to pilot an airplane as agricultural equipment. The airplane will be equipped with wireless, and stations will be established at intervals on the ranch.

On a ranch the size of Mr. Morgan's it was impracticable to build roads to enable the manager to get around the ranch in an automobile, so the owner adopted the airplane, which will save much time and undoubtedly will prove to be less expensive.

Mr. Schmitt is a wireless operator, and so the manager will be able to keep in touch with every section of the territory. Mr. Schmitt was discharged recently from the United States Army. He was a First Lieutenant in the American Air Service in France.

Time Signals Changed on Schedule

IN accordance with the daylight saving law, daily telegraphic time signals are now sent from the United States Naval Observatory at noon Washington summer time, i. e., at four hours Greenwich mean time.

Daily noon and night radio time signals are sent from naval radio stations on the Atlantic coast at four hours and fourteen hours Greenwich mean time (noon and 10 p. m. Washington summer time), except Washington, which will remain, as formerly, five hours and fifteen hours Greenwich mean time (1 p. m. and 11 p. m. Washington summer time), and from the stations on the Pacific coast at seven hours and seventeen hours Greenwich mean time (noon and 10 p. m. San Francisco summer time).

Only American Paper in Germany Has Wireless News Service

SOLDIERS of the Fourth Army Corps are responsible for the "Only American Newspaper Published in Germany," as The Fourth Corps Flare is proclaimed, being published at Mayen every Friday, with wireless news from all parts of the world up to the time of going to press.

The biggest headlines, according to a dispatch from Coblenz, are devoted to speculation as to when the return trip to America will be made, and news of the Peace Conference, interior happenings in Germany, of the United States, France and England, is picked up from the air as needed to complete each edition.

The editor of the Flare is a well known amateur, Wallace W. Smith, of the Radio Club of Louisville, Ky., now a Second Lieutenant with the A. E. F.

Doctors Aboard Troopships Consult by Wireless

ANOTHER instance of the practicability of diagnosis, treatment and medical consultations by wireless at sea was recorded in the westward passage of two transports early in March.

Sierra in mid-ocean received a wireless telegraph message from the captain of the British steamship Pollac, saying that a member of his crew had been taken sick suddenly. The message gave symptoms and asked for diagnosis and treatment. Further messages brought a clearer knowledge of the case to Lieut.-Commander A. E. Younie, of the Medical Corps of the army, chief surgeon aboard. Treatment was ordered and hourly reports were made by the captain of the merchantman to the doctor a hundred miles away. In two days the man had showed marked improvement, and when last reported was recovering rapidly.

The wireless telephone was also used for a consultation of all the doctors aboard the Sierra and those aboard the Powhatan, another troop transport. The two vessels were fifteen miles apart, at a point about five hundred miles north of the Azores, when a consultation about influenza cases developed on the Powhatan was determined on. Six doctors, via wireless telephone, "attended" the conference, the cases being discussed as freely as if the physicians were gathered in one room.

"It doesn't take much imagination to see what a wide field of possibilities the wireless opens up to the medical profession," Lieut.-Commander Younie said. "America is building up an enormous merchant marine. The greater portion of the ships will not be large enough to carry doctors, but in an emergency the captain of one of these ships, using her wireless set, can always call upon expert medical advice, either from ashore or from the doctors aboard the larger ships."

Liberian Station at Monrovia No Longer German

LIBERIA has advised the American Government that the former German wireless station at Monrovia has been opened with a Liberian staff for general public service.

Canadians Install Commercial Wireless Telephones

THE wireless telephone is to be put to practical commercial use in Canada.

Instruments are being installed in the offices of the Montreal Board of Trade and these will enable brokers to talk with Kingston, Ottawa, Three Rivers and Quebec.

It is expected that ultimately conversations will take place between the Board of Trade and Ireland over the Marconi Company's wireless.

Eight Radio Compass Stations for New England

THERE will be eight radio compass stations established along the New England coast, according to a statement made by Rear Admiral Spencer S. Wood. Deer Island station has been repaired and made over. North Truro on Cape Cod and Otter Cliff, Me., are working.

Argentina and Paraguay Make Radio Exchange Agreement

THE Governments of Paraguay and Argentina will exchange radio telegraphic service. An agreement has been signed by the respective representatives of the two Governments. Wireless telegraphic communication is a government monopoly in both countries, and it is hoped that the arrangement will result in much better service for Paraguay than it has enjoyed heretofore.

Naval Operators to Be Taken Off Merchant Ships

GOVERNMENT wireless operators will be removed from all merchant vessels as soon as the ships are returned by the shipping board to their owners, is the announcement made by the hydrographic office at the Maritime Exchange upon the receipt of a communication from the Navy Department.

The apparatus was installed by the Navy Department and will be permitted to remain intact on the vessel for a time, but private interests operating the boat must furnish their own operators. If, however, the company is unable to maintain service, they may employ the navy operators until efficient ones can be had.

A Magnetic Detector of Radio Frequency Oscillations

CLAIMING to have discovered that the super-position of a high frequency current upon an iron core already excited by a low frequency current, reduces the area of the hysteresis loop for the low frequency current, G. W. Elmen has recently disclosed the circuits of a wireless receiving system based upon this principle. His explanation of the phenomenon is that the high frequency oscillations seem to shake up the iron molecules, thereby reducing the force required to set them into motion. Low frequency energy is thus saved, for the energy required to agitate the molecules is supplied by the high frequency source.

Currents of very high frequency are not necessary to carry out the principle of Elmen's receiving system, for it has been found that if low frequency current of approximately 15 cycles per second is employed, another current of 60 cycles per second is sufficient to cause the reduction sharp click or signal in the receiver or translating device which is independent of the frequency of the low frequency magnetizing force. Mr. Elmen's method of reception differs, in that he makes use of the change in the hysteretic energy which must be supplied by the low frequency source when high frequency oscillations are received. Since the change in hysteretic energy is equivalent to a change in the effective resistance of the coil surrounding the iron, any method for indicating or measuring this change in effective resistance may be employed to detect the presence of the radio frequency current. Accordingly, the inventor makes use of Wheatstone's bridge as shown in figures 1 and 2.

Figure 1 shows one circuit for detecting radio frequency currents; figure 2 is a modification, and figures 3 and 4 show forms of coils which have been found useful.

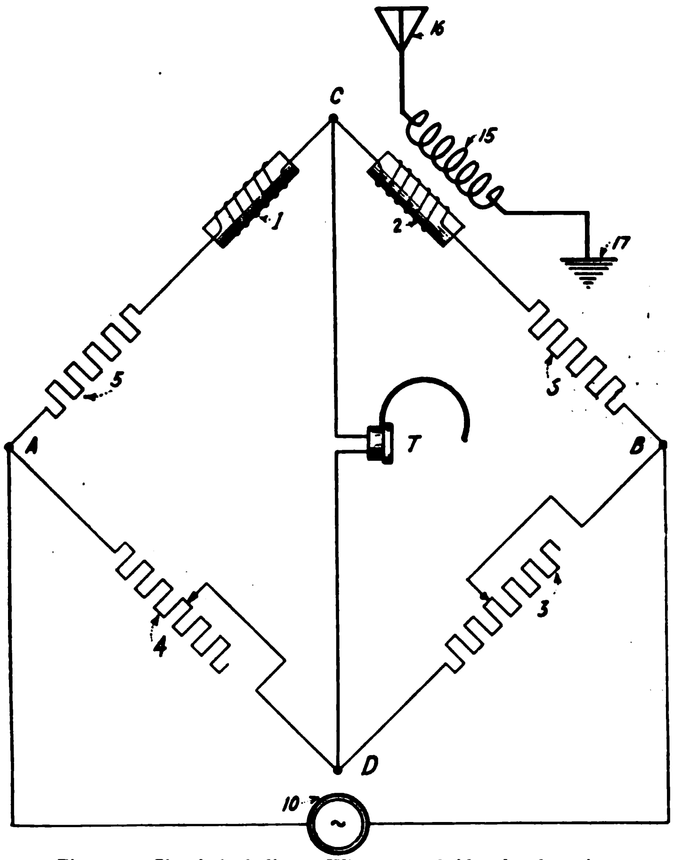


Figure 1—Circuit including a Wheatstone bridge for detecting radio frequency currents

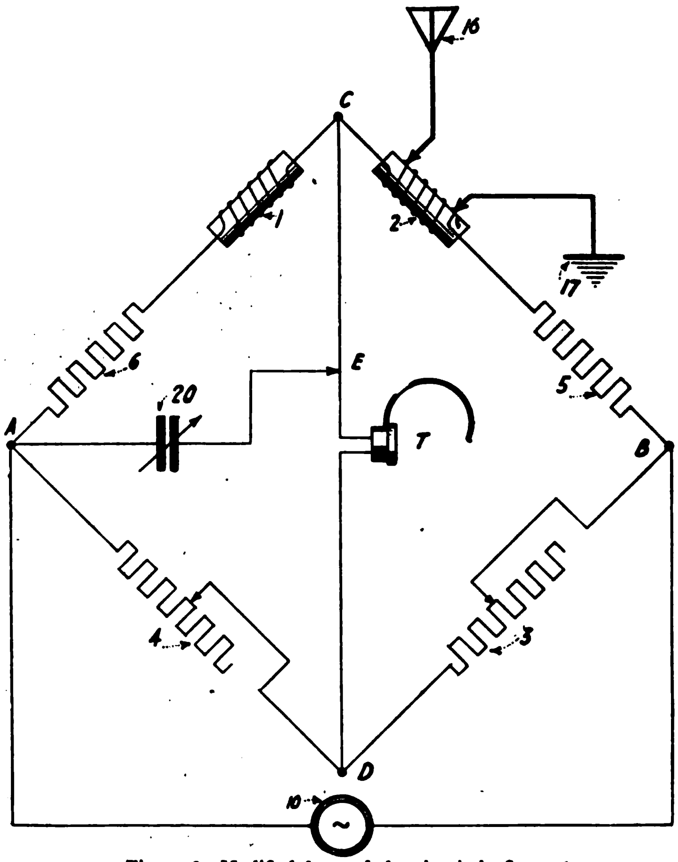


Figure 2—Modified form of the circuit in figure 1

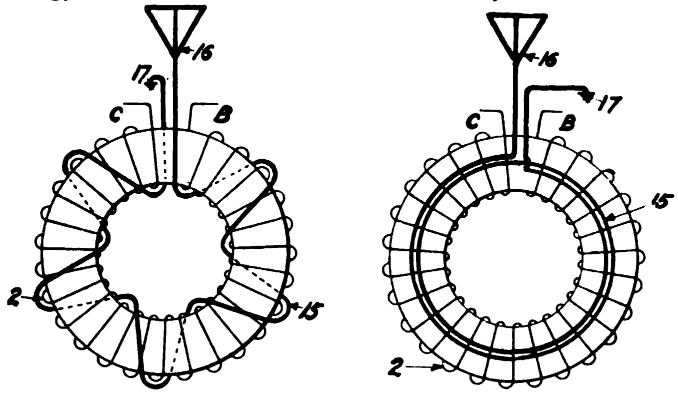
of the hysteresis loop on the low frequency side to practically zero. If the current of lower frequency is then increased, the high frequency current must be increased correspondingly, and may be made very much higher than the lower frequency.

By selection of suitable iron and properly constructing the coil Mr. Elmen claims it is possible to make the ohmic and eddy consumption losses so small that they will be wholly due to hysteresis, thereby enabling the most effective results to be secured from the system.

In magnetic oscillation detectors use has heretofore been made of the suddenly induced effects produced in a receiver circuit when the hystersis cycle in a body of iron is brought partially or wholly into phase with the magnetizing force by the received high frequency oscillations. This sudden breaking down of the magnetic condition gives a

In figures 1 and 2, the iron core coils 1 and 2 are made as nearly identical as possible, and of such form that the ohmic and eddy losses are very small. The cores should be of low coercive force and high remanence. The two other arms of the bridge contain non-inductive resistances 3 and 4 which should be adjustable. Connected to the terminals of the bridge A and B, is the source 10 of alternating or pulsating current of low frequency. Across the terminals CD are connected the head telephones T. Inductively connected to the coil 2 is the coil 15 which is the inductance element of the antenna current.

The circuit in figure 1 operates as follows: The bridge is balanced both for ohmic resistance and for reactance, so that no current flows through the phones T. In order to assist in this adjustment it may be desirable to place the non-inductive resistances 5 and 6 in the branches containing the coils 1 and 2, but these will not always be necessary, for if the coils 1 and 2 are made as nearly identical as possible, any slight difference in them can be adjusted by means of the resistances 3 and 4. Under these conditions, low frequency oscillations will pass continually through the network, and the iron cores of the coils 1 and 2 will be caused to pass through a magnetic cycle, and energy will be consumed because of the hysteresis of the iron. Since the bridge is balanced, however, no current will pass through the translating device T.



Figures 3 and 4—Coils used in the Elmen magnetic detector

When high frequency oscillations are impressed upon the coil 2 by means of the antenna coil 15, the magnetic condition of the core of this coil will be suddenly brought into phase, wholly or partially, with the magnetizing force. As a result the bridge will be thrown out of balance and an indication will be given at T. In general this lack of balance is due to two factors, the first of which may be designated as e_1 and is due to the change in the flux in the coil 2, giving rise to a sudden induced electromotive force, which causes a flow of current through the telephone T. In addition to this effect there is a second effect which may be designated as e_2, and is due to the reduction in the hysteretic energy absorbed as a result of the hysteresis cycle through which the iron is carried by the low frequency source 10. This reduction in the amount of the hysteretic energy represents a reduction in the amount of energy which is consumed in the coil 2, and is therefore equivalent to a reduction in the effective resistance of the coil. This change in effective resistance produces a lack of balance in the bridge, and consequently there is a flow through the translating device T of current from the source 10.

It will be noticed that the first effect e_1 corresponds to the effect which is ordinarily made use of in magnetic detectors as heretofore constructed, and that the effect produced in T is simply a sharp click due to the sudden induced electromotive force. The second effect e_2, however, is independent of this, and is due to a lack of balance in the bridge, as a result of which there will be heard in the telephone receiver T a note which corresponds to the frequency of the generator 10, which will be heard as long as the coil 2 is subjected to the high frequency oscillations impressed upon it by the antenna.

Any other network which is adapted to measure inductances may be used in this system. An example is shown in figure 2, in which a variable condenser 20 is connected from the point A to some point E on the branch CD, which in this case has a small resistance. The bridge is brought into balance either by an adjustment of the capacity 20 or by an adjustment of the point of contact E. Having brought the bridge into balance, no current from the generator 10 will flow through T, but upon the receipt of high frequency oscillations, the bridge will be thrown out of balance and a signal will be received at T.

In order to obtain low coercive force and high remanence, it is desirable to use for the two arms of the bridge a closed core, as shown in figures 3 and 4. Furthermore, in order to reduce the eddy currents, these cores should be laminated or stranded. In figure 3 the high frequency coil is shown as wound upon the core in the same manner as for the coil 2. In figure 4 this antenna or high frequency coil is shown as being wound parallel to the core and preferably embedded in its center. It has been found that in this case the effect of the high frequency oscillations in reducing the hysteresis loss is as effective as in the coils shown in figure 3. Furthermore, it will be noticed that in figure 4 the coil 15 is at all points at right angles to the coil 2, and in consequence there is no induced effect of the coil 15 upon the coil 2.

The frequency of the generator 10 may be varied between wide limits. If the translating device T is to be the ordinary telephone receiver, then it is obvious that the frequency should be within the limits of audibility, and in this case a frequency of about 800 is very good indeed. If the translating device is a vibration galvanometer or some such device, the frequency may be made either lower or higher than the limits of audibility, this being determined by the frequency for which the device is adapted to be used.

Negative Resistance Vacuum Tube as an Amplifier and a Beat Receiver

FULL description of the pliodynatron devised by A. W. Hull appeared in the June and August, 1918, issues of The Wireless Age. Although this detector has not been employed commercially, it involves certain operating characteristics which have aroused considerable interest and incidental argument amongst wireless engineers. Numerous circuits have been devised, but Mr. Hull declares that those shown in the accompanying figures 1 and 2 give very marked amplifications and selectivity and, furthermore, permit the reception of continuous oscillations by the so-called heterodyne principle.

Throughout a certain range of adjustment, the Hull tube acts as a true negative resistance. An externally applied E.M.F. under proper adjustments of the tube will actually set up a current in the circuit in the reverse direction.

The circuits shown contain an inductance and capacity in the negative resistance circuit, making it resonant to the frequency of the incoming signal, with the result that when the incoming oscillations are impressed upon the grid or controlling circuit, the value of the negative resistance will change so that similar oscillations are produced in the local circuit. This results in amplification and marked selectivity. An audio frequency tuning circuit is provided which affords additional tuning means; and through the medium of a resistance 18 of figure 2, sufficient energy is transferred from the circuit containing the negative resistance to the control circuit to compensate for the losses in that circuit and the antenna circuit.

The heterodyne effect is obtained by causing the circuit containing the negative resistance to oscillate at a slightly different frequency from that of the incoming signal.

In the diagram, 6 is a filament cathode surrounded by the grid or controlling member 2; 4 is the so-called anode and 5 a third electrode which is connected to the positive terminal of a battery 8.

In the operation of this device a definite positive potential is applied to the anode 4 by means of a battery 7, the cathode being considered as at zero or earth potential. When the cathode is heated to incandescence, electrons flow from the cathode to the anode. If the third electrode 5 is at the same potential as the cathode no electrons will be received by it, but if a small positive potential less than that of the anode is applied to the third electrode, a portion of the electrons will pass through the anode and reach the third electrode.

The velocity with which these electrons will strike the third electrode will depend upon the potential between it and the cathode. If this potential is increased, the velocity will increase until the electrons, striking the third electrode, are able, by their impact, to liberate secondary electrons. These secondary electrons leaving the third electrode will be attracted to the more positive anode. As the potential is increased, a point will be reached at which the number of secondary electrons leaving the third electrode will begin to decrease. As the potential of the third electrode is increased beyond this point, the current will continue to decrease and *may even reverse* in direction up to a point where the potential of the third electrode approaches that of the anode. Thus it will be apparent that the device has a working range through which it has a negative resistance characteristic; that is, over which the current in the external circuit, between the cathode and the third electrode, varies inversely as the potential between the electrodes.

If a constant potential is applied to the third electrode, by means of the battery 8, of such value that the device will operate as a negative resistance, there will be a constant flow of current in the external circuit. If, however, a variable potential is applied between the cathode and the discharge controlling member 6, the number of electrons which leave the cathode and reach the third electrode will be varied, and the current in the external circuit will be varied accordingly; that is, if the member 6 is made more positive, the flow of electrons to the third electrode will increase, and if the member 6 is made more negative, the flow of electrons will decrease and a small change in the potential of the member 6 will be capable of producing a large change in the current between the cathode and the third electrode.

In utilizing this device for the reception of wireless signals, waves which are received upon the antenna 9 are impressed upon the discharge controlling member 6 by means of an oscillating circuit comprising an inductance 10 which is coupled to the antenna inductance 11 and a variable condenser 12. In the external circuit between the cathode and the third electrode are placed a variable inductance 13 and a variable capacity 14 in parallel. This circuit may include the usual telephone receiver 15 shunted by a variable condenser 16.

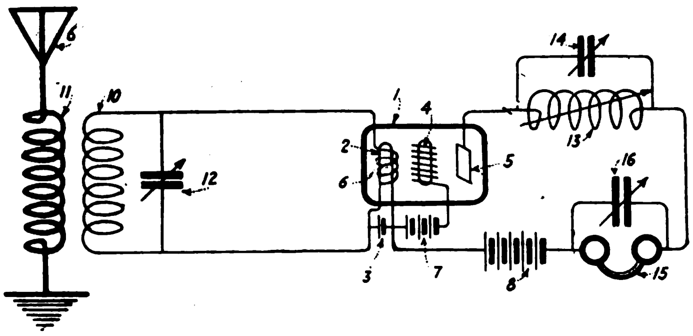


Figure 1—Circuit using the heterodyne principle to secure increased amplification and selectivity in receiving

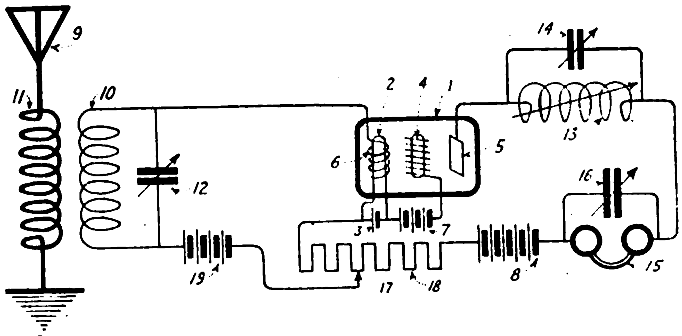


Figure 2—Another form of figure 1 which permits reception of continuous oscillations by the heterodyne principle

In receiving signals, by this system, the inductance 13 and capacity 14 may be so adjusted that the circuit is capable of oscillating at frequency equal to that of the received signals. The value of the negative resistance is adjusted to such a point that the circuit is near a point of instability or a point where oscillations will begin. When the potential of the member 6 is varied by received oscillations, the value of the negative resistance will be changed sufficiently so that the circuit will start oscillating. Under these conditions the amplification of the received signals will be assymetric and the resulting current will operate the telephone receiver.

Without the condenser 16, the circuit would tend to produce oscillations of an undesirable audio frequency. This condenser 16, however, may be so adjusted as to prevent the setting up of audio frequency oscillations, or may be so adjusted as to produce audio frequency oscillations of a frequency equal to the group frequency of the incoming waves. The final adjustments of the system may conveniently be made by varying the value of the negative resistance, which is done by regulating the temperature of the cathode 2.

In order to secure the highest degree of amplification in the system described, the positive resistance of the circuit should be approximately equal in value to the negative resistance.

In the arrangement shown in figure 1, the negative resistance compensates for the losses in the positive resistance of the circuit between cathode and third electrode. In the modification shown in figure 2, means are indicated for compensating also for the losses in the resonant receiving circuit and the antenna. In this case the discharge controlling member 6, instead of being connected directly to the cathode 3, is connected to a suitably selected point 17 on the resistance 18, which is in series with the negative resistance. The voltage supplied to the device by the battery 8 is of such a value that the current in the circuit is negative; that is, positive electricity or its equivalent flows from cathode 2 to the third electrode 5 across the evacuated space and thence through the battery 8 and resistance 18 back to the cathode. If the potential of member 6 is made more positive, the current through the resistance 18 will increase, and thus the potential of the point 17 and of the member 6 will be still further increased. By means of this resistance coupling, energy is fed back from the negative resistance circuit to the resonant receiving circuit and by properly adjusting the point 17, the amount of energy thus transferred may be made sufficient to compensate for the losses in the receiving circuit and in the antenna without producing oscillations.

An anonymous donor has deposited with the Institute of Radio Engineers, New York, the sum of $10,000, the principal to be preserved in perpetuity and the income each year to be awarded to that member of the institute who shall have made the most important contribution to the art of radio during the preceding year. This, in addition to the Institute's Medal of Honor, should spur forward American students in the radio field.

Exhausting Vacuum Tubes

READERS of The Wireless Age who are identified with the manufacture of vacuum tubes may be interested in the process of evacuation devised by H. D. Arnold. The method shown in figure 1 provides particularly for heating the exterior of the tubes during the exhausting process; also for heating one or more of the inclosed electrodes by the passage of an electric current and also for heating another electrode by electronic bombardment due to the application of a local E.M.F.

In the drawing, figure 1, thermionic repeater elements 2, each having the customary filamentary cathode 3, grid 4 and anode 5, are inclosed in an oven 6 which may be electrically heated by a resistance element 7 connected to a source of current 8. The glass containing vessels 9 of the elements 2 have tubular extensions 10 connected to a main tube 11 leading to an exhaust apparatus 12, such,

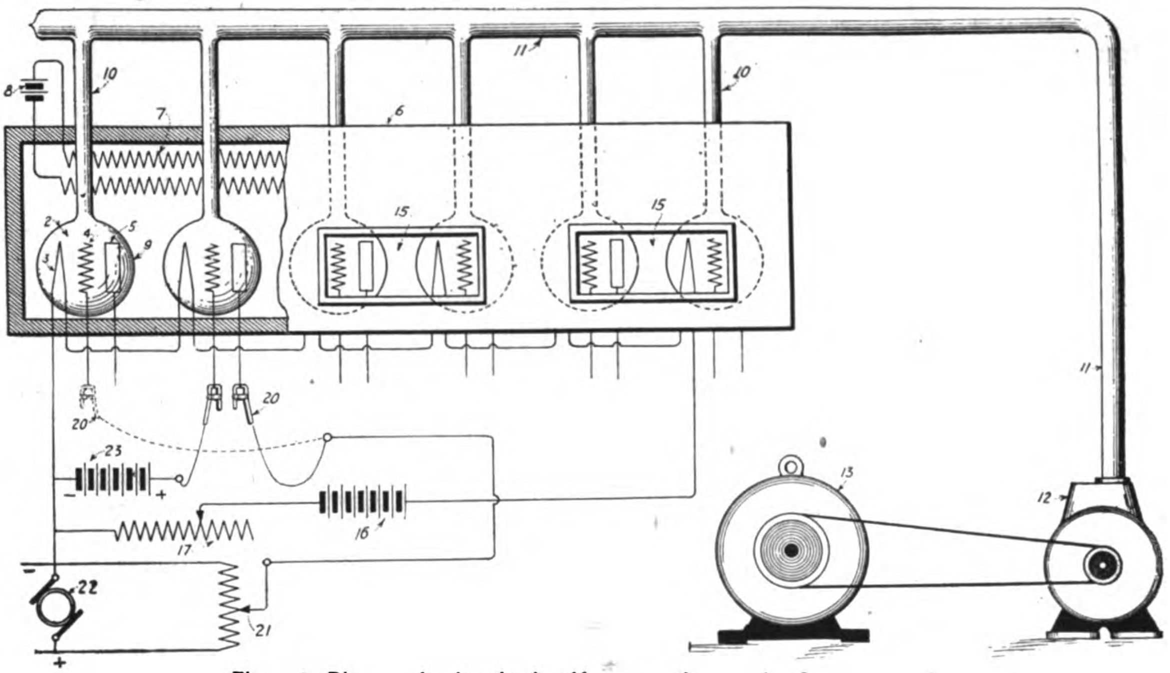


Figure 1—Diagram showing the Arnold process of evacuation for vacuum tubes

for example, as a Gaede molecular pump, connected to a source of motive power 13. The terminals of the electrode elements 3, 4 and 5 are brought out through apertures in one of the walls of the oven 6, so as to be readily available for test purposes and for the application of any desired electromotive force.

A suitable number of windows 15 are provided in the front of the oven 6 so that the tubes 2 being exhausted may be observed during the evacuation process. The filaments 3 are connected in series with a source of current 16 and a variable resistance 17.

The process of exhausting the vessels 9 is as follows: The pump 12 is started and the temperature of the oven 6 is gradually raised until it has reached approximately 350° C. The purpose of this heating is to drive out the gases occluded by the walls of the vessel 9. After the temperature of the oven has risen to about 250° C., the filaments 3 are brought to incandescence by current supplied from the source 16, which is raised to a value approximately 10 per cent greater than the current normally to be used in the operation of the completed device. A potential difference is thereupon successively applied to the terminals of the electrodes 4 and 5 by means of a test clip 20 connected through the potentiometer 21 to a direct current source 22 of about 220 volts output. The filament 3, being connected to the negative terminal of the source 22 as shown, and the test clip 20 being connected to the positive terminal of the source 22, there will result an electron discharge from the cathode 3 to the electrode 4 or 5, to which the test clip 20 is temporarily connected. This potential difference is made sufficiently high, through adjustment of the potentiometer 21, to cause an electron discharge of sufficient volume to heat the electrode (to which the test clip 20 is attached) to incandescence. This drives out any gases which may be occluded by the electrode.

The electron discharge, which passes from the cathode 3 to either electrode 4 or 5 when a potential difference is established between them, partially ionizes whatever gas may be in its path. When gas in sufficient quantity is thus ionized, a blue glow results in part or all of the vessel 9, which may readily be observed through one of the windows 15. The intensity of this blue glow depends upon the amount of gas present and upon the current and potential difference impressed between the cathode 3 and electrode 5. For a given current and potential difference, therefore, this blue glow will gradually become fainter as the gas within the vessel becomes more attenuated, until the glow finally disappears.

When the proper degree of exhaustion is obtained, the tubes are allowed to cool gradually and are sealed off of the pump 12 and given an aging run. This consists of applying the normal heating current to the filaments 3 and impressing the customary operating potential difference between the cathode 3 and anode 5. It has been found that after an aging run of from fifteen to twenty hours duration the repeaters have reached a stable condition and may be relied upon to give constant and uniform results.

In case the thermionic device to be exhausted is equipped with a grid 4 of very fine mesh, as in the case of a repeater tube designed for voltage amplification, it may be difficult to obtain a current to the electrode 5 sufficient to heat it properly. In such event, it has been found desirable to apply an additional positive potential from a source 23, for example, of perhaps 60 volts output, to the grid electrode 4 at the same time that the positive potential from source 22 is being applied to the anode 5. This increases the flow of electrons to the anode 5, and as some current will also flow between the filament 3 and grid 4, the voltages may be adjusted so as to heat both electrodes 4 and 5 at the same time.

Langmuir's Mercury Vapor Modulator for Wireless Telephony

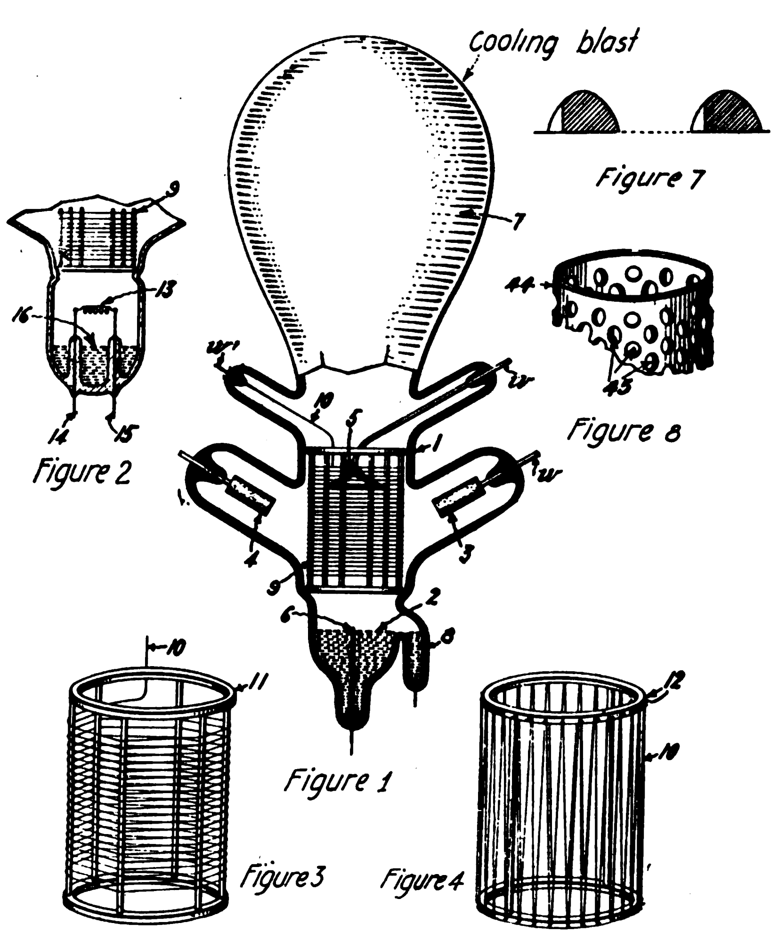
A METHOD of controlling the output of a radio frequency alternator at speech frequencies for radio telephony is the subject of a recent patent granted to Dr. Irving Langmuir. The control device illustrated in figure 1 comprises a glass or quartz envelop 1 containing a body of mercury 2 (constituting the cathode), and main anodes 3 and 4 which may be made of graphite, tungsten, molybdenum or other highly refractory material.

Above the cathode 2 is an anode 5 from which a constant arc is formed with the cathode. The steadiness of the arc is insured by the conductor 6, of platinum or copper projecting above the surface of the mercury. A condenser chamber of the correct size to give the proper mercury pressure is shown at 7. The arc is started by the small electrode 8; 9 is a grid of tungsten wire placed between electrodes 5 and 2 and the anodes 3 and 4. Suitable constructions for the grid are shown in figures 3 and 4. Figure 8 shows a modified form.

Two circuits for wireless telephony are shown in figures 5 and 6. In figure 5 energy is withdrawn from the antenna at speech frequencies; in figure 6 modulated currents are supplied to the antenna from the radio frequency alternator.

In figure 5 the usual antenna 17 is shown containing an inductive coil 18 and a series condenser 19. Electrical energy is supplied by a high frequency alternator inductively coupled to the antenna coil 18. The coil 22 is also located in inductive relation with the coil 21 and has its terminals connected by conductors 23, 24, to the anodes 3, 4 of the control device. The cathode 2 is connected in series with the resistance 25 by a circuit conductor 26, carrying rectified current, to a point of intermediate potential on the coil 22. The circuit represented by conductor 27 connecting the cathode 2 and the anode 5 contains a battery 28 for supplying energy to continuously maintain an arc between these electrodes. This same battery may also be used to start the device by completing a circuit to the auxiliary electrode 8 through the switch 29.

When the arc between the electrodes 5 and 2 is normally operating, energy is supplied by the alternator 20, and successive arcs would ordinarily pass from the anodes 3 and 4 to the cathode in the usual manner. When, however, the grid 9 is negatively electrified to a sufficiently high potential the starting of these arcs is prevented. In order to take advantage of this fact a variable negative potential may be impressed upon the grid, thereby causing variable amounts of energy to be passed by the arc device. As this energy is consumed in the resistance 25, it is subtracted from the energy available for the antenna. In this way signals may be transmitted. For example, a telephone transmitter 30 containing a local source of energy such as battery 31, may be connected to the primary of a transformer 32, the secondary of which is connected to its negative terminal by the conductor 33 to the grid 9. The positive terminal of the secondary is connected by a conductor 34 in series with the battery 35 to the cathode 2. The battery 35 is not absolutely essential, but is desirable as it maintains the grid at a definite negative potential so that the variations impressed by the signaling current vary the grid potential to values above or below the battery potential.



Detailed diagrams of Langmuir's mercury vapor modulator for wireless telephony

High frequency current in the circuit 33, 34 is damped out by a condenser 36 and the resistance 37. When a voice produces variation in the conductivity of the transmitter 30 the resultant variable current in the transformer 32 is stepped up in potential, superimposed upon the battery potential 35 and thus varies the charge on the grid. The grid, in accordance with the degree of its negative charge, delays the starting of the wave impulses from the anodes as shown diagrammatically in figure 7, the shaded portions of the waves indicating the energy transmitted through the control device.

Instead of withdrawing energy from the antenna by the control device, it may be directly transmitted to the antenna from the high frequency source through the control devices, as shown in figure 6. In this figure the high frequency alternator 20 is connected with the primary of the transformer 38, the secondary of which is connected by conductors 39, 40, to the anodes 3, 4 of the arc control device. The cathode 2 is connected by a conductor 41 in series with the primary of a transformer 42 to a point of intermediate potential of the transformer 38. The other connections of the control device are similar to those already described. When a variable potential is impressed on the grid 9 by the telephone 30, variable portions of the wave impulses from the high frequency supply are transmitted by the arcs and impressed as rectified current impulses on the transformer 42, the secondary of which is included in series with the antenna 43. A high frequency current having double the frequency of the source 20 is generated in the antenna, varying in accordance with the variations of the signaling current.

It would be of interest to know whether this device operates without distortion. It is not quite clear that it will give as effective modulation as the 3-electrode vacuum tube.

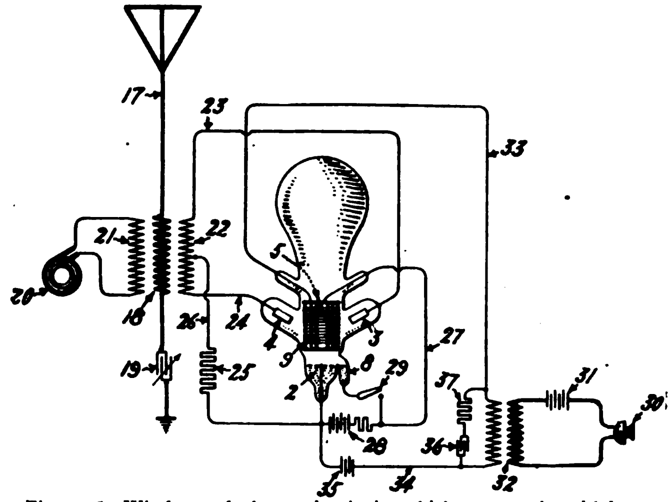


Figure 5—Wireless telephone circuit in which energy is withdrawn from the antenna at speech frequencies

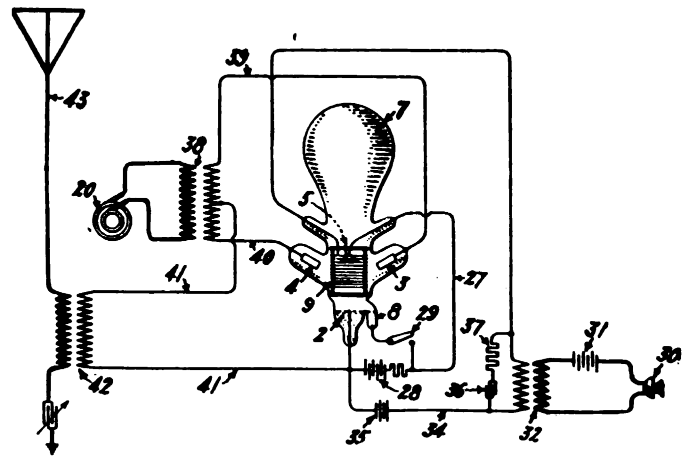


Figure 6—Circuit for wireless telephony in which modulated currents are supplied to the antenna from the radio frequency alternator

Receiving Antenna

THE accompanying diagrams illustrate a specially constructed aerial designed to block out waves or disturbances of a frequency differing from the one which it is desired to receive. The antenna construction is the joint invention of Roy A. Weagant and Harry Shoemaker. They have observed in the average case that resonance adjustments of the receiving aerial are well defined for any particular frequency being received, yet oscillations of other frequencies emanating from near-by powerful transmitters may set the receiving antenna into oscillation

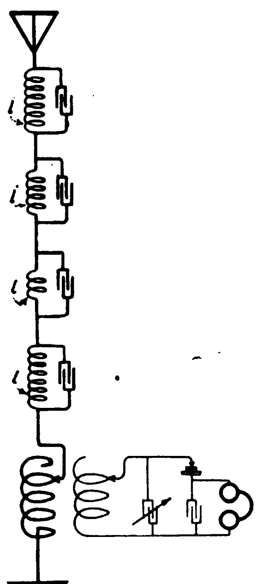


Figure 1

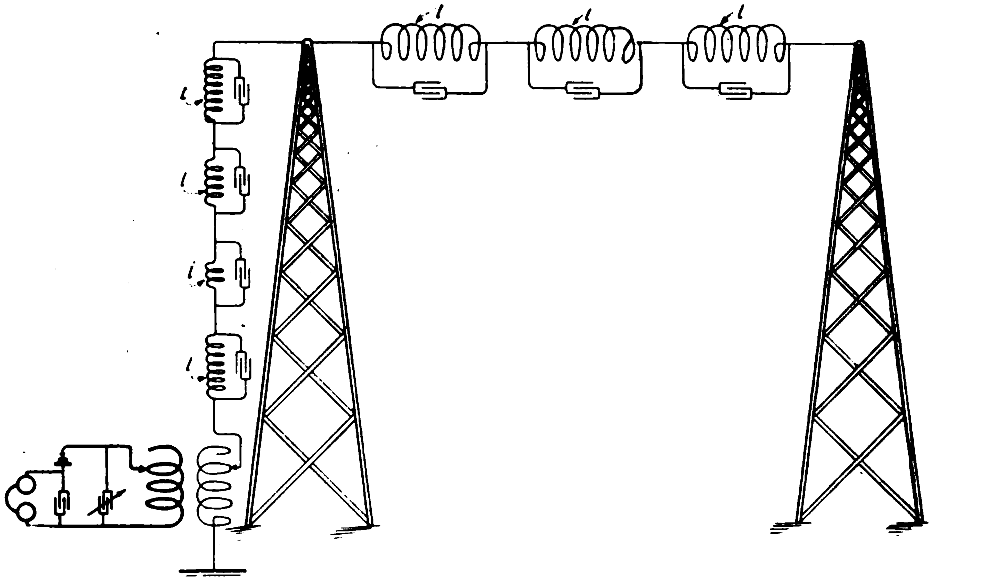


Figure 2

Diagrams illustrating a specially constructed aerial designed to eliminate oscillations of undesired frequencies

at its own frequency, causing a powerful interference. By utilizing the special antenna having loading inductances inserted as shown in figures 1 and 2, undesired frequencies have been eliminated in the manner now to be described.

It will be noted in these figures that loading inductances i of various values are inserted in the antenna at regular or irregular intervals. These coils are shunted by fixed condensers giving a plurality of oscillation circuits of different frequencies. By this means, the characteristic of the antenna is changed from a condition of substantial uniformly distributed capacity and inductance to a condition of non-uniform distribution.

Such an arrangement of inductance with a capacity in parallel, connected in series in an antenna circuit, has a very high impedance to electrical oscillations with a time period which is the product of the localized inductance and capacity. If the resistance of these lumped circuits was zero, their impedance would be infinite; but by keeping the resistance small, the impedance will be sufficiently large to effectively block out interfering frequencies.

It is preferable that the natural period of any of these lumped circuits be short in comparison to the wave lengths which it is desired to receive. For example, when receiving a wave of 12,000 meters, it is undesirable to use any inserted lumped circuit having a natural period greater than 5,000 meters.

While the insertion of these lumped circuits in the antenna circuit has the effect of blocking out higher frequencies, the entire antenna system must be so designed that its natural frequency will permit resonance at the wave length it is desired to receive.

The Design of 60-Cycle Transformers for Amateur Transmitters

By John J. Holahan

THE fundamental equation of the transformer is

$$E = 4.44 \times \phi \times n \times f \times 10^{-8}$$

Where, E = voltage

ϕ = maximum flux threading the coil at no load and equals the density in lines of force per square inch, B, multiplied by the area of the core A.

n = number of turns in the winding

f = frequency of applied E.M.F.

For the primary E.M.F.

$$E = 4.44 \times \phi_1 \times N_1 \times f \times 10^{-8}$$

For the secondary E.M.F.

$$E_2 = 4.44 \times \phi_2 \times N_2 \times f \times 10^{-8}$$

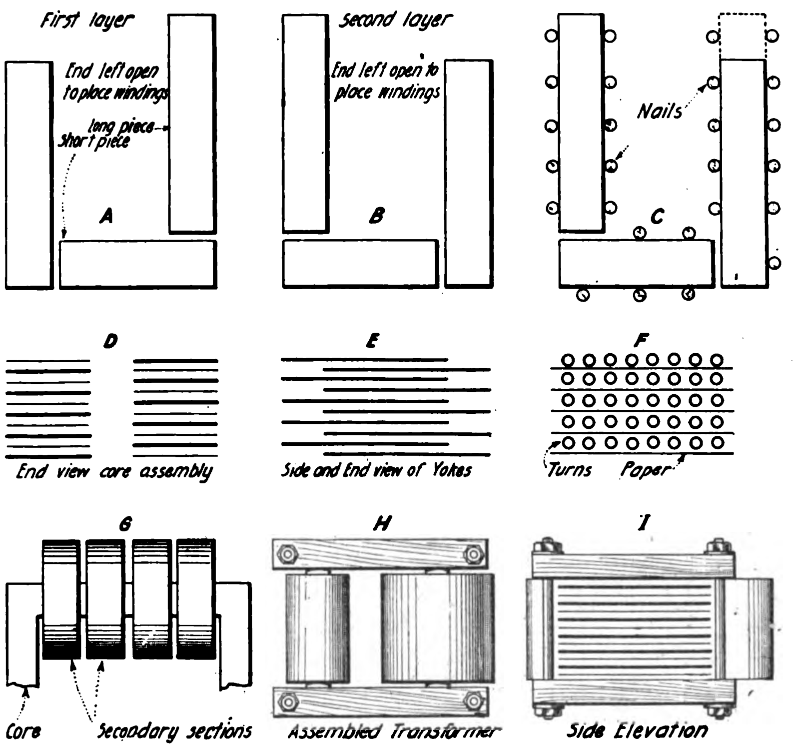
The ratio of primary E.M.F. to the secondary E.M.F. is,

$$\frac{E_2}{E_1} = \frac{4.44\,\phi_2\,N_2\,f\,10^{-8}}{4.44\,\phi_1\,N_1\,f\,10^{-8}} = \frac{\phi_2\,N_2}{\phi_1\,N_1}$$

If $\phi_2 = \phi_1$, that is, if there is no magnetic leakage so that all of the flux produced by the primary cuts the secondary, this becomes,

$$\frac{E_2}{E_1} = \frac{N_2}{N_1}$$

This is the ratio of the secondary E.M.F. to the primary E.M.F. and is equal to the ratio of the number of turns on the two coils. The relation does not hold for open core transformers as they have a large magnetic leakage.



Detailed design of the 60 cycle transformer for amateur transmitters

No Load Losses

The losses at no load are practically those due to hysteresis and eddy currents in the iron core.

The hysteresis loss is $W = K B^{1.6} f \overline{W}$

The eddy current loss is $W = K_2 B^2 f^2 t^2 \overline{W}$

Where, K = hysteresis constant² and varies with the grade of iron.

= $.0027 \times 10^{-7}$ for alloyed iron

= $.0615 \times 10^{-7}$ for ordinary iron

K_2 = a constant inversely proportional to the electrical resistance of the iron

= 2.29×10^{-11} for ordinary iron

= $.792 \times 10^{-11}$ for alloyed iron

B = maximum flux density in iron in lines per square inch

f = frequency cycles per second

t = thickness of laminations in inches

$\overline{W}$ = weight of iron in pounds

Iron .014" thick is suitable for transformers. At 60 cycles alloyed iron is preferable to ordinary iron.

Losses Under Load

The losses when the secondary is connected to a load are those due to the resistance of the current in the primary winding, which equals $I_1^2 R_1$

Where, I_1 = current

R_1 = resistance of the primary winding

The resistance and current in the secondary winding is equal to $I_2^2 R_2$, where I_2 = current and R_2 = resistance of the secondary winding. Added to this are the iron losses.

The I^2R losses are known as the copper losses and vary with the load. The iron losses are practically constant at all loads. The total losses are simply the addition of the foregoing losses, viz.:

Iron loss $+ I_1^2 R_1 + I_2^2 R_2$

Efficiency of Transformation

The efficiency

$$= \frac{\text{output}}{\text{input}} \text{ or}$$

output ÷ (input + iron losses $+ I_1^2R_1 + I_2^2R_2$)

The efficiency of a transformer is maximum when the iron losses equal the copper losses.

A study of the fundamental formula shows that the number of turns of wire does not depend on the kw. rating of the transformer nor on the current the transformer will draw, but depends solely on the E.M.F., flux and frequency. The only effect the load rating has is to fix the size of wire. The size of wire should be from 1,000 to 2,500 cir. mils per ampere for ½ kw. and about 500 cir. mils per ampere in 10 kw. sizes or larger. To illustrate the point let us change

$$E = 4.44\ A\ B\ n\ f\ 10^{-8} \text{ to}$$

$$An = \frac{E \times 10^8}{4.44\ B\ f}$$

Substituting $E = 110$, $B = 60{,}000$, $f = 60$, we have

$$An = \frac{110 \times 10^8}{4.44 \times 60{,}000 \times 60} = 688$$

Now if $A = 1$, n should equal 688

(*Continued on page 22*)

Personalities

Lieut. Walter W. Massie, an old-timer in wireless, who commanded the crew of radio installers of Newport shown in the photo below

W. W. MacFarlane of Philadelphia with his radiophone that establishes fifty-yard communication by stovepipe aerial

Quite a number of ex-amateurs are to be seen in this group, credited with the radio installations on practically all the ships attached to the Second Naval District. Top row, left to right: Johnson, Pelletier, Gallinagh, Sumption. Second row, standing: Newcomb, Whittaker, Lester, Stewart, Wood, Martin, Litchman. Third row, sitting: Bowen, Miss Cavanagh, Clayton, Miss Pfannenmeller, Mair. Bottom row: Sweet, Vaughan, Carter, Crocker, Manuel, Downie and Riccius

My Experiences in the War

Third Instalment of the Personal Narrative of a Pioneer in Aircraft Wireless Who Was Wounded and Captured in the Attempt to Stop the Hun Invasion

By Captain Gordon Adams
South Lancashire Regiment

(*Continued from the April Issue*)

AS I lay sprawled out and helpless in the farm field, I peered through the dark. All around were other wounded, and many dead. The wounded numbered about 300, and as it was impossible for our stretcher bearers to take us away, we were left where we lay. There was a man who stayed with me for some considerable time regardless of the hail of bullets and rain of shells. I have often wished that I could find out his name. He refused to leave me, and only at last consented to go when I gave him a military order to rejoin the regiment and carry on with the retirement.

The first agony of my shattered leg was frightful. Then, when the pain had subsided to a certain extent, my chief sensation was one of raging thirst. I attempted to get my water bottle, but it was attached to my belt and I was lying on top of it, and every movement caused me excruciating pain. After a long time, however, I was successful. But I was not to have my drink. The cork was jammed. I pulled and tugged without result, and then began further struggles in an attempt to draw my sword, with which I proposed to attack the refractory cork. I was finally successful; after many futile attempts I managed to extract the cork. Then—how painful is the memory—my hand slipped and I upset the water bottle, spilling the whole of its contents!

After I had been lying there among the turnips for an hour or so the German hordes started advancing upon the position we had just evacuated. I have never heard anything more impressive. Had I known then what I know now about the Hun I doubt if I should have looked at it in the same light, but at that time we thought the Germans an honorable enemy.

The night was gorgeous; no wind and the stars brilliant. After the recent din the deathly silence was all the more marked. Suddenly, far away in the distance, I heard the faint notes of a long trumpet call. This was taken up by others like an echo; nearer and nearer came the notes; they passed, receded into the distance, and finally died away. Then a moment of dead silence, followed by the distant sound of thousands of men singing in beautiful harmony some very majestic battle song. The music swelled to thrilling intensity as nearer and nearer they came; finally, with a triumphant pæan of song the advancing Germans reached their goal. The horde had swept on.

Later in the night I had fits of delirium from which I would recover to find myself chatting merrily with a neighboring turnip. Only one man came near me during the night, and he was one of our own men who was struggling into Solesmes with 13 shrapnel bullets in him. Later I met another man who had exactly 13 bullets in him; but in his case the German soldier who picked him up, thinking it unfortunate for a man to have an unlucky number of honorable wounds, added one more to the total by pushing his bayonet through his face.

About 6 o'clock the next morning the Germans continued their advance; as a preliminary measure, however, they deliberately shot all the British wounded they could find. Out of those left with me on the top of that hill only twelve were spared. My escape was a most fortunate one. The first act of the German who found me was to pull my revolver out of its holster, point it at my face and pull the trigger. Fortunately for me it was not loaded. Just at this moment I looked round and saw a Hun officer approaching me, revolver in hand, ready to finish me off. Luckily, just before he reached me, the order came from their commanding officer to continue the advance. Otherwise, I should never have escaped the brutal end arranged for my gallant comrades.

After this I remained lying where I was. Several small parties of Germans visited me. I was greatly amused at one very juvenile Hun officer who came up, and on searching my haversack discovered my field service note book. The German did not know a word of English, but he could see that this note book contained carefully written out operation orders. He beamed all over his face, imagining no doubt that the finding of such valuable information would get him promotion. I have often wondered what happened afterwards, when it was discovered that the note book was a very old one and the orders it contained were written during Irish command manœuvres three years before.

At length a German doctor arrived and I was taken on a stretcher down to a convent in Solesmes which had been converted into a hospital. They let me lay there without attention for two or three hours. Finally, two savage Boche doctors came and proceeded to set my leg without any anaesthetic. Their method was positively inhuman. One sat on my chest while the other one hauled the leg into position and put rough splints on. In the bed next to me was a French soldier who had been hit in the knee by a shell. His leg from the knee down was only attached to the remainder of the leg by a small strip of flesh. For four days he received no attention, and by that time the lower part of the leg had started to decay. The venom of the Hun medicos passed all understanding. Yet the game spirit of the Allied soldiers was unquenchable. In the room with me were men of my own regiment, Frenchmen and Germans. Suffering as they were, though, I recall how vastly delighted was everyone when a French soldier, who apparently had not shaved for some weeks, just before his departure for some other hospital, came over to my bed and kissed me warmly on both cheeks.

I spent some time at Solesmes, and just when my thigh bone was commencing to mend orders were given that I should be moved back to Valenciennes. The only vehicle available was a small two-wheeled cart. I was put into this on a stretcher but, as luck would have it, after traversing some four miles, the horse fell down and broke my leg again. On arrival in Valenciennes the splints were removed and I was left for the night. That was the worst night I have ever spent. The muscles of the leg set up violent contractive spasms, which drove the splinters of bone inside the leg into the various nerves, adjacent to them. The pain was beyond comprehension; I thought I should never survive it. But I had more to learn of German methods. The leg was not reset until I had been at Valenciennes a week!

The hospital where we were quartered had been a girls' school and owing to the shortage of German nurses the mistress of the school had been roped in and made to do the necessary nursing. No words of mine can ever express my gratitude to those good French ladies of Valenciennes. They wore themselves to shadows, working for the English and French wounded. The old lady who looked after me had nearly been killed in the Franco-Prussian war of 1870. She was then a small girl and was sitting on her father's shoulder when he was shot by the Prussians. Her hatred of Germany and everything German was positively venomous. She was the professor of Psychology and Literature at the School and we used to have great psychological discussions together.

Masses of men, trained and highly disciplined, made the Hun army a vastly impressive machine. This view of a telegraphic headquarters gives an insight into the well organized methods within their lines

There was one particularly unusual thing which came under my observation in that hospital. I had often been told that many Orientals can die simply through an effort of will, but had never believed it until I actually saw it happen at Valenciennes. A Gurkha was brought in, wounded in the calf of the leg. Fearing that the Germans might amputate it, which is contrary to their religion, he calmly stated that he was going to die. There was no earthly reason why he should, but he did. It took him 36 hours to accomplish his end.

It was the custom to move all wounded prisoners back into Germany itself as soon as—and very often before—they were fit to be moved. In due course my turn came. I was taken to the station on a stretcher in company with several others and put into a train which was to convey us to Cologne. The senior of the French ladies who had been nursing us was allowed to come into the station to see us off. As she was handing me in some sandwiches for the journey a German medical officer doctor saw her, and for no greater offence than that of giving food to a "damned Englander" he clenched his fist and knocked her down. Not content with that, he assembled a party of soldiers who fixed their bayonets and hustled her out of the station. You may imagine how our blood boiled.

Arrived at Cologne, we were taken straight to a hospital where I found the second in command of one of our infantry regiments. He had been wounded on the same day that I had been. His instructions had been to hold a position and "never to retire," consequently although only about four of his men survived he stuck to his post though very seriously wounded himself and was subsequently taken prisoner.

Revolting is a mild term to describe the food at Cologne; in quantity it was just sufficient to keep body and soul together. And the medical manhandling was in equal evidence. During the whole time I was there a Turk derived a great deal of daily pleasure in what he pretended was a massage to my leg, his object being to inflict as much pain and do as little good as possible. Everything conceivable was done to make our lives as unpleasant as possible. For one thing, we were allowed no knives or forks to eat with, a deprivation irritating to us, but possibly meaningless to the German himself, who makes as little use of these implements as he possibly can, preferring to use his fingers. Another thing that irritated me was that shaving was forbidden.

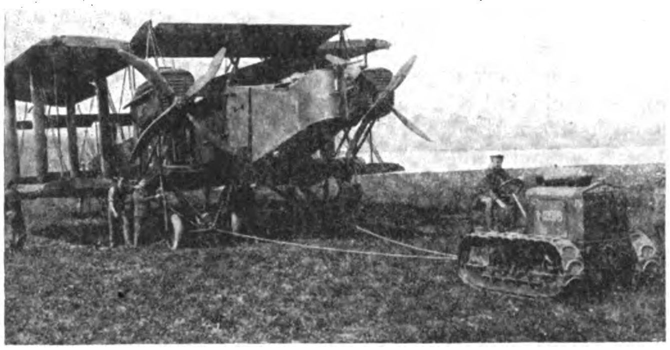
I might mention here, that just before my arrival at this hospital one of the prisoners had lost his way in the building and accidentally got into a passage which the prisoners were forbidden to use. A sentry who he there encountered did not trouble to explain to him his error, but shot him instead. No attempt was made to reconcile the language difficulties, which were considerable, in learning the hospital regulations. It apparently gave little concern to the captors that small infractions might be expected of a most cosmopolitan collection of men, including English, French, Belgians, Turks, Arabs, Senegalese, Sikhs, Gurkhas, and others.

From Cologne I was taken to a prison camp at Osnabruck. Snow was falling when I arrived. Notwithstanding the cold I was put, along with four others, into a stone cellar and kept there for seven days. During that time the cold was intense but we were given fuel sufficient only to last us for three hours altogether. Our beds consisted of three planks and a sack of straw; these we had to burn in order to get a little warmth. After the week had elapsed we were put into other rooms where conditions were only slightly better. The English were always selected for the worst treatment. In order to annoy us, orders were issued that all the English were to be kept apart from each other. The sanitary conditions were filthy. We were allowed a bath but once a fortnight, and that was given grudgingly.

At length, on a certain afternoon I was told by a German *unter offizier* that I was going to be exchanged because they considered me totally incapacitated for further military service. I was taken down into the town of Osnabruck and there at a hospital I met the rest of the English prisoners who were about to be exchanged. We had dinner at this hospital and the Germans told us we could have anything we liked. There was a certain amount of grim humor in their imagining that by one hour of good treatment they could wipe out the memory of months of ill-usage. But then, in any question of psychology the German is the most perfect ass.

Clean, cheerful quarters and a staff of sympathetic attendants are the rule in American hospitals, where wounded soldiers are instructed in useful vocations, by contrast with the German idea which Capt. Adams describes

At 9 in the evening we were put on board what they were pleased to term a hospital train. It consisted merely of cattle trucks and into these were put the wrecks of humanity whom the Germans were liberating. I have never seen such a disgraceful sight in my life as presented by those English soldiers. A large proportion were blind, and practically all the remainder were deficient of legs and arms. The whole lot were filthy and absolutely in rags. It took us 14 hours to get to Flushing and then we saw the Germans for whom we were being exchanged. They



This British official photograph shows a tractor bringing a huge Royal Air Force bomber into position, illustrating the magnitude of the problems of the author, who compiled technical data for all types of machines

all looked well fed; and they were clean and well clothed.

After a very rough crossing we landed at Folkestone and went straight up to London, where I was sent to a hospital to undergo a small operation. I shall never forget what luxury a fire and the clean sheets seemed to me.

After this I had to wait for months to get sufficiently fit for the big operation. The bone of my leg had healed up crooked, the result being a shortening of 4½ inches. The operation, which was performed in the autumn of 1915, consisted in opening the leg, sawing the bones apart, putting them into their proper places and then screwing steel plates down the side. As a testimonial to Hun savageness, for the rest of my life I shall carry about with me 16 inches of steel plating and 24 screws.

During the time I was in the hospital recovering from this operation I met another exchanged prisoner who had been shot in the arm. The Germans cut the entire arm off, leaving no stump to which could have been attached an artificial one. Shortly afterwards, when he was being moved by train from one prison to another, he asked a sentry for a glass of water. The sentry replied by sticking his bayonet through the other arm. The German doctors then removed that also, leaving in this case, as in the former, not a vestige of a stump.

It was eight months after my operation before I was fit to do even an office job; but finally, after worrying medical boards, I was taken on as head of one of the sections of the design branch in the Air Ministry. My work consisted of compiling all technical data about different types of machines and their performances when undergoing official tests. I also had to interview all inventors of new types of machines. Most of them were extraordinarily funny. One bright individual claimed that he had invented a machine which would fly for thousands and thousands of miles at a speed of 300 miles an hour without any engine power at all. He had to have an engine to get up flying speed to start with but then he claimed that further power was unnecessary, as the wind pressure would push the propeller round.

Another man had spent nine years in trying to produce a machine of the ornithopter or wing-flapping type. For experimental purposes he had rigged up in his garden a large iron frame work to which were attached the wings that flapped. The flapping power was supplied by one or more of his numerous small children who were put on in turn to wind a handle which operated the mechanism. He wished to demonstrate that by flapping the wings the whole contrivance could be made to leave the ground. It certainly did jump about 6 inches off the earth, but it did so at the moment when the wings were at the top point of each flap, when aerodynamically the machine should have been resting most firmly on the ground. The explanation was that the whole affair was jerked upwards by the inertia of upward-moving wings.

Still another budding inventor was responsible for the following bright idea: In order that fast scout machines of small gasoline carrying capacity might be enabled to remain in the air for a longer time at a stretch, he suggested that they should be followed by slow machines carrying a large supply of gasoline. When running dry, all that would be required of the pilot of the scout machine would be to fly under the large machine, and, after seizing the end of a long india-rubber pipe which the pilot of the large machine would hang overboard, deftly insert it into his own tank. Then by a manipulation of cunningly devised tap he would be enabled to replenish his tank and go on his way rejoicing. Although the inventor was suitably thanked for placing at the disposal of the Air Board his exceedingly original scheme, the idea was not acted upon as the authorities did not deem it advisable to include in the syllabus of a pilot's training instruction the art of the milkmaid.

From the Air Ministry I was appointed instructor in theory and construction at the Central Flying School. My work there was varied and interesting. On arrival I was told to reorganize the whole system of training of engine men, fitters and riggers. It entailed a tremendous amount of work, but finally I got it straightened out. My system was as follows: Each class, consisting of about 200 fitters and 200 riggers, went through the course in about 9 weeks. About the first half of this time the fitters were given instruction of a more or less general nature on each of the different types of engine which I kept in the instruction shops. The remainder of the time was devoted to specialized instruction on one particular engine. In selecting the men for their specialist course I endeavored as far as possible to allot each man to the particular type of engine which interested him most, in addition to which each man completed a short course of instruction on the simple repairs which could be done on a workshop lorry. I also endeavored to send each man for a short time to one of the flying squadrons to get practical experience of squadron work.

A remarkable picture of a group of all the American "Aces" in France, taken in France during the days of fighting, just before the armistice was signed

The training for riggers was run along similar lines, with the exception that in place of the repair work on the workshop lorries I gave them instruction in splicing and sail-making.

Each man during his course received about 400 hours instruction. I endeavored, whenever possible, by arrangement with squadron commanders and the officer in charge of workshops, to give the men repairs to do which would actually be used on machines in the air. I found that it stimulated their interest considerably if they knew that some real use would be made of their work.

Apart from training mechanics I was also responsible for all the ground instruction to officer pupils. I had under me instructors in wireless, bombing, artillery observation, photography, gunnery and reconnaissance, who carried out instructions in these special departments. The theory of flight and construction of machines I dealt with myself. At one time I started to organize a wireless flight which I considered would facilitate the instruction of wireless and artillery observation. It did not last long, however, as Training Brigade H. Q. said that although this idea was excellent the necessary machines could not at that moment be spared. My perfectly good wireless flight therefore came to a sudden end.

From the Central Flying School I returned to the Air Ministry and joined the department which dealt with the design of armament, compasses and bomb sights. I had charge of designs of bomb sights and bomb carriers, and in addition I again had to interview inventors and receive their ideas and suggestions. It was to this department that the famous and historic woodpecker scheme was submitted.

In all seriousness a certain man forwarded a suggestion for training thousands of woodpeckers to fly to Germany and on arrival to get busy with their beaks and pick out the mortar from between the bricks in Krupp's gun factory so that eventually the whole building would crash to the ground.

Leaving the Air Ministry again, I took over command of and organized a new type of supply depot. This depot I found to be in a very unsatisfactory state. It was the property of one aircraft manufacturing company and was used by four others. The mechanics were entirely civilian. Its inefficiency was due to three causes: (1) lack of military control; (2) lack of co-ordination between the R. F. C. and the firms supplying the machines; (3) difficulty in obtaining pilots to take new machines to their destinations.

With the new organization I had under me a staff of expert technical R. F. C. officers and mechanics. Machines arrived from the makers in parts and were immediately turned over to the riggers for assembly. That completed to the satisfaction of the inspecting officers, they passed into the hands of the engine men, who tuned up the engine. After that they passed through various other departments for gun testing, instrument adjusting, and so on. When finally ready for flight they were handed over to the despatch officer. His duty was to know the exact position of each machine, find out in advance to what squadron it was allotted, and then have it tested and delivered at its destination. For this purpose he had under him a staff of twenty pilots. From start to finish each machine went through eleven different processes. Owing to the extremely urgent need for machines at the front all ranks had to work at least 12 hours a day.

I succeeded in a very short time in trebling the output, but I had hopelessly overworked myself and finally, after carrying on as long as possible, my leg troubled me to such an extent that I had to go on leave and was invalided out of the service on April 23, 1918.

The Design of 60-Cycle Transformers for Amateur Transmitters

(*Continued from page* 17)

and if $A = 688$, n should equal 1
if $A = 2$, n should equal 344
and if $A = 344$, n should equal 2, etc.

Any value can be chosen for A or n provided $An = 688$.

Number of Turns

The number of turns can be determined approximately as follows:

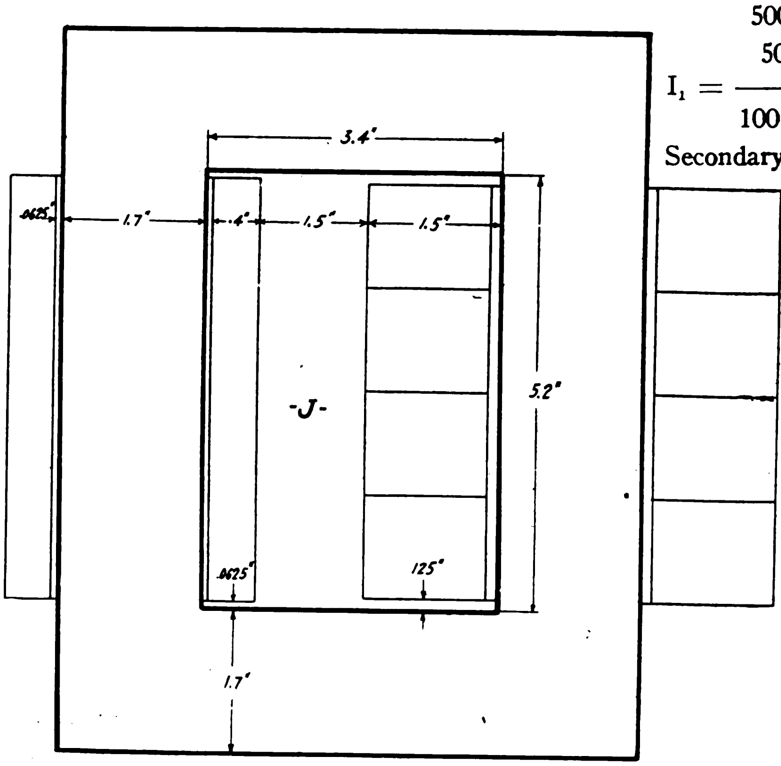
$$n_1 = \frac{E}{K\sqrt{W}}$$

Where E = coil voltage
W = watts capacity of the transformer
K = .021 for small 60 cycle transformers and K = .03 for larger transformers.

If the formula above is used to find the primary turns, the secondary turns equal

$$n_2 = \frac{E_2 n_1}{E_1}$$

In transformers for radio work, the current should be determined from the kilovolt-ampere rating rather than from the kw, rating as the power factor ($\cos \phi$) is rather low.



General plan with dimensions of the core, primary and secondary coils

Example

Let $W = 500$ watts
$E_1 = 110$ volts (primary)
$f = 60$ cycles
$E_2 = 13{,}500$ volts (secondary)
Power factor = .8 (assumed) = $\cos \phi$.

The power $W = E_1 I_1 \cos \phi$. Substituting the above values,

$$500 = 110 \times I_1 \times .8$$

$$I_1 = \frac{500}{100 \times .8} = 5 \text{ amperes (approx.)}$$

Secondary current

$$I_2 = \frac{E_1 I_1}{E_2} = \frac{110 \times 5}{13{,}500} =$$

.04 ampere approx.

The area of the primary wire, allowing 1000 cir. mils per ampere $= 5 \times 1000 = 5000$ cir. mils. From a wire table we find that the wire nearest to this is No. 13 DCC wire. Its resistance is 2 ohms per 1000 feet. For the secondary, the area $= .04 \times 2500 = 100$ cir. mils and from

(*Continued on page* 26)

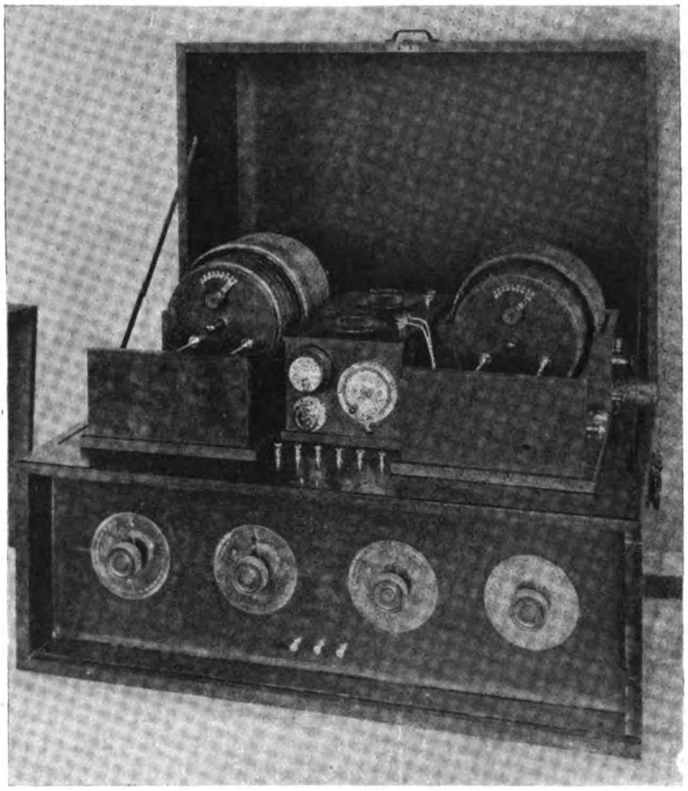
Simultaneous Sending and Receiving

A Wireless System for Duplex Operation and the Prevention of Interference

The paper read by E. F. W. Alexanderson at the April meeting of the Institute of Radio Engineers

An Abstract by E. E. Bucher,
Director of Instruction, Marconi Institute

OUTLINING an extensive series of experiments conducted mainly at the Marconi Company's high power station at New Brunswick, N. J., Mr. Alexanderson interestingly described three recent lines of radio development. Explaining how, with a duplex system for radio telephony, a land line telephone subscriber at any point in the city may pick up a local telephone and speak by radio through the wireless telephone transmitting station and receive a reply as in every-day wire telephony, the speaker gave details of what he terms the "bridge receiver" and the "barrage receiver."



Radio receiving set with barrage attachment invented by E. F. W. Alexanderson

The bridge receiver is a device which permits reception of signals at a given station while the local transmitter is in operation, with little or no interference. In this system, separate transmitting and receiving antennae are used, but they are erected close enough so that the receiver and transmitter may be considered to be in paired branches of a Wheatstone bridge.

The barrage receiver is a combination of two aperiodic horizontal antennae, which are said to have distinctly unilateral directional characteristics. By means of appropriate phase shifting devices, signals from any given direction can be balanced out while the desired signal is retained.

Regarding the system of duplex radio telephony, Mr. Alexanderson made public the diagram in figure 1, in which the left hand part of the drawing shows a radio frequency alternator N in series with the antenna system shunted by the well-known magnetic amplifier M for control of its output. The right hand part of the drawing shows a receiving antenna which is separated from the sending antenna at a satisfactory distance so that the selectivity of ordinary receivers and transmitters can be depended upon for differentiation between the wave lengths of the sending and receiving stations. Each pair of sending and receiving stations is connected together by a wire line and to the exchange of a local telephone system, so that the land line telephone subscriber may be connected to the radio station.

In the diagram, the lines from the sending and receiving stations are introduced in series with the subscriber's line. These circuits involve certain novelties of operation which the speaker explained. For example, a telephone current originating in the wireless receiving station from a distant transmitter sets up currents flowing between the telephone subscriber's instrument and the radio transmitting station. The telephone current originating from the subscriber's instrument takes the same path. This brings about the interesting condition that the currents originating in the receiving station will be re-transmitted by the sending station. As a consequence, both sides of the conversation are transmitted by each sending station and a third party may hear both speakers by tuning in on either of the two transmitted wave lengths.

In order to prevent self-exciting oscillations which may result from amplification of the local receiver currents by the proximity of the transmitter, it is necessary that the amplification of the receiver be held within a certain critical value; for if telephone currents are set up in the subscriber's line of greater intensities than the currents originally produced by the speaker, the same current will be relayed again through the sending station and come back to the speaker in an intensified form, and would be again transmitted from the first sending station. The resulting cumulative effect would be similar to that obtained in ordinary wire telephony when the receiver is held close to the transmitter.

Simultaneous Transmission and Reception with the Antennae Suspended from the Same Mast

Mr. Alexanderson showed a system for duplex radio telephony whereby two antennae were supported from the same mast, interference between them being prevented by inductive and capacitive neutralization. A diagrammatic representation is shown in figure 2, in which A is a radio frequency alternator shunted by the magnetic amplifier M, and T-1 is the microphone transmitter connected in the control circuit of the magnetic amplifier. Antenna A is the transmitting aerial and antenna B is used to create a potential of opposite phase to the potential of the sending antenna. This negative potential is transferred to the receiving antenna through the transformer T and through what is termed an exposure condenser E. The magnitude of this negative potential is adjusted to counterbalance the direct exposure between the antenna A and B, thus leaving the receiving apparatus with the coupling L at ground potential. Since the phase relation of the transformer is not exactly 180° a residual potential is left in the receiving apparatus which may be effectively blocked out by the trap F, comprising an inductance and a capacity in shunt. This gives a very high impedance to the interfering current but allows the incoming signal to pass.

Mr. Alexanderson mentioned certain tests made at Schenectady, when it was possible to receive signals from stations 2,500 miles distant without appreciable interference from a sender giving 20 amperes at 10,000 volts in the antenna A.

He described the system of capacitive neutralization between the transmitting and receiving antenna as shown in figure 3; since this circuit has many of the characteristics of the Wheatstone bridge (as shown diagrammatically in figure 4) it has been termed the "bridge receiver."

In figure 3, the receiving antenna A-2 is connected to the primary loading coil T-2 through the counterpoise condenser C-3. The loading coil is coupled aperiodically to the secondary of the receiving set through a linking circuit. The counterpoise condenser is connected through the exposure condensers C-1 and C-2 to the transmitting antenna. Although this method of neutralization, in large measure, eliminates the interference of the local transmitter, local induction other than that due to the capacity coupling between the antennae gave a residual effect that was eventually taken care of by a device called a phase rotor. The phase rotor feeds currents from the transmitter to the receiver at any desired phase angle; in one branch it consists of an inductance and capacity in series; and in the second branch of an inductance, capacity and resistance in series. By adjusting the position of the rotor L the electromotive

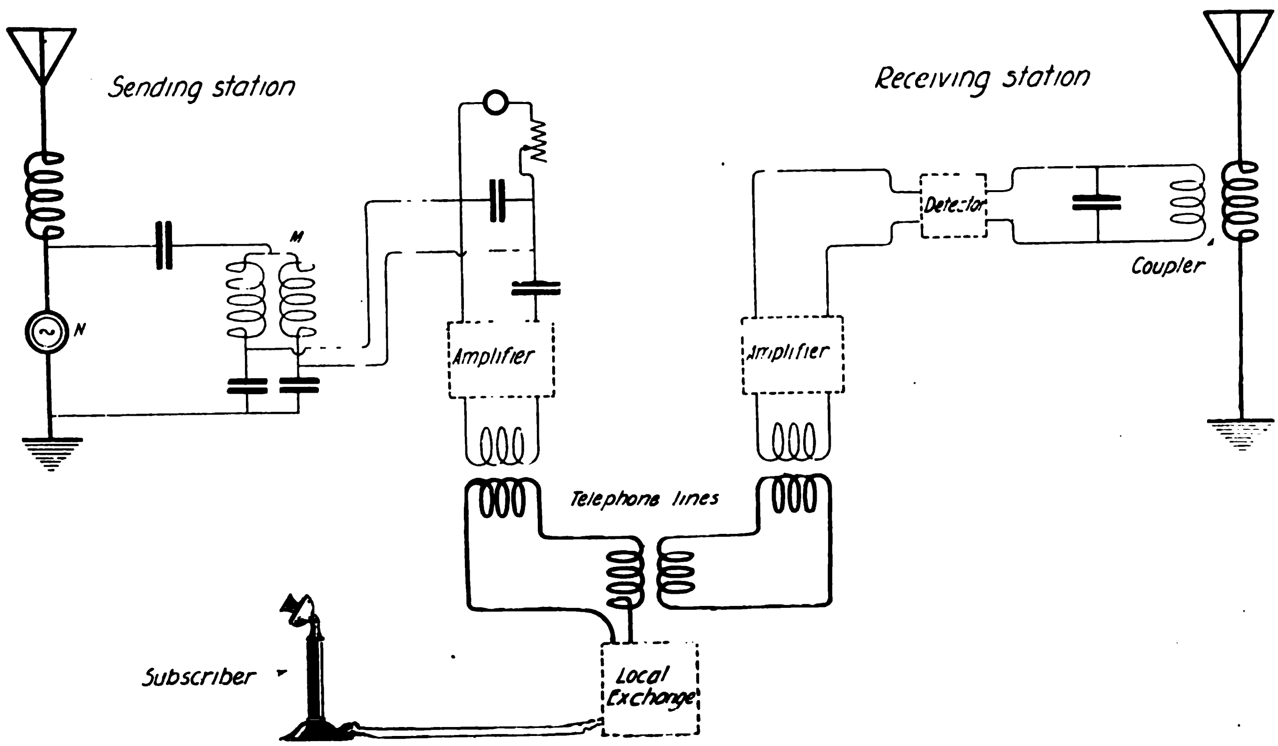


Figure 1—Radio telephone system permitting communication with land-line exchange

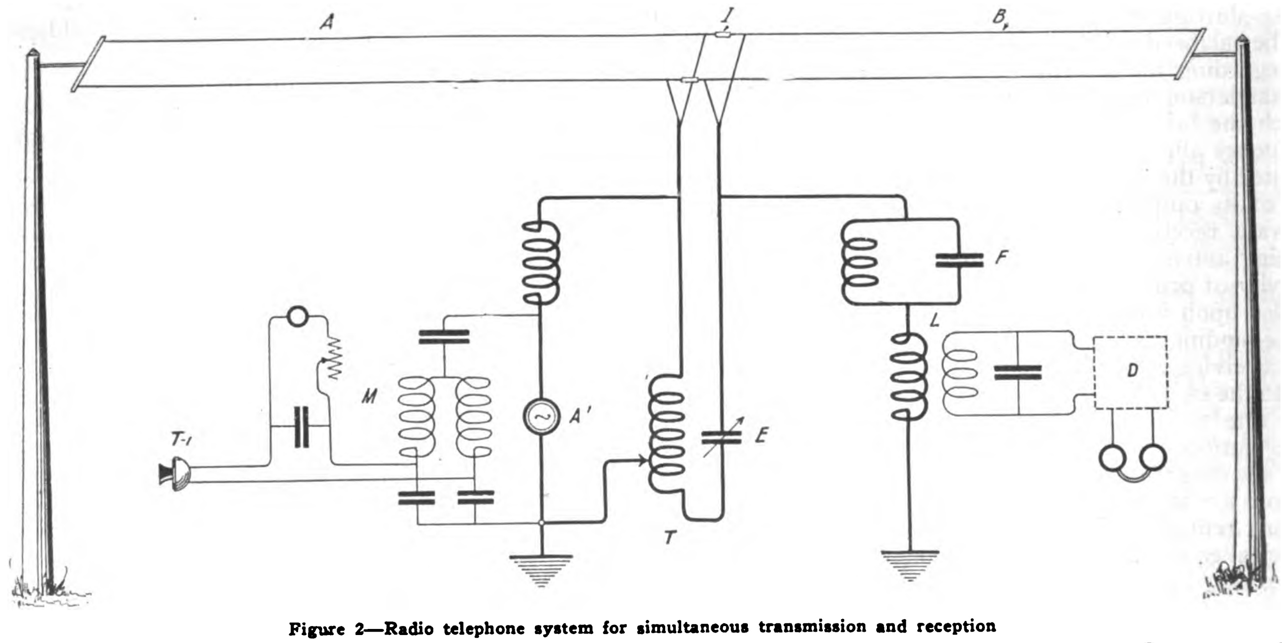


Figure 2—Radio telephone system for simultaneous transmission and reception

force induced in it may be made to assume any desired phase relation to the primary voltage. In other words, the rotor of figure 3 is adjusted to withdraw energy from the antenna circuit of the transmitter, through the coil F-1 and the transformer I, of the proper phase angle to neutralize the local action of the transmitting apparatus upon the secondary circuits of the receiver R.

In the equivalent circuit shown in figure 4, the exposure condensers and counterpoise condensers form an artificial circuit duplicating the potential drops between the sending antenna, the receiving antenna and ground. By adjusting the exposure condenser, two equipotential points are found between which the receiving set is connected. The right hand arm of the branch is effectively represented by the dotted lines, the receiving antenna in this diagram having been assumed to be one of the umbrella type.

Construction and Operation of the Barrage Receiver Described

The so-called barrage receiver is shown in figure 5. It comprises two horizontal aperiodic antennae which Alexanderson declares should preferably have one-quarter wave length separation for the particular signals being received. In designing the barrage receiver he observed the following principles: In his estimation, the difficulty of balancing two tuned circuits is very great and accordingly the antenna or energy collectors should be aperiodic. Second, the balancing should consist in neutralizing the electromotive forces before they have a chance to create oscillating currents. Third, the two antennae should be of the same characteristic; in other words, it is preferable to balance a magnetic exposure against another magnetic exposure rather than against an electrostatic exposure, as is done in the Bellini-Tosi uni-directional receiver.

This is accomplished in the diagram of figure 5 by two phase rotors which are coupled to the horizontal antenna. The rotors are coupled to a common detector circuit which in this diagram comprises a three electrode vacuum tube. By turning the rotary coil of the phase rotators, signals may be drawn from the antennae at any desired phase angle and thus interference from any direction neutralized.

Mr. Alexanderson states that with this apparatus it was possible to receive signals from San Diego at New Brunswick while the large transmitting station at New Brunswick was in operation. The receiving station in this case was erected about three miles from the New Brunswick transmitter.

Each of the antennae used for this demonstration were two miles in length.

A discussion of the paper followed, in which several previous patents bearing upon the principle of simultaneous transmission and reception were cited. Lester

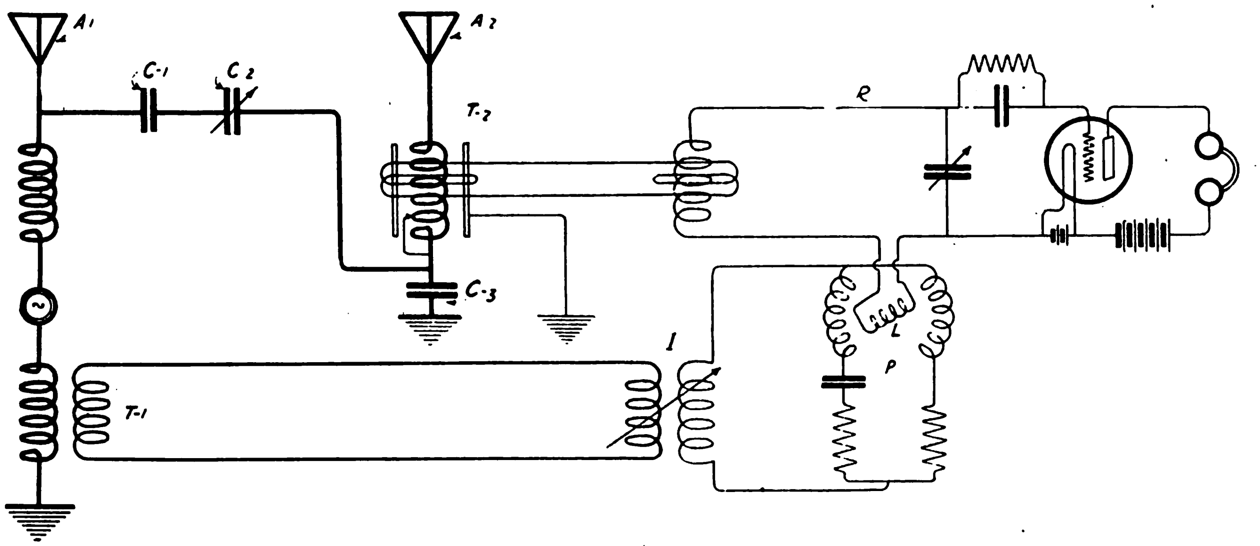


Figure 3—Fundamental circuits of the "Bridge Receiver"

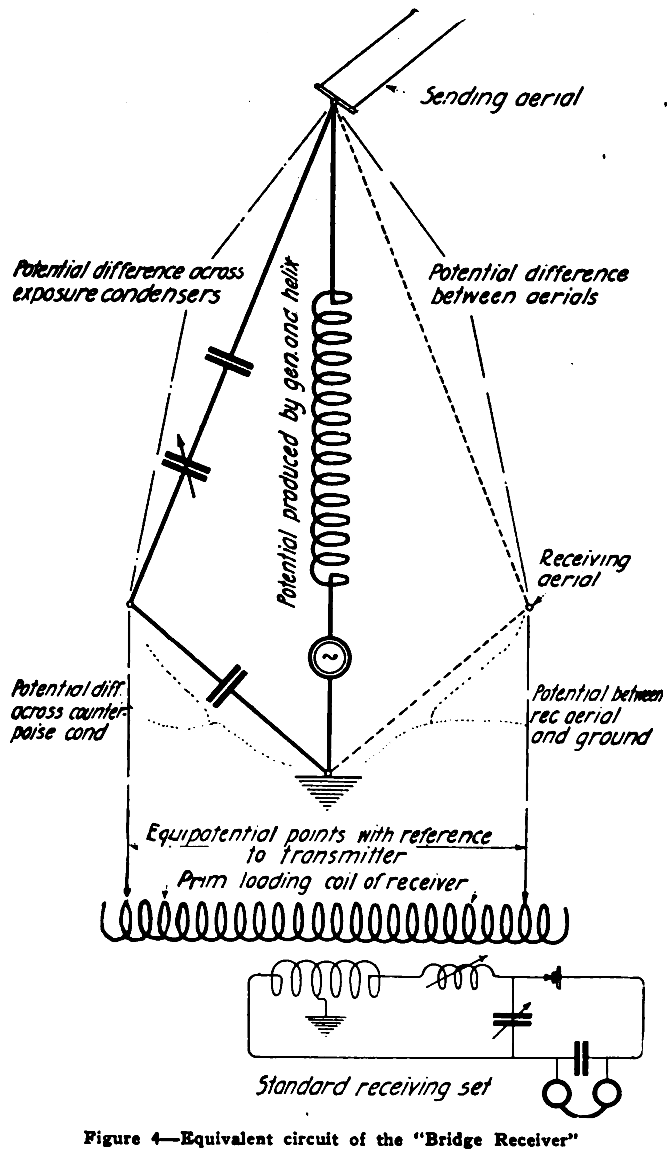


Figure 4—Equivalent circuit of the "Bridge Receiver"

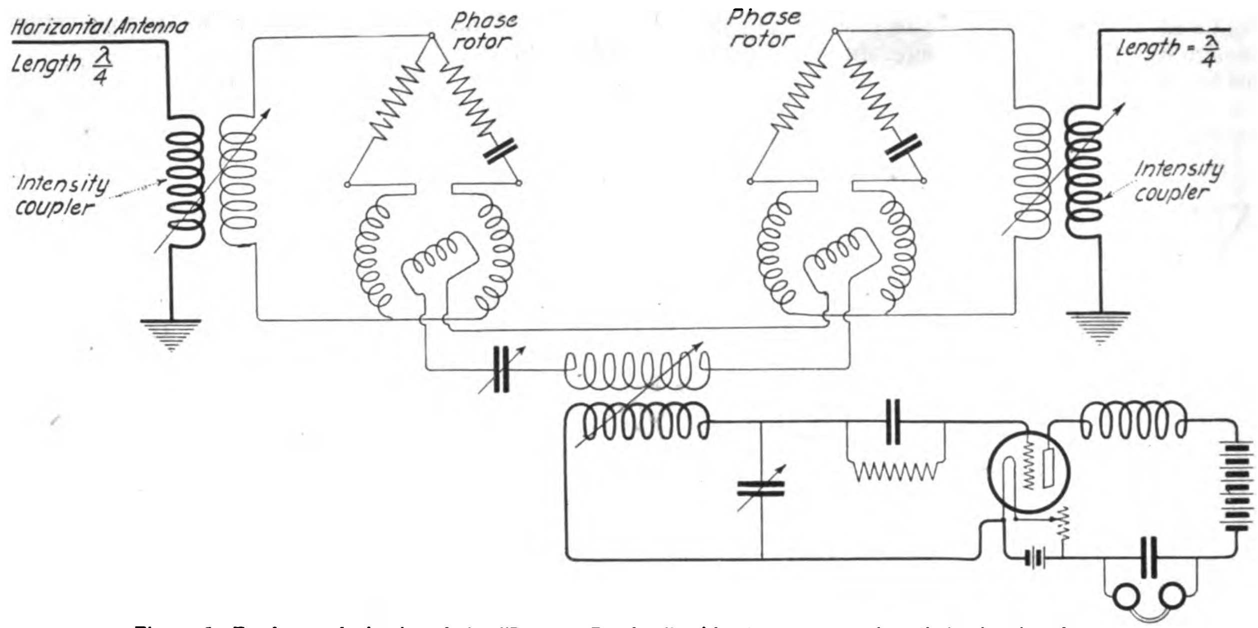


Figure 5—Fundamental circuits of the "Barrage Receiver" with phase rotators for eliminating interference

Israel and Wm. H. Priess described some experiments along that line, conducted by them at the instigation of the U. S. Government. Mr. Priess remarked that a 50 per cent difference in wave length between the transmitter and receiver was necessary to insure a factor of safety.

It was brought out that Alexanderson's duplex system with closely supported antennae, operated more effectively with undamped waves than with damped waves.

The Design of 60-Cycle Transformers for Amateur Transmitters

(*Continued from page* 22)

a wire table we find that this corresponds to No. 30SSC wire. Its resistance is about 103 ohms per thousand feet.

To obtain the number of turns on the primary

$$n = \frac{E}{.021\sqrt{W}}$$

$$= \frac{110}{.021\sqrt{500}} = 238 \text{ turns}$$

At 60,000 lines per square inch, A n should = 688, so that

$$A = \frac{688}{n} \text{ or } \frac{688}{238} = 2.89 \text{ sq. in.}$$

For economy of copper, the coil and core should be square in cross section; hence the core should be $\sqrt{2.89} = 1.7''$ on side.

The secondary turns

$$n_2 = \frac{E_2 \times n_1}{E_1} = \frac{13{,}500 \times 238}{110} = 29{,}274 \text{ turns}$$

DETERMINING THE PRIMARY AND SECONDARY DIMENSIONS

The voltage per section of the secondary should not exceed 4000 volts. Dividing 13,500 by 4 gives 3375 volts per coil, and dividing 29,274 by 4 gives 7319 turns per coil of the secondary. If we make each coil of the secondary square in cross section, we have $\sqrt{7319}$ or approximately 85 turns on a side. Allowing for pieces of insulation .05" thick between coils, and .125" micanite between the ends of the coils and the core, gives, allowing 4 mils insulation, 4 (85 × .014") + (3 × .05) + (2 × .125) = 5.2" as the height of the transformer window. (See figure J). Since the diameter of No. 30 D.S.C. wire is .014", the thickness of the secondary coil = (85 × .014") + 0.125 + one layer of tape = 1.5". The factor 0.125 is the thickness of the micanite tube.

Allowing .0625" as the thickness of the micanite tube between the primary coil and core, gives about 5" winding space. Dividing 5 by .078" gives about 64 turns per layer for primary coil. Dividing 64 into 238 gives 3 layers for the primary and calls for 46 additional turns to give the full 238 turns. The thickness of the primary coil is then 4 × .078 + .0625 or 0.4" approximately.

Mean length of secondary turn = 4 (1.7 + 1.4) = 12.5". And

$$\frac{12.5'' \times 29{,}274}{12} = 30{,}494 \text{ ft. total length of secondary wire.}$$

At 103 ohms per thousand, the resistance of the secondary = 30.5 × 103 = 3141 ohms. The copper loss of secondary = $I^2_2 \times R_2 = 3141 \times .04 \times .04 = 6.7$ or 7 watts.

The mean length of primary turn = 4 (1.7 + .4) = 8.4". This multiplied by 238 = 1999" and divided by 12 gives 166 feet as the length of the primary wire. The total resistance at 2 ohms per thousand = .166 × 2 = .332 ohms. The primary copper loss = I^2_1 R = .332 × 5 × 5 = 8.36 watts. Total copper loss = 8.36 + 7 = 15.36 watts.

The iron loss of good silicon steel is approximately .8 watt per pound. For the highest efficiency, the iron loss must equal the copper loss. Dividing 15.36 by .8 gives 19.2 pounds as the weight of iron in the core. Dividing 19.2 by .278 gives 69.4 as the total volume of the core. The length of the core with corners equals (5.2 + 1.7 + 1.7) = 8.6 inches and for two cores = 2 × 8.6 = 17.2 inches. The total volume of the cores therefore equals 1.7 × 1.7 × 17.2 = 49.7 cubic inches. Subtracting this from the total volume, 69.4 — 49.7 = 19.73 as the volume of the yokes. Dividing this by 2.89 gives 6.8 as the length of both yokes. Dividing this by 2 gives 3.4 inches as the width of the transformer window.

(*Continued on page* 38)

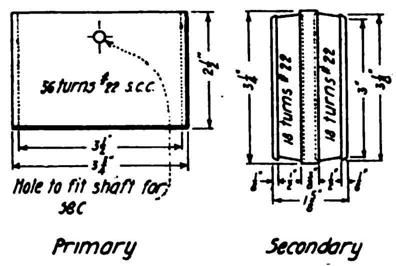
EXPERIMENTERS' WORLD

Views of readers on subjects and specific problems they would like to have discussed in this department will be appreciated by the Editor

My Conception of the Ideal 200 Meter Receiving Set

By Frank V. Bremer

A RECEIVING tuner for amateur wave lengths should have a range of tuning between 180 and 580 meters, and should be fitted with a regenerative coupling. With the set described here, amateur stations as far west as Denver have been copied in New York, a distance of approximately 1900 miles.



Figures 1 and 2—Dimensions of the primary and secondary coils of the receiving tuner

Aerial

The amateur aerial should consist of from 4 to 8 stranded wires with a horizontal length of from 80 to 100 feet and a vertical height of from 30 to 100 feet, with an approved type of modern lead-in insulator. All connections must be securely soldered.

Earth Plate

A good earth plate can be formed by burying square sheets of copper or brass about three feet below the surface under the whole length of the aerial. In addition, the ground lead should be connected to all gas and water pipes available in the building.

with 56 turns of No. 22 SCC wire with a tap taken from it every eight turns. These should be brought out to a switch. The dimensions are shown in figure 1.

The secondary should consist of a ball turned to the shape of a variometer, 3¾ inches long by 1⅝ inches in diameter, wound with 18 turns of No. 22 SCC wire on

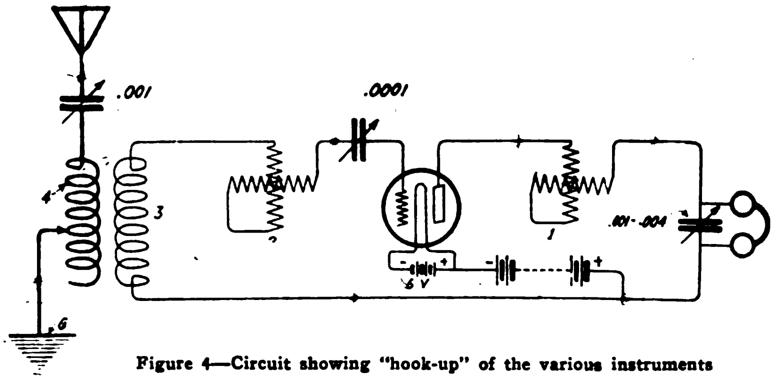


Figure 4—Circuit showing "hook-up" of the various instruments

each side, or 36 turns in all. Both coils are wound in the same direction and no taps are to be taken off. The inductance is varied by turning the rotating coil. The dimensions are shown in figure 2.

Variometers

The variometers are turned from wood and should consist of two field frames and one rotor, sizes as per the drawing, figure 3. Two are required, both of the same size.

The field frames of the variometer for the grid circuit are wound with 30 turns of No. 20 SCC wire, wound clockwise; the rotor is wound with 32 turns No. 20 SCC wire, wound counter clockwise.

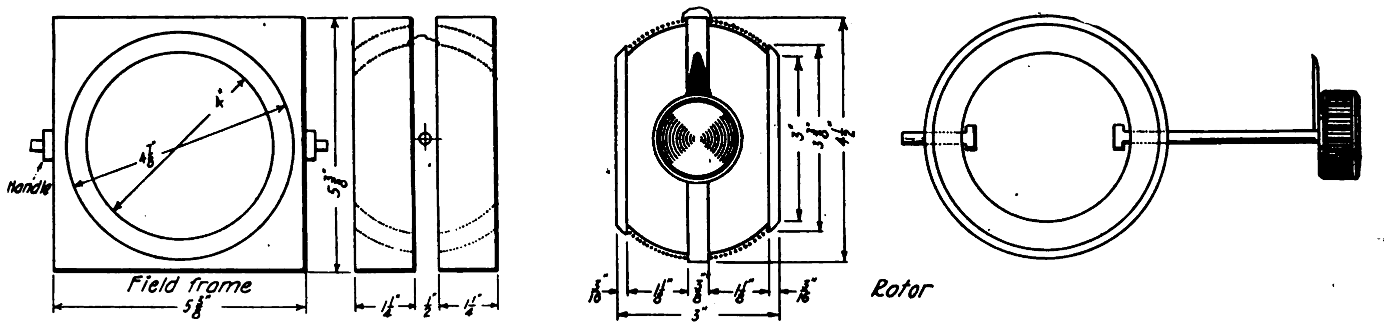


Figure 3—Dimensions of field frames and rotor for the variometer

Receiving Tuner

Special care should be taken in the construction of the tuning transformer. The regenerative valve short wave receiver, consisting of two variometers and a coupler which can be mounted together, or separately, constitutes in my mind the most efficient set.

The primary should consist of a cardboard or bakelite tube 2½ inches in length by 3¾ inches in diameter, wound

The field frames of the variometer for the plate circuit are wound with 25 turns of No. 18 SCC wire, wound clockwise; the rotor has 27 turns of No. 18 SCC wire, wound counter clockwise. The dimensions of the rotors are given in figure 5.

The design of the variometers should be such that they may be rotated throughout 180°. Coil 3 in figure 4 must rotate through 90°. Coil 4, the primary, is stationary.

The field frames are stationary and must be separated ½ inch. The horizontal axes of the variometers must be at least 12 inches apart.

TELEPHONES

For the best results a pair of Baldwin amplifying telephones should be used, but any pair of 2,000 ohm telephones will prove satisfactory.

DETECTOR

It is essential that a good three element valve detector of either the round or tubular type should be used and special attention paid to the voltage adjustments. A storage cell should be used for lighting the filament, as it is important that the current be constant. For the plate circuit, flashlight batteries or a bank of small storage cells may be used. For maximum signals, a single cell adjustment of the plate battery should be provided for.

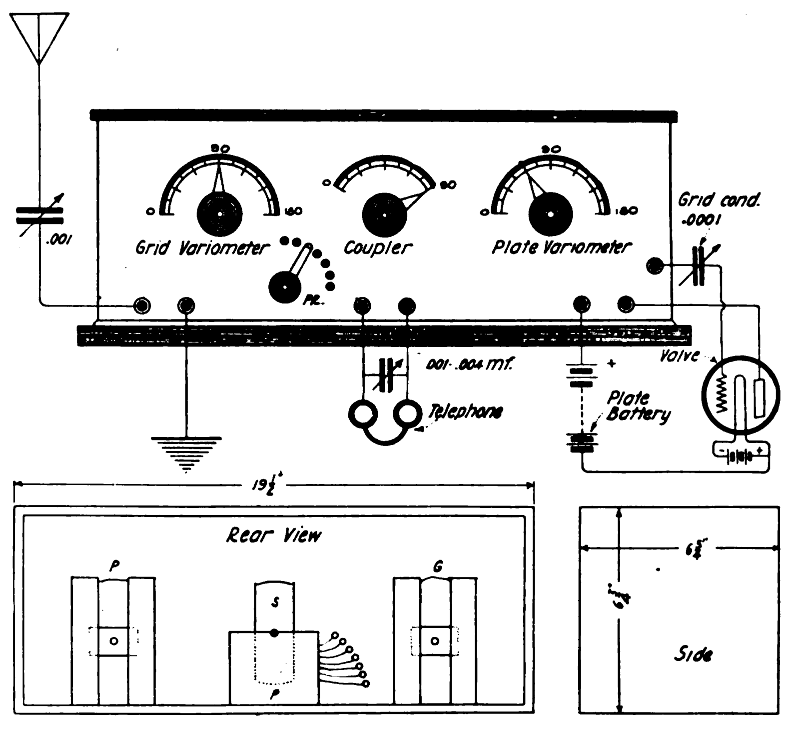


Figure 5—Design of a cabinet set

VARIABLE CONDENSERS

Three variable condensers of the following capacities are required, viz.: one of .001 mfd. for variation of the primary wave length, one of .0001 mfd. for the grid circuit; and one of .001 to .004 mfd. for shunting the telephones.

If these instructions are carefully carried out, a set capable of amplifying 100 times will result. All connections should be thoroughly soldered and the dimensions of the coils and the capacities of the condensers duplicated in detail.

For those who prefer the cabinet type of apparatus, a suggested design is shown in figure 5.

Useful Experimental Apparatus for the Amateur's Laboratory

By Thos. W. Benson

HOW TO DESIGN A WATER RHEOSTAT

IT is seldom that the experimenter gives a second thought to the proper design of a water rheostat. The usual method is to use as large plates as possible and add salt or acid to the solution until sufficient current flows. Often the water heats badly and boils, resulting in a constantly changing resistance. To the many experimenters who use this convenient and cheap form of resistance the following suggestions are offered to assist them in building a rheostat suitable for the work in hand.

The problem of designing a rheostat is usually a question of the size and kind of plates, the density of the solution and the chemicals at hand. The following method will give accurate results within the range of the usual amateur's requirements.

The maximum current that can be handled by a water rheostat depends chiefly, among other things, on the cubic inches of electrolyte in the container. It would appear that the energy absorbed would be limited by the radiation surface, but calculations on this basis do not agree well with experimental results.

Suppose we have a large porcelain battery jar and wish to construct a rheostat to use with an arc lamp. First determine the cubical contents of the container in the usual manner. The jar used by the writer in an experiment of this kind measured 7 inches inside diameter and 12 inches high. Allowing one inch at the top gives a solution height of 11 inches, or a trifle over 422 cubic inches of solution. When used indoors without special cooling, the rheostat is limited to 2 watts per cubic inch, hence the rating of the rheostat would be 2x422 or 844 watts.

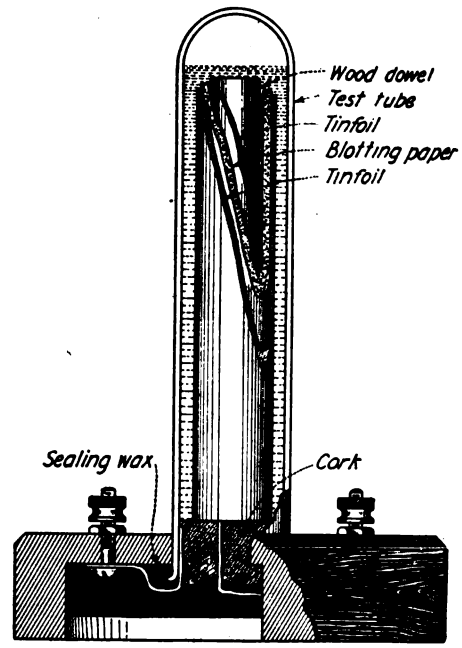


Figure 1—Showing construction of an experimental type of the photo-electric cell

We must decide on the maximum voltage drop desired. Since the rheostat in question was to operate with an arc lamp, 80 volts drop was decided upon, allowing 30 volts minimum across the arc. Dividing the wattage (844) by the voltage drop (80) we find that the current in amperes will be 10.55 or roughly 10 amperes.

The allowable maximum current density for the plates is one ampere per square inch. However, there is plenty of room for the plates, which were cut from 1/16 inch iron, 5 inches in diameter, giving an area of 19.6 square inches. The upper plate was perforated with holes by means of a twenty penny nail and fastened to the adjusting rod by two bolts, one on either side of the plate. The lower plate was left plain, a rubber covered wire being used to make connection to it.

Now that we have finished the mechanical design of the rheostat, we will determine the proper density of the solution. The chemical is a matter of judgment. We have the choice of sodium sulphate, sodium chloride or copper sulphate with iron plates. Where lead or carbon plates are used sulphuric acid may be employed.

The formula for calculating the density of the solution in per cent is as follows:

$$\% = \frac{DK}{V}$$

Where, D = the maximum distance between plates
V = maximum voltage drop
K = constant obtained from table following

Sulphuric acid—.08
Sodium Chloride—.25
Sodium Sulphate—.45
Copper Sulphate—.90

For the rheostat under consideration copper sulphate was selected because it does not gas or polarize the electrodes. The density from the preceding formula is:

$$\frac{10 \times .9}{80} = \frac{.9}{8} = .1125, \text{ or a little over } 11\% \text{ by weight.}$$

This was found to give the desired result and worked perfectly with the arc without heating to a noticeable extent. A water rheostat for any experimenter's requirements can be designed from these data by bearing in mind the relations the various factors bear to each other. These may be listed as follows:

Energy absorbed depends on cubic inches of electrolyte.

Area of plates depends on current. One ampere per square inch is not to be exceeded.

Voltage drop depends on maximum distance between plates. When this is determined by size of container the density of solution is varied to obtain the proper result.

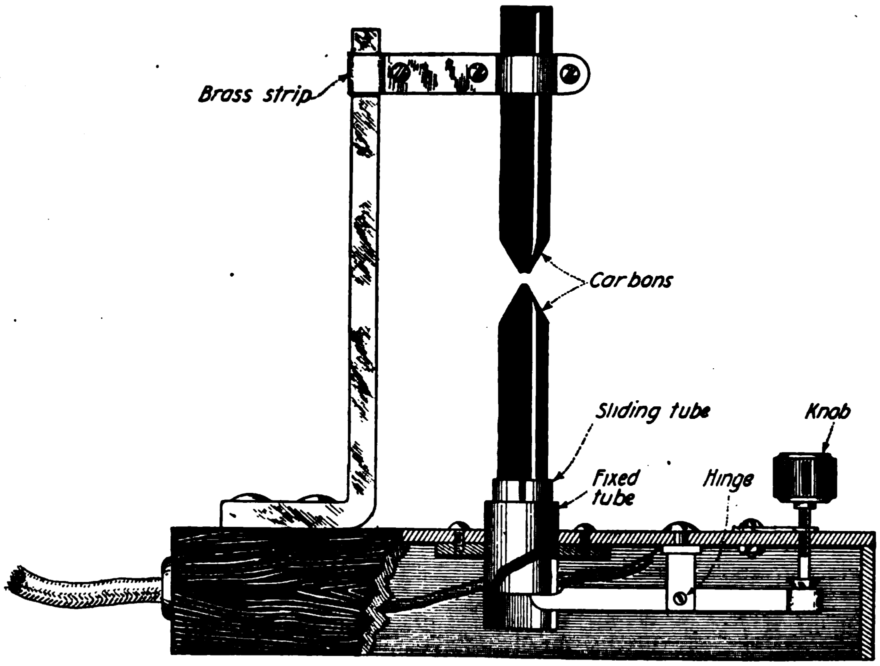


Figure 2—Showing the design of the hand-fed arc light

Experimental Photo-Electric Cells

Photo-electric phenomena offer such a fascinating field of study that it is strange more experimenters have not turned their attention to the subject. It is a simple matter to construct the various cells that have been developed in the past, while the study has many possibilities.

The simplest form of photo-electric cell consists of two sheets of tin foil in a solution of salt water. One of the sheets is exposed to light while the other is kept in darkness. A modified form of this cell devised by Fleming can be constructed as shown in figure 1. A sheet of heavy tin foil measuring 4 inches square is wrapped around a wooden dowel ½ inch in diameter. A sheet of thin blotting paper is wrapped over the tin foil and a second tin foil wrapping applied. The whole can be held together with small rubber bands. A tiny wooden dowel serves to fasten the elements of the cell to the cork of the test tube. Tin foil leads are brought out through slits in the cork. The whole is placed in a test tube filled with water to which a little salt has been added.

With this form of construction, the inner tin foil plate is protected at all times from the light. When the cell is connected to a sensitive galvanometer a slight current will be detected, even with the cell in the dark. This is due to the fact that a current is generated when two electrodes are put in a solution, regardless how similar they may be in their physical appearance.

When a strong light falls on the cell a marked increase of current will be noted flowing from the shaded cylinder to the lighted one, in the exterior circuit.

In experiments with photo-electric cells some form of artificial light is preferred to sunlight. The light from burning magnesium ribbon is very satisfactory, but where lighting current is available an arc light is the better of the two.

A hand-fed arc light that can be easily constructed from parts on hand is shown in figure 2. The base is a shallow cigar box; a bent rod and a holder made from strip brass holds the upper carbon. The lower carbon is fitted into a tube that slides in a larger tube attached to the base. A slot cut in the fixed tube allows free movement of the brass lever to raise and lower the carbon holder. The lever is made from a switch blade drilled at the center and pivoted on a switch hinge clip. A threaded rod with an insulating knob serves to operate the lever. A water rheostat made from an Edison battery jar, 13 by 7 inches with circular plates 5 inches in diameter, will give the necessary current regulation.

Returning to the photo-electric cells, the Fleming cell can be improved by using silver foil for the plates. Still further improvement can be obtained by coating the lighted plate with silver salts.

A cell employing chloride of silver can be made as shown in figure 3.

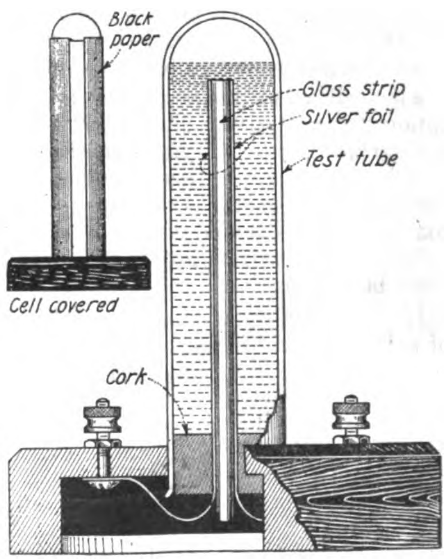


Figure 3—Photo-electric cell using chloride of silver for coating the lighted plate

Strips of silver foil are attached to a narrow strip of glass by means of melted pitch, the strips extending 1½ inches over one end. An emulsion is prepared, consisting of a little finely powdered silver chloride and collodion which are shaken together in a test tube in the dark, or at least the tube should be covered with black paper. Pour this emulsion on one of the silver plates in a dark room and allow it to dry.

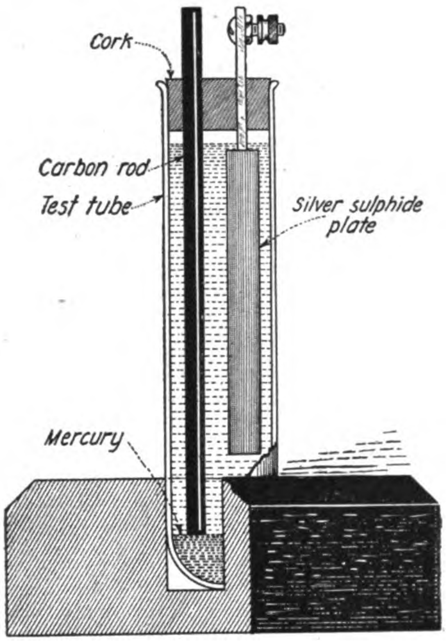


Figure 4—The Sauer photo-electric cell

The glass strip with the plates is now mounted in the test tube by cutting the cork in half and hollowing out the center so as to pass the strip tightly. The test tube is filled with distilled water to which a little table salt has been added. The cell can now be assembled and after making connections to the protruding strips of silver foil, the whole can be sealed with sealing wax as shown. The test tube is now covered with black paper with the exception of a space ½ inch wide down the side nearest the coated plate.

The cell when connected to a galvanometer will give a slight current in the dark, but when light from the arc is allowed to pass through the uncovered part of the tube on to the coated plate, a decided deflection of the galvanometer will be noted, the coated plate being positive.

If a solution containing a few drops of sulphuric acid is used in the cell the results will be the same. This indicates that the action is independent of the electrolyte, the salt or acid serving merely to reduce the resistance of the water.

This cell is fairly sensitive; dull sunlight will give a current and even a candle will cause a deflection if a sensitive galvanometer is used. It will be noted also that the current generated varies directly as the strength of the light falling on the cell.

Different colored lights will also give varying current strengths. The light from the violet end of the spectrum has the greatest effect, while the effects of red are scarcely noticeable.

Similar effects may be observed if any of a number of other silver salts are employed for coating the plate. Thus a silver bromide emulsion may be made as explained, keeping it away from the light while preparing it. A few grains of potassium bromide is added to the water in the cell. A mixture of silver nitrate and rather thin gelatin may also be used with the results noted, barium nitrate being used in the solution.

Possibly the most sensitive cell using silver salts is that devised by Sauer. A cell of this type may be constructed as shown in figure 4. A large test tube contains at its bottom a small quantity of mercury, to which connection is made with a thin carbon rod. If preferred, a platinum wire can be sealed into the bottom of the tube to make this connection. A plate of silver sulphide is supported in the upper part of the tube and in a position to be freely acted upon by the light. The solution used in the cell consists of 100 parts water, 15 parts common salt, 7 parts copper sulphate. The cell is mounted upright in a wooden block.

This cell is very sensitive to light and gives quite an appreciable current. The rapidity with which it follows variations in light intensity would make it suitable for registering light variations, and perhaps with modifications, would make it rank a close second to the unreliable selenium cell.

The reaction taking place in this cell is rather complicated and is thought to be as follows: The copper sulphate and salt (sodium chloride) form a cupric chloride which is reduced to cuprous chloride by the mercury. The cuprous chloride acts on the silver sulphide plate in the presence of light to

dized by holding it in a Bunsen flame until black. Another similar strip is cleaned with sand paper. The two are then fastened to a strip of glass in a manner similar to that employed with the silver cells. The details of the mounting are the same, a few grains of copper sulphate being added to the water in the cell. The test tube is covered with black paper, excepting a space down the side nearest the oxidized strip.

This cell will give a fairly strong current in bright sunlight. By coloring the plate exposed to light with such dyes as eosin, malachite green, or napthol yellow, the effect will be increased. It will be found also that the violet end of the spectrum gives the strongest current.

In all probability the following is the true explanation of the action of all photo-electric cells: Ultra-violet light, whose waves are shorter and more rapid in vibration than the visible violet rays, has a marked reducing effect on many chemicals in solution. Oxidization or reduction at any pole in a solution will produce a current of electricity. This would then explain the action in the case of cells employing silver salts, for their reduction by light is utilized in photography. Furthermore, it has been found that some metals when immersed in a solution and exposed to strong ultra-violet light throw off tiny charged particles in what is termed a collodial condition. This cannot be done without leaving an opposite and equal charge on the plate, and the result is the passage of this charge to the other pole not so exposed. This, then, must be the action in cells employing similar plates for the electrode as the Fleming tin foil coil.

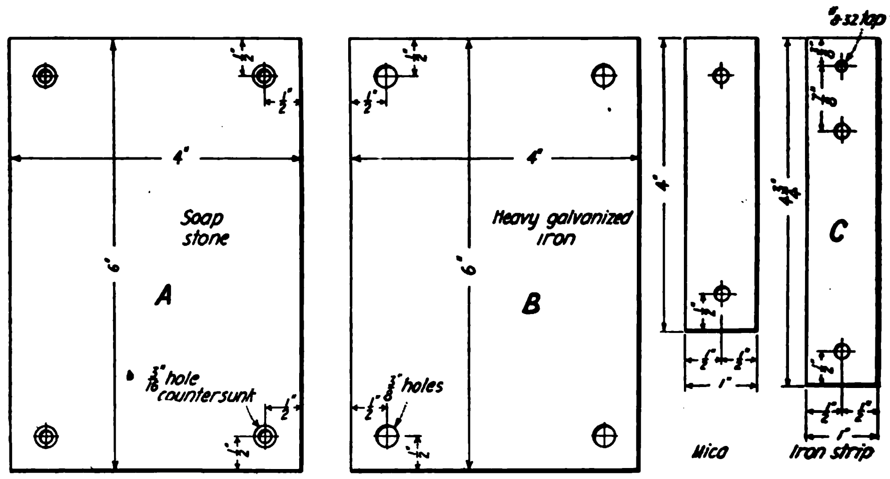


Figure 5—General plan of construction of the graphite laboratory stove

form silver chloride with the result that a current is generated.

Another type of cell that is rather sensitive employs copper plates. The one under the influence of light is oxidized while the other can be left plain. A strip of thin copper is oxi-

Summing up, a photo-electric current is produced in two ways. First, by the use of a cell in which the chemical action depends on the presence of light. Second, by a cell that depends upon the discharge of negatively charged particles under the influence of light to cause a disturbance of the electrical equilibrium between the poles. The latter type is, strictly speaking, the true photo-electric cell and this form no doubt will solve the problem of utilizing the sun's energy. Further investigation of metallic colloids may add considerable to our knowledge of photo-electricity.

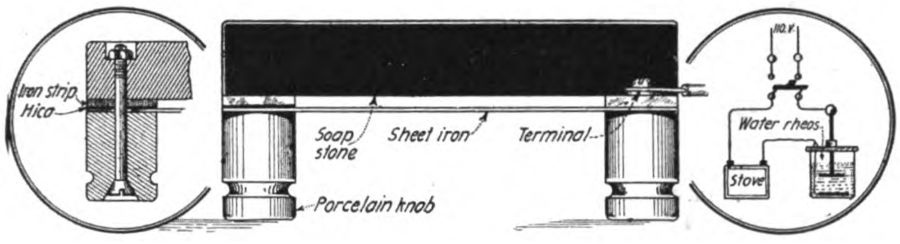


Figure 6—Graphite laboratory stove assembled

A Graphite Laboratory Stove

Although graphite is a conductor of electricity, it differs from metals in that its resistance drops as the temperature increases. If it could be evenly distributed in sufficient quantities on a smooth surface and made to adhere with sufficient tenacity, it would be a convenient means for generating heat by electricity up to the point where graphite is burned by the oxygen of the air.

Unfortunately the rubbing of graphite alone on a surface does not give a coating heavy enough to conduct an appreciable amount of current. Although it can be applied with a brush in the form of a paste, the results are very unsatisfactory, for it flakes off easily.

This makes it necessary to use some form of binder, but because they are not able to stand the high temperatures to which graphite can be submitted without harm, the maximum temperature of the device is limited. However, very satisfactory heating units for the laboratory can be constructed in the manner hereafter described.

The mechanical details are of little importance, but the form of stove described will fill the usual requirements of the experimenter's laboratory.

From soapstone 7/8 inch thick cut a piece measuring 4 by 6 inches. This is drilled as shown in figure 5, the holes being countersunk to a depth of 3/8 inch with a 3/8th drill.

Two strips of iron 1/8 inch thick, 1 inch wide and 4¾ inches long are procured. These strips are drilled as shown at B in figure 5. A sheet of heavy galvanized iron 4 by 6 inches is cut and drilled with holes as shown at C, figure 5. Two strips of mica 4 inches long and 1 inch wide with a hole punched at each end, four 8/32 flat head iron bolts 1½ inches long, and four porcelain knobs 1 inch in diameter and 1 inch high, are required to complete the stove.

The graphite used in constructing the stove can be purchased in the form of a well known stove polish on sale in every grocery store. This is to be mixed with water and applied with a brush.

Lay the soapstone slab on a tripod or other support and arrange to heat it with a bunsen burner. Take the two iron strips and smear them thickly on one side with the stove polish; similarly treat the ends of the soap stone slab where they will be fastened. Lay them on the slab and drop bolts through the holes to keep them in position. By means of screws in the end holes of the iron strips connect them to the 110 volt supply through a lamp bank or other resistance.

Heat the stone with the bunsen burner till it is hot enough to evaporate water rapidly but without sputtering. Apply a rather thin coating of the paste with a brush to the surface of the stone, using long strokes. Cover the entire surface on each application but do not pass twice over the same place with the brush. The stove polish is known as X-Ray Stove Polish.

After each application polish the surface vigorously with a stiff tooth-brush. As the process continues the graphite coating will soon become thick enough to conduct electricity, which will then serve to heat the stone. If an ammeter is handy it should be connected in the circuit and the application of graphite continued until two amperes flow in the circuit. In the absence of a meter, two 50 watt incandescent lamps can be connected in parallel and when these light to full brilliancy the coating is heavy enough.

When the stone has cooled the stove can be assembled. Remove the bolts from the corner holes without disturbing the iron strips, lay a strip of mica on each iron strip, cover the whole with the galvanized iron plate, centering the small holes in the strips with the larger holes in the plate. A bolt is then dropped through each porcelain knob and the protruding end of the bolt passed through the stove unit and fastened thereto by a nut fitting into the countersunk holes on the top surface of the soapstone slab. When all four legs are securely bolted in place the stove is complete.

Connections are made to the extending iron strips, a water rheostat being included in the circuit to control the current and hence the temperature of the stove. The temperature should not exceed 400° C. Before using, the stove should be matured by heating to 400° C. and kept there for two or three hours. Thereafter its temperature at any given current input will be fairly constant. The assembly is shown in figure 6.

Speaking Incandescent Lamp

Those having the facilities may perform the rather novel experiment of making an incandescent lamp reproduce words spoken into a telephone transmitter.

A 500 watt, type B, mazda lamp is connected to the 110 volt direct current supply as in figure 7. Shunted across the lamp, as shown in the diagram, are the secondary of a telephone induction coil and a ½ mfd. condenser. A telephone transmitter and six dry cells are connected to the primary of this coil.

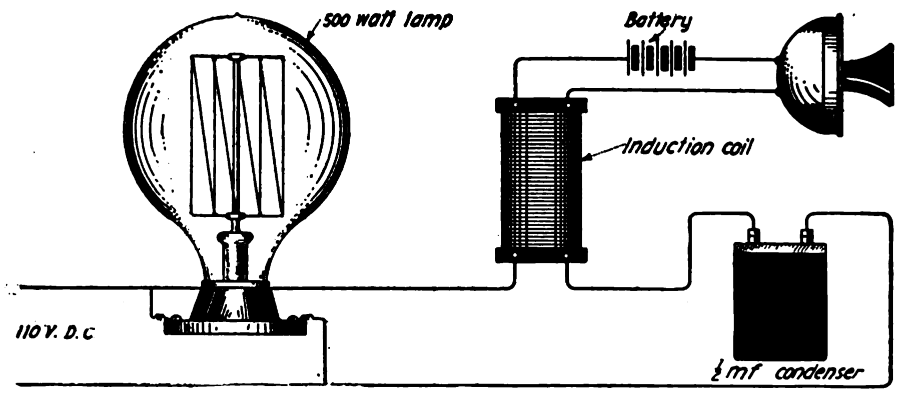


Figure 7—Diagram showing connections and installation of the speaking incandescent lamp

On speaking into the transmitter the lamp will reproduce the words, which can be heard when the ear is held rather close to the globe.

To explain the action we may suppose that the voice currents are added to the current flowing in the lamp circuit, causing it to burn more or less brilliantly. The resulting changes in temperature are communicated to the glass and thus to the air. It is not improbable that some similar arrangement might be used to modulate the waves emitted by the electronic relays used in short range wireless telephones.

Hot Wire Ammeter

By C. J. Fitch

ARTICLES have appeared in the various magazines describing the construction of a hot wire ammeter for the wireless experimenter, but the main objections to these meters are the uncertainty of the zero positon on the scale, and inaccuracies due to a change of the surrounding temperature. To overcome these disadvantages I designed the meter shown in the diagram, figure 1.

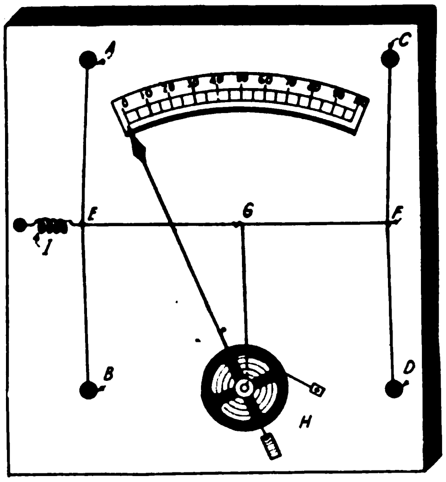


Figure 1—Design of the hot wire ammeter

Two resistance wires AB and CD, each 4 inches long by .003 inches in diameter, are clamped between binding posts, using a paper washer to prevent slipping. EF is a silk thread 4 inches long. Another thread is tied at G and wound around the shaft on which the hair spring H is mounted. The hair spring tends to move the pointer to the right, but it is held on the zero position by the silk thread. The hair spring and its bearings were taken from an old alarm clock. I is a small spring, or rubber band, which should be very strong as compared with the hair spring. The pointer is cut along the band of a folded paper to give it stiffness. It is fastened to the shaft with a bit of sealing wax, by melting it off the point of a file.

If the wire AB expands, the spring I will pull up on G and move the pointer to the left. If the wire CD expands, it will slacken up on G and the hair spring will move the pointer to the right. It is evident then, that when both wires expand or contract alike, due to a change of the surrounding temperature, the pointer will not move. The current to be measured should flow through the wire CD. The meter may then be calibrated by comparing it with a standard instrument.

Those who have a larger meter at hand, or who wish to make extremely small measurements, should note the diagram, figure 2. Here the wire AB has a shunt in parallel with it, and the instrument is connected in series with an adjustable rheostat, the large meter and a battery. The scale of the meter is also changed as shown.

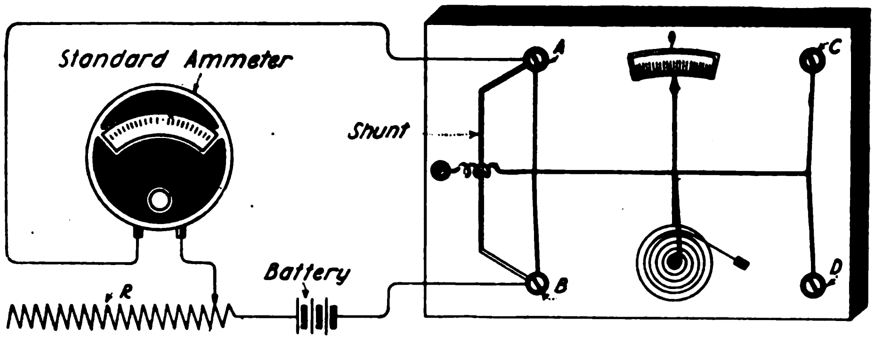


Figure 2—Showing the hot wire ammeter connected up for calibration

The current to be measured is passed through the wire CD, which moves the pointer to the right of the zero position. By adjusting the rheostat R, the value of the current flowing through the wire AB can be varied until it equals the current through CD, and the pointer will move back to zero. At this position the reading of the large meter should be taken and divided by the ratio of the shunt across AB. This result will be the value of the current through CD. For example, suppose the shunt has such a resistance as to allow 1/100 of the current to pass through AB. When .01 ampere flows through CD, to bring the pointer back to zero, .01 ampere should flow through AB, or 1 ampere through the large meter, which can be read more accurately. In this case a rheostat of 5 ohms maximum should be used, with a battery of two dry cells.

QRM Amongst Amateurs

THE articles I have read from time to time regarding wave length restrictions, interference, power input, etc., do not seem to present the solution to the problem. Nor will I pretend to offer a complete solution; but I have some suggestions which may prove of interest.

There are those who apparently believe that by requiring a speed test of from 15 to 20 words a minute, a minimum amount of interference between amateur stations would result. In my opinion, such would not be the case. I have heard the 20-words-a-minute man QRM the air to as great an extent as anyone else and, at times, there were some who seemed to think that their superior operating ability entitled them to hold the ether indefinitely.

QRM is QRM any way you may take it, and the imperative thing is to eliminate it in a systematic manner. This elimination will come in time, but only as experience suggests the remedy. I cannot see that the amateur would be any better off with a speed requirement of 15 words a minute, from a QRM standpoint. I must confess that I am not sufficiently informed to determine the best method for controlling QRM, or the amateur, but I do not believe that the solution of the trouble lies in the matter of speed.

In my opinion, the requisites for a *transmitting license* should be based upon the following:

1. Character and responsibility of the applicant.
2. Care and operation of apparatus.
3. Knowledge of the laws pertaining to the amateur.
4. Application for license to be approved by nearest recognized radio club or association, before being filed with radio inspector. No transmitting license to be granted unless this is done.

Advanced amateurs can help educate those who are striving for a license to operate their apparatus so as not to cause needless interference. I refer more particularly to the small boy and the irresponsible person.

I believe that radio clubs throughout the country, if they are permitted to do so, can solve the amateur problems better than anyone else.

As to power input and wave lengths, I make these suggestions: Let the standard wave be 250 meters. Relay work on trunk lines should be conducted at 425 meters, and certain hours alloted for trunk line work. All stations not officially designated as trunk line stations should operate on wave lengths not exceeding 250 meters. This will effectually eliminate interference with relay work, or at least reduce it to a minimum. Official relay stations when operating between each other during relay hours, except for trunk line work, should be compelled to confine their operations to a wave length not exceeding 250 meters. This is only meant as a suggestion, as conditions in some localities may warrant something different from the actual figures I have given.

The standard power input should be 1 kw. except for those stations situated within a certain distance of government stations, when it might be advisable to curtail the power.

W. T. GRAVELY, *Virginia*

Donle's Variable Condenser

IN the usual type of rotary variable condenser, the capacity is almost directly proportional to the movement of the rotary plate. Although this type

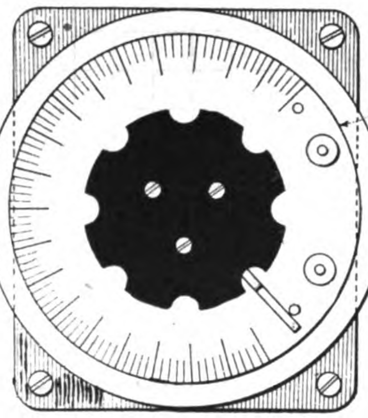


Figure 1—Top view

has proven fairly satisfactory for radio work, it possesses certain serious defects. For one thing, the percentage variation in capacity is small for it is impossible to adjust with any degree of accuracy below a certain point on the scale, say 15 degrees, and because air is the usual dielectric, a condenser of small capacity occupies considerable space. Furthermore, in the usual type, the rotating plates tend to throw the shaft out of balance so that a slight jar results in a movement which is sufficient to destroy the adjustment. This is quite a serious defect on shipboard.

In the construction shown in the accompanying figures 1 to 8, the inventor employs a pair of condenser plates one of which is covered with a thin layer of mica or light dielectric material, the capacity being varied by the adjustment of the plates in respect to each other; that is, the plates are shifted toward each other so as to avoid a rubbing engagement.

Figure 1 is a top view; figure 2 is a side elevation; figure 3 is a cross sectional view taken on the plane of the line 3-3 of figure 1, showing the condenser plates in a partially separated condition; figure 4 is a similar view showing the condenser plates brought together. Figure 5 is a bottom plan view of the device with the bottom cover removed; figure 6 is a detailed sectional view of one of the binding posts, showing the flexible connection

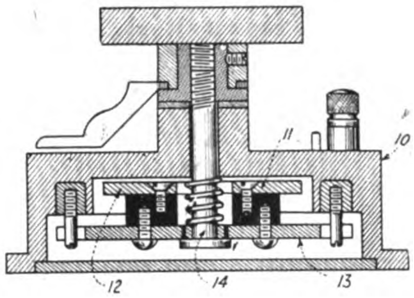


Figure 3—Cross sectional view

therefrom to the movable condenser plate; figure 7 is a cross sectional view of a slightly modified form; figure 8 is a bottom plan view of the main portions of the device and figure 9 shows graphs plotted from some of the results obtained with the device.

In the first form illustrated, a metallic supporting base 10 is provided, made

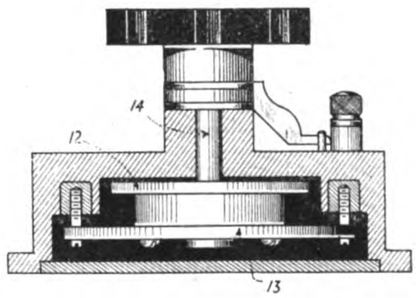


Figure 4—Cross section showing condenser plates brought together

hollow to serve as a casing for certain of the parts, and constitutes a plate or condenser element 11. The second condenser plate is designated at 12 and is shown as housed within the hollow base opposite the condenser surface 11. This condenser plate is insulated from its support by a block of insulating material 13, having a central passage through which the stud 14 extends.

A layer of dielectric material is interposed between the condenser plates, mica having been found a desirable material. It is secured to the face of the upper condenser plate in the illustration.

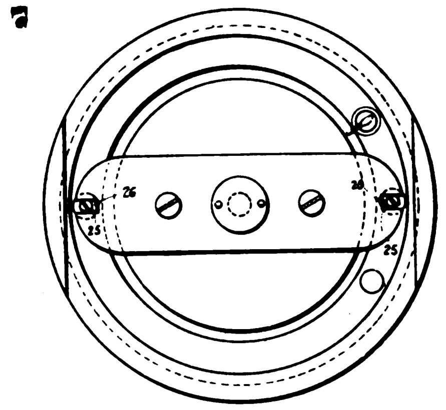


Figure 5—Bottom plan view

The construction illustrated in figures 7 and 8 is similar to the preceding figure, the main distinction being that in the latter form, the hollow base 10' is made of insulating material; this necessitates applying a separate metallic condenser plate 11' to the underside of the base as the opposite element of the movable condenser plate; the secondary condenser plate in this case is secured directly through the operating screw without any insulation.

In this construction, the movable condenser plate is guided in a straight path into engagement with the other condenser plate by forming the guiding slots 26' directly in the peripheral portion to receive the guide studs 25'.

Some of the results obtained from the condenser are shown in the graphs figure 9. The horizontal graduations from 0° to 10° indicate figures on the condenser scale, the vertical graduations indicating the capacity in microfarads. The solid black line indicates results of an actual test using an adjusting screw of thirty-six threads to the inch. The range of control and the ease of adjustment will be apparent from the curve. The dotted line indicates the calculated results using mica of approximately five ten-thous-

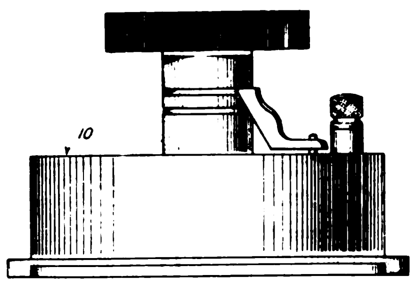


Figure 2—Side elevation

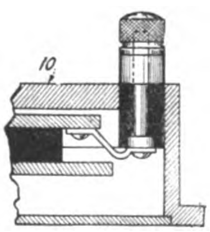


Figure 6—Detailed sectional view of one of the binding posts

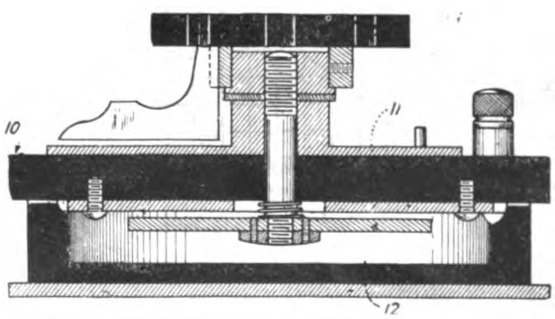


Figure 7—Cross section of a modified form

andths of an inch in thickness as the dielectric; the dot and dash line indicates calculated results without the mica. The dash line indicates results

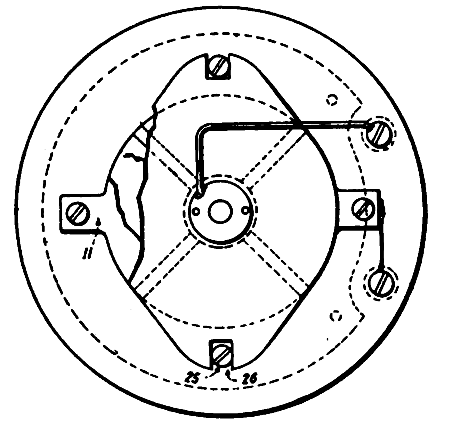


Figure 8—Another bottom view of the main portions of the variable condenser

using an adjusting screw of sixty-four threads to the inch.

The capacity of the condenser without the mica, neglecting edge effect, would be inversely proportional to the separation of the plates. With the one plate, however, covered with mica, (which material has a dielectric constant of approximately six times that of air) the capacity would be inversely proportional to $\frac{M}{K} + A$: where M equals the thickness of the mica, K equals the dielectric constant of mica, and A equals the distance from the outer surface of the mica to the other plate.

It will be apparent from the shape of the solid line curve that this type of condenser is especially valuable for use in a wave meter or in the wing circuits of a vacuum tube detector.

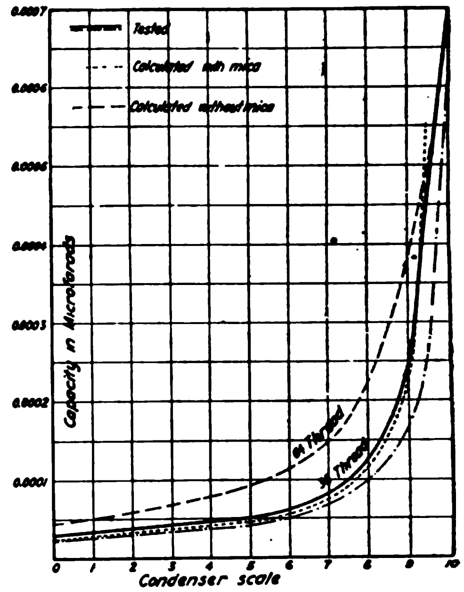


Figure 9—Graphs plotted from some of the results obtained

Locating the Taps on a Tuning Coil for Equal Increments of Inductance or of Wave Length

By Ralph R. Batcher

THE tendency in the past few years has been to replace the sliding contacts on the inductance coils of receiving sets with multi-point switches. It may prove advantageous in some cases to bring out taps from the coil so that each section would add a definite amount of inductance to the circuit. In other cases it would be desirable to divide up the coil so that each section would produce an increment proportional to $\sqrt{L}$; or, in other words, proportional to the wave length λ, since

$$\lambda \propto \sqrt{L}. \qquad (1)$$

For a single layer coil this is readily accomplished. It is necessary first to determine some relation between the inductance of a coil and the number of the turns. Lorenz's inductance formula for a single layer winding is perhaps the most simple one to use:

$$L = r\, n^2\, Q, \qquad (2)$$

where r represents the radius, n the turns, and Q a factor depending upon the ratio of $\frac{\text{diameter}}{\text{length}}$. The factor "Q" is obtained from handbooks for different values of shape ratios.

If it were not for the fact that in a single layer inductance all of the lines of force from each turn do not cut each of the other turns, the inductance would be proportional to the square of the number of turns. The fact is, that L varies as some power of the number of turns less than 2.

Changing equation (2) to read:

$$L \propto n^3 \frac{Q}{n} \qquad (3)$$

and plotting $\frac{Q}{n}$ one gets a curve having the appearance of a hyperbola.

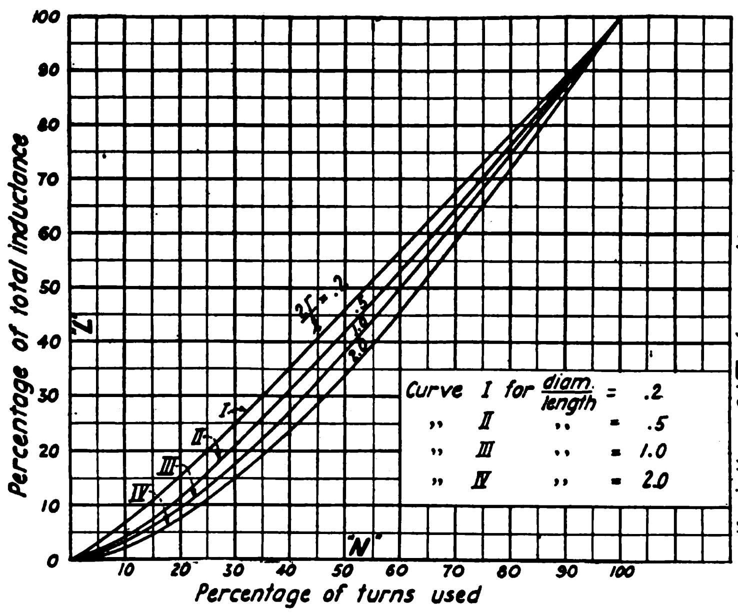


Figure 1

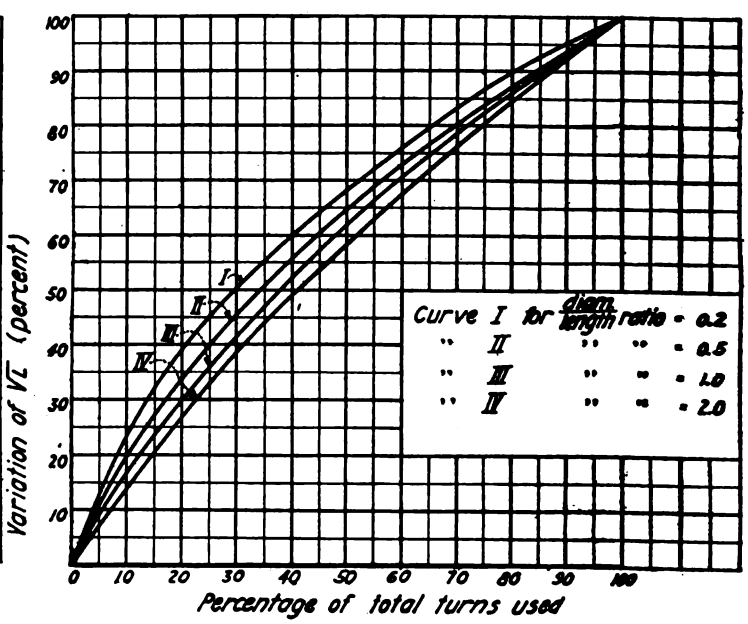


Figure 2

An equation roughly representing (3) deduced from the curve follows:

$$L \propto n\ (1.45 + \frac{\text{length}}{8\ \text{dia.}}) \qquad (4)$$

The equation shows that the inductance is more nearly equal to the first power of the number of turns than to the second power.

As this equation is a rather difficult one to use, curves have been constructed to show this relation graphically. To obtain greater accuracy, these curves have been plotted from the original formula rather than from equation 4. The curves represent four values of shape ratios but interpolation for other values of $\frac{\text{diameter}}{\text{length}}$ is a simple matter.

An example of how the curves may be applied in practice is as follows: Suppose it is desired to divide a coil 15.75" long, 7.87" in diameter having 400 turns of wire, into eight sections (the taps leading to a nine point switch), so that inductance could be added by equal amounts. The total inductance of this coil is 12.9 millihenries. Referring to curve II on figure 1:

Tap		Inductance	Millihenries
1	located on first turn gives	0 % =	0
2	" " 84th " "	12.5% =	1.61
3	" " 138th " "	25.0% =	3.22
4	" " 185th " "	37.5% =	4.83
5	" " 228th " "	50.0% =	6.45
6	" " 272d " "	62.5% =	8.06
7	" " 316th " "	75.0% =	9.66
8	" " 358th " "	87.5% =	11.27
9	" " last " "	100.0% =	12.9

If this coil were to be used alone as the secondary coil of a receiving transformer, the taps might be taken off according to the curves of figure 2. In this case taps should be taken off from turns 1, 27, 84, 91, 136, 190, 252, 320, and 400. This will insure a constant wave length increment for each additional section of the winding cut in the circuit. (If a secondary loading coil is used these results will not be strictly correct.) Shunted with a .0005 mfd. condenser the wave length on each of the respective points would be: 0, 600, 1800, 2400, 3000, 3600, 4200, 4800 meters, neglecting the distributed capacity of the coil.

Group Frequency Tuner

WHAT we are told by the inventor is a novelty in the wireless telegraph art but which is well understood by wireless engineers is the group frequency tuning apparatus described by John Hays Hammond, Jr., in a recent patent specification.

The transmitting apparatus is shown in the accompanying diagram, figure 1 and the receiving apparatus in figure 2. In figure 1, a source of undamped oscillations B is coupled to a transmitter aerial inductively at the oscillation transformer L-1 and L-2. A resistance changing device such as C (which may be a microphone) is placed near a tuning fork D which can be replaced by any device operating at audio frequencies which is capable of modulating the antenna oscillations. When D is set into vibration, periodical changes in the amplitude of the antenna oscillations occur and consequently the signals can be received by any detecting apparatus responsive to damped oscillations.

The inventor attaches to his receiving apparatus as in figure 2 an audio frequency tuning circuit comprising the secondary inductance L-6, the variable condenser J and head telephone K. As is possible with all group frequency tuners, selectivity is obtainable not only by radio frequency tuning, but by audio or group frequency tuning as well, that is, for best response the operator must vary the natural frequency of the audio frequency circuit L-6, J, K, as well as adjust the radio frequency tuning elements of the receiving transformer. The inductance of L-6 is obviously very large for the frequency 500 cycles.

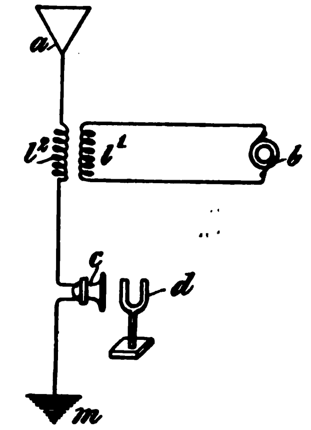


Figure 1—Transmitting apparatus

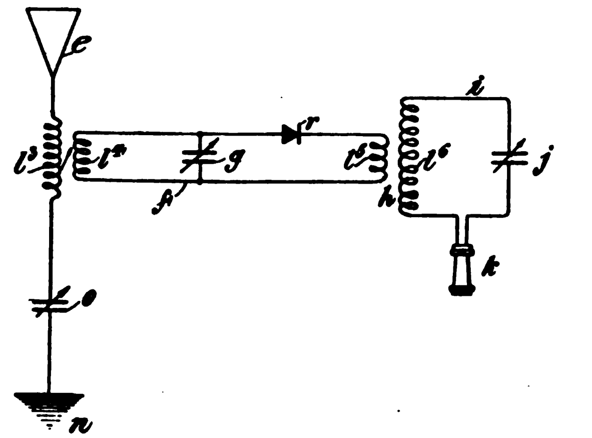


Figure 2—Receiving apparatus

What Is the Most Efficient Receiving Set for Amateur Use and What Should Be the Dimensions of the Aerial and Tuning Coils?

THERE are many short wave regenerative receiving sets on the market, all of which are as good as present-day knowledge of radio telegraphy can make them; but for the benefit of the experimenter who prefers to assemble the apparatus himself, I am presenting the hook-up and dimensions of what is, in my opinion, the most efficient short wave receiver.

A receiving set for short waves should have low resistance, stability of adjustment, reliability and be easy to operate. It should be highly selective and is preferably fitted with an end-turn switch.

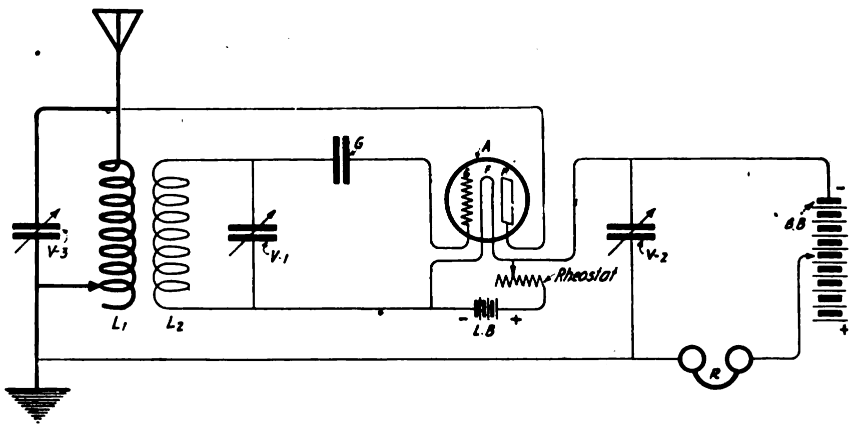


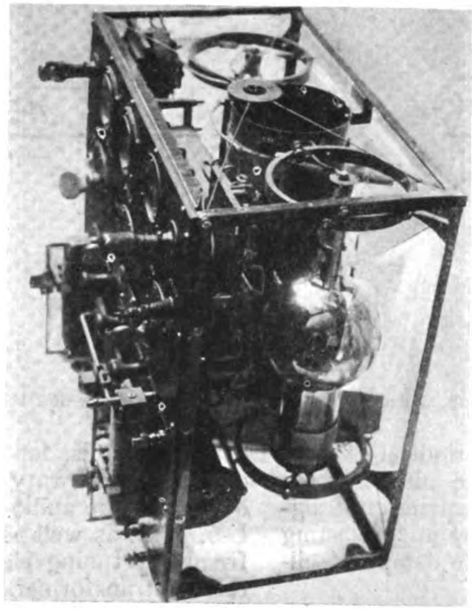
Figure 1—Circuit for the amateur receiving set

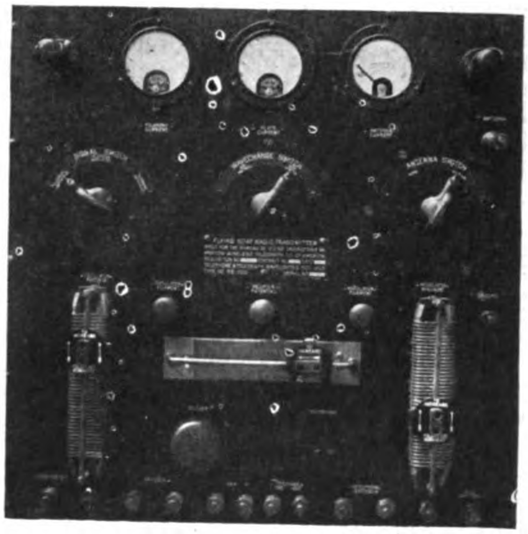
The Aerial

If a well balanced, efficient receiver is desired, the size and location of the aerial must be taken into consideration, as well as the other components of the receiving set. An aerial of the following dimensions will be found most satisfactory—4 to 6 No. 14 bare copper wires, spaced three feet apart, one hundred feet long and sixty feet high. The aerial may be supported by different means, but for strength and durability, I have found that a mast consisting of three joints of 20' iron pipe, of 3", 2" and 1" diameters respectively, connected by reduction

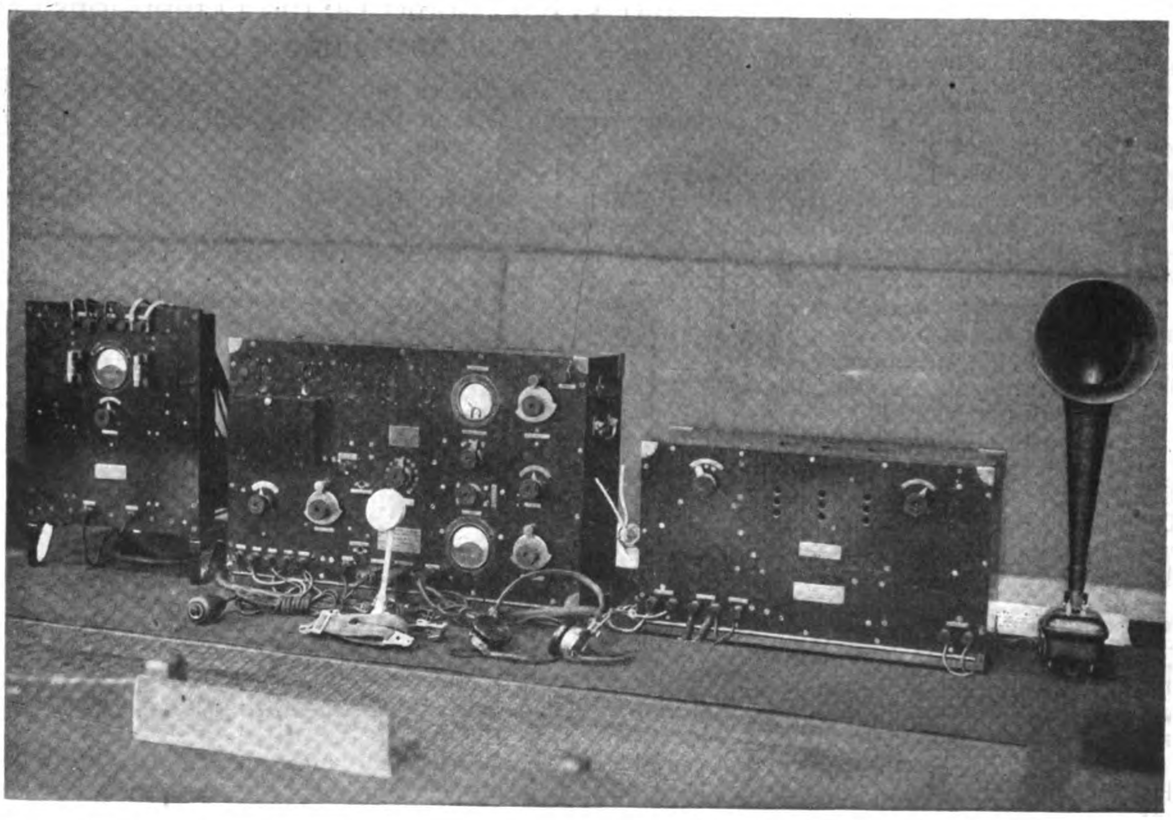
Wireless 'Phones

Photos, Intl. Film.





To the left: An interesting view of the Marconi transmitter used on naval flying boats, showing the arrangement and installation of the vacuum tubes and the means of control. Above: A front view of the same set showing the registering devices and control handles. At the top are the ammeters for filament current, plate current and antenna current; the three switches below are for the following purposes: the Signal Switch effects the change from telegraph to telephone; the Wave Change Switch changes the radiated wave from 600 to 1600 meters; the Antenna Switch has the usual send and receive positions. The rheostats regulate filament current and are respectively connected to oscillator and modulator



The radio ground set and amplifier of the Signal Corps as exhibited and demonstrated at the recent New York Aeronautic show couplings and well guyed to be permanent and substantial. After coupling the sections together, drive an eight foot, creosoted, locust post securely into the base of the mast, about two feet, so that when the mast is raised it will be supported on the post, which should be set three feet in the ground. This insulates the mast fairly well, preventing radiation losses to the ground when transmitting.

The aerial should be located so that no trees, smokestacks, wires, buildings or other objects are directly under it, as these will cause some loss of energy, both in transmitting and receiving. The lead-in should be taken from one end, because if it is brought from the center it causes the aerial to sag, spoiling its appearance. The fundamental wave length of such an aerial is a little below 200 meters, making it possible to tune to amateur wave lengths without resorting to the use of a series condenser, and on the other hand it is large enough to permit efficiently the reception of 600 meter wave lengths and above provided a vacuum tube detector is employed.

RECEIVING TRANSFORMER

The loose coupler L_{-1} and L_{-2} in figure 1 should have enough wire to tune to 600 meters but not so much as to cause a dead-end loss when receiving 200 meter stations. The primary should consist of 60 turns of No. 18 S. C. C. copper wire wound on a tube 3½" in diameter and 6" long. The dead-end losses of this primary are negligible, rendering the use of dead-end switches unnecessary. The secondary should be wound with 125 turns of No. 24 copper wire on a tube 3" in diameter and about 6" long, taps to be taken off every six or eight turns. Precise tuning may be accomplished by the use of a small variable condenser, V-1 across the secondary.

VARIABLE CONDENSERS

Two condensers (variable) are sufficient for this set, but another condenser V-3 should be connected across the primary if close variation of the primary wave length is desired. Condenser V-2 should be a 43 plate, oil-immersed, rotary variable, while V-1 may be of 19 or 23 plates, not oil-immersed. Fixed condenser G is the usual grid condenser.

DETECTOR

The valve A should be of the tubular type, and one which oscillates readily. It is sometimes difficult to obtain uniform oscillations from the bulb at high frequencies. The lighting battery L, B, for the filament is preferably a storage battery as it will prove much more economical in the long run than dry cells, because the filament draws a considerable amount of current. The high potential battery B,B may consist of ten three-cell flat, flashlight batteries, as these are compact and have long life. In place of regulating this battery, cell by cell, by means of a rotary switch, a high resistance potentiometer gives closer regulation. It should be connected in shunt with the cells being connected as any potentiometer.

TELEPHONES

The mica diaphragm amplifying receivers are by far the most sensitive for wireless reception; they are also the least uncomfortable to wear for long periods and they fit the ears closely enough to exclude outside noises. If the cost of these is prohibitive, however, I would recommend any standard make of 2,000 ohm telephones.

CONNECTIONS

All connections should be as short and as direct as possible. No. 18 wire is satisfactory. After the set is connected up, the aerial, ground and lighting battery connnections should be reversed until the best results are obtained.

OPERATION

The valves should be adjusted to a point below where a hissing sound is heard in the head telephones. This is the most sensitive point. This set is not affected by the proximity of the operator's hand or body, as in the Armstrong circuits, making it unnecessary to use long adjusting handles. For general "listening in," the coupling should be close, but by judicious use of the coupling when receiving through heavy QRM or QRN much of the interference can be eliminated.

It has been found that a magnet placed near some bulbs in a certain position, will increase its sensitiveness. The operator must determine by trial the correct position for the magnet.

It is to be noted that I employ regenerative coupling but instead of coupling the plate to the grid circuit, I connect to the antenna circuit, with equal results and with greater simplicity of operation.

The above described apparatus, connected according to the diagram will fulfill all the requirements for a simple, reliable and efficient receiving set for amateur wave lengths.

J. E. LAW, JR.—*West Virginia.*

A Variable Condenser Adapted for Small Variations in Capacity

IN the ordinary type of variable condenser it is difficult to obtain a fine adjustment of the capacity values because a slight movement of the movable plate causes a considerable change in capacity. N. H. Slaughter has devised the variable condenser shown in figures 1, 2, 3 and 4, which permits a very close adjustment of its capacity.

He provides two sets of movable plates, one set comprising the bulk, which may be 10 or 20 in number, the other set having only a small number of movable plates, say 1 or 2. These sets are independently movable and both

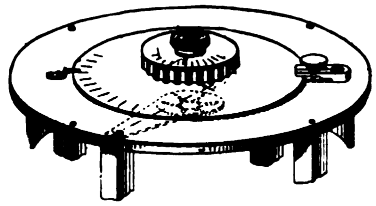


Figure 1—Top view

sets may be adjustably interleaved with the stationary set.

The construction is such, that the larger set of movable plates may be adjusted in any position to roughly give the desired capacity; and then for purposes of finer adjustment, the smaller set of the plates may be rotated to give the exact capacity desired.

In the drawings, the semi-circular plates 13 are approximately the same in number as the stationary plates 1. The

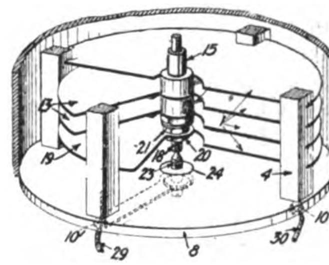
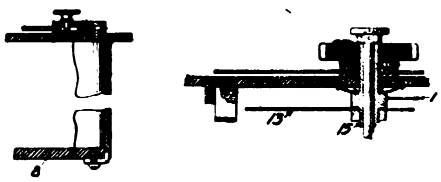


Figure 2—Interior view

shaft 15 is hollow and placed within the same is a shaft 18, to the lower end of which is clamped a single blade 19. This blade which provides for fine adjustment, is held in position by the shaft 18 by means of the clamping nuts 20 and 21 which are inserted on the shaft 18.

Both of the movable sets of plates are carried by the shaft 18, the lower end of which is adjustably supported by the set screw 23, which is threaded in the bushing 24 in the bottom 8.



Figures 3 and 4—Details showing construction of frame and rotating shaft with semi-circular plates attached

Electrical connection may be made to the system by means of the lead 29 which is electrically connected to the movable plates by means of the set screw 10' which serves as a binding post. The other terminal is a lead 30, one end of which is electrically connected to the stationary plate by means of the set screw 10' which is screwed into the lower end of the standard 4.

The Design of 60-Cycle Transformers for Amateur Transmitters

(*Continued from page* 26)

With steel laminations .014 thick, a core 1.7 inches will require $1.7 \times 59 \times 4 = 404$ pieces in all; 202 of these should be cut 1.7 inches wide and $(5.2 + 1.7) = 6.9$ inches, say 7 inches, long. The other 202 pieces should be cut 1.7 inches wide and $(3.4'' + 1.7'') = 5.1$ inches, say 5 inches, long. The builder may be able to get these cut to these dimensions by the manufacturers of the steel.

We may now determine the efficiency of the transformer from the foregoing formula. Summarizing,

Primary copper loss	= 8.36 watts
Secondary copper loss	= 7. watts
Iron loss	= 15.36 watts

$$\text{Therefore, Efficiency} = \frac{500}{500+15.36+8.36+7} = 94\%$$

Assembly

Stack up the laminations as in figures A and B and be sure to stagger the joints. Drive nails in a board as in figure C and lay on sheets until the pile is 1.7 inches thick. The ends of the cores are shown in figure D. Figure E shows how the yokes will appear finally. After making up two cores and one yoke like figure C, bind them with one layer of friction tape.

Next put 1/16 inch washers on primary and ⅛ inch washers on the secondary. These should be made of micanite. Next place the micanite tubes on the primary and secondary cores. Make them about the same thickness as their respective washers.

The winding form for the primary is 1.8 inches on side and 5 inches long. Put on one layer of fishing twine, then one layer insulating paper, and finally 238 turns of No. 13 DCC wire. Now take off one end of the form, pull out fishing twine, whereupon the coil will come off very easily. Next solder on 1 foot of No. 12 machine cable to act as leads and then dip the coil in clear insulating varnish and bake for about 6 hours. Then wrap it with one layer linen tape, lapping the tape for half its width and then place the coil on the core. This completes the primary.

The form for the secondary will be 1.9 inches square and 1.2 inches long. First wind it with cord and paper as the primary, and put on 85 layers of 85 turns per layer of No. 30 D.S.C. wire. Place 1 layer of .007 inch oiled paper between the layers, then solder on leads of No. 20 silk covered lamp cord. Now remove the coil from form and wrap it with one layer of empire cloth. Construct the other three coils the same way.

The builder may be able to get these coils wound by some manufacturer of armature and field coils. The wire should be wound very carefully in even layers. It may be better to allow a little of the paper to extend beyond the ends of the winding as in figure F.

To finish the job, place the four coils on the core and connect up as in figure G. Be sure to connect the sections so the current travels around the core in the same direction. Place the remaining yoke in position, carefully watching the ends. Secure the core with oak clamps and bolts as in figures H and I.

The transformer should be placed in a tank and the leads brought out through suitable bushings. The secondary bushings should have an insulating value of at least 20,000 volts. Fill the tank with transil oil and put on a suitable cover.

The transformer has a leakage reactance suitable for a condenser of .008 mfd. using a quenched gap. When used with a non-synchronous gap the number of studs times the R.P.S. of the gap motor should not exceed 400. A method of finding suitable condenser values for various transformers will be discussed in an article on resonance to follow.

Contest Winners for the May Issue

In response to the call in the March issue for manuscripts concerning "The use of a quenched spark gap in connection with an amateur's 60 cycle transmitter," prizes have been awarded to the writers of the following articles

First Prize—The Quenched Spark Discharger Is Not the Most Desirable from the Amateur Standpoint

NO one who understands the principles of radio engineering doubts that the quenched spark discharger is the most efficient gap yet devised for low powered transmitters. The writer, however, will attempt to show that the amateur in the majority of cases is not in a position to take full advantage of the benefits thus to be obtained, and as a consequence a non-synchronous rotary spark gap is the one to be preferred for amateur use.

In the first place, many amateurs are of the opinion that simply to substitute a quenched gap for one of the plain rotary type will result in increased antenna current and range of transmission; but it is safe to say that those who have tried to experiment have been amazed at the degree of *inefficiency* which the quenced gap brought about! In all probability it will be found that such amateurs have never been told the requirements of a radio transmitter that gives good quenching. It is not alone the quenched spark gap that prevents the interchange of energy between the open and closed circuits with the consequent double wave emission, but it is the design of the whole transmitter which must be considered.

To begin with, there must be a certain amount of magnetic leakage in the power circuits of the transmitter, for otherwise when the condenser discharges across the spark gap, the transformer is short circuited and the resulting arc at the gap is too powerful to be quenched out. This permits the antenna circuit to react upon the spark gap circuit and results in a double wave emission. This is substantially what the amateur with the average 60 cycle transmitter will find.

A transformer fitted with a magnetic leakage gap will give some relief; even the insertion of a reactance coil in the primary circuit of the transformer will help some, but the best results will be obtained with a transformer having a magnetic leakage gap and utilizing the principles of resonance; that is, the transformer circuit with the secondary condenser should be tuned near to resonance with the frequency of the alternator.

The operation is then somewhat as follows: Due to resonance, the secondary voltage of the transformer rises to the point where the spark gap breaks down. The resistance of the spark gap is then reduced and the secondary of the transformer is short circuited. This throws the transformer circuits out of resonance with the alternator, resulting in a very marked drop in the secondary voltage This drop in voltage combined with the heat dissipating qualities of the copper plates in the quenched gap permits the primary to oscillate only through two or three swings, whereupon the primary oscillations increase. The antenna circuit then oscillates at its own frequency at damping with a single wave emission.

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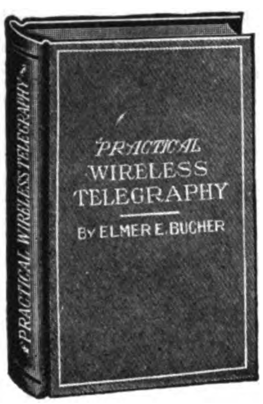

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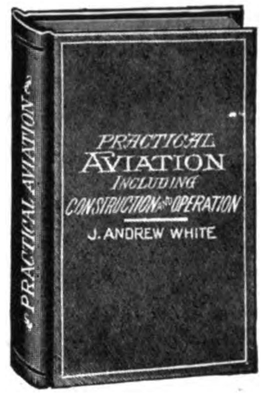

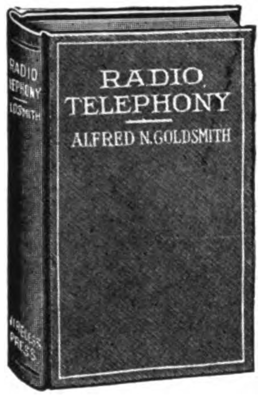

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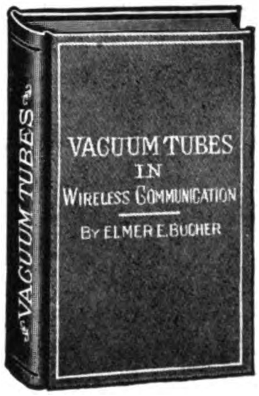

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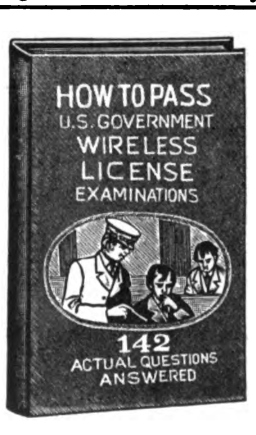

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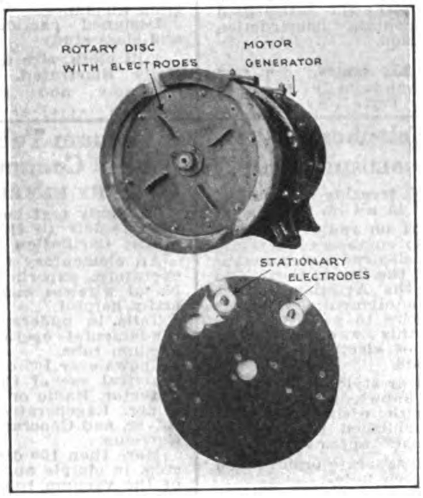
Experiment has proven that it is difficult to maintain a clear spark note with a resonance transformer, hence the natural frequency of the transformer circuit with its secondary condenser is designed to be 15 per cent or 20 per cent lower than that of the alternator. This prevents the breaking up of the spark note and still retains enough of the good effects of resonance to obtain the detuning results mentioned. In some types of transmitters like the Marconi quenched spark sets, the necessary magnetic leakage takes place at the alternator, the transformer



Synchronous rotary spark gap giving the high pitched note desired by amateurs

being closely coupled; but since the amateur has no control over the source of power, he is required to obtain the necessary leakage at the transformer.

Suppose, for example, he possesses a transformer with a magnetic leakage gap and desires to operate near to the point of resonance. The necessary condenser capacity can be readily obtained in the following way: An ammeter is placed in the primary circuit, the key closed and the capacity of the secondary condenser varied until the primary ammeter reads the maximum. This indicates resonance. Then the capacity should be increased by 10 per cent to 15 per cent in order to slightly detune the circuit. With some types of transformers, the necessary capacity for resonance, or near resonance, may exceed .01 mfd. and as a consequence the amateur cannot operate on the wave length of 200 meters. If this is found to be the fact, he may obtain some relief by placing a reactance coil in series with the primary circuit of the transformer, using it, as well as the secondary condenser, to tune the circuit. By giving proper attention to the foregoing suggestions, very good results can be obtained with the quenched gap. There is, however, one all important factor that has not yet been taken into account.

Some experimenters are of the opinion that a quenched gap will increase the frequency of the spark discharge. This is not true. The quenched gap has the effect of smoothing out the tone of the spark, but at best the resulting spark note will be relatively low and will hardly compare with the musical note of non-synchronous rotary spark gap which amateurs are accustomed to employ. The average 60 cycle transmitter gives, with a quenched gap, what is known as a "mush" note, which, while it may be pleasing to some ears, cannot be said to be the most desirable tone. There are no ready means available to increase the tone of the spark except the type of transmitter which involves both a rotary spark gap and quenched gap. Some experimenters have placed these gaps in series using the rotary gap to increase the tone, and the quenched gap to give the necessary quenching. Experiments in circuits of this type do not always give the desired results. In fact the writer has found that the system is not very efficient.

This discussion, of course, does not include the rotary quenched spark discharger which has been supplied to the amateur market, but the writer has observed that these transmitters have such a large capacity in the closed circuit that they cannot be operated efficiently on a wave length of 200 meters. Such a large capacity results from the use of a low voltage secondary, usually no more than 2500 volts, but if it were not for that disparaging feature, it is safe to say that it would be employed universally by amateurs; for it is well known that a set of this type now supplied to the amateur market produces a spark tone equivalent to a 500 cycle transmitter.

Another item which experimenters should take into account is the cost of the quenched spark discharger. It has been the writer's experience that the expense of milling, cutting and casting the plates for quenched gaps exceeds the cost of a good rotary gap; and moreover, unless the amateur is willing to put the best possible construction into the quenched gap, he will find that it will not operate over a considerable period of time without trouble.

The average wireless experimenter prefers a high pitched spark note, or at least a note equivalent to a non-synchronous rotary gap. The writer has yet to see the quenched gap operated on 60 cycle current that will give a note equivalent to the non-synchronous rotary gap.

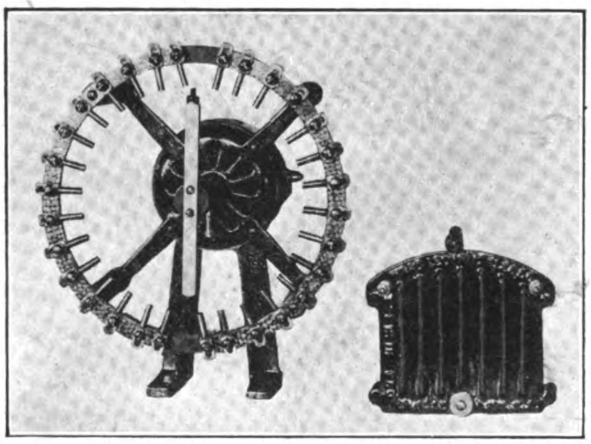
This discussion, of course, does not apply to 500 cycle transmitters, but since the amateur has not available a source of current of this frequency, the use of such frequencies need not be considered.

The writer firmly believes that in the future the approved transmitting set for amateur use will be one of the vacuum tube type, because these transmitters are rugged, fairly efficient, can be connected up to generate radio and audio frequency currents simultaneously and thus produce musical tones so desirable for all-around wireless transmission. No one has yet put such a transmitter on the market, but it is safe to say that one of these types will appear in due time.

A. J. HOLBORN, *New York.*

Second Prize—Arguments Against the Use of a Quenched Spark Gap in Connection with an Amateur's 60 Cycle Transmitter

IN spite of the fact that the stationary quenched spark gap is considered to be one of the most efficient types of spark dischargers, it has not been extensively used by amateur experimenters. This is probably due to the reduced efficiency of the gap when operated on 60 cycle transmitters of the type amateurs are accustomed to use.



Non-synchronous rotary gap suitable for use with 60 cycle transmitters

A transmitting circuit containing a quenched gap operates somewhat on the principle of impulse excitation; that is, the oscillations of the condenser circuit are rapidly damped out by the quenching action of the gap, allowing the antenna circuit to oscillate at its own natural period. The gap operates most efficiently when the spark frequency of the condenser circuit is around 1,000 per second. At this frequency the oscillations of the condenser circuit, which are rapidly damped out by the quenching action of the gap, transfer impulses of oscillating current energy to the antenna circuit at a very rapid rate. In the case of a 60 cycle transmitter where the spark frequency of the condenser circuit is low, say 120 per second, the condenser circuit will transfer impulses to the antenna circuit at a very much lower rate with greater current at each impulse than in the case where the higher frequency is employed. This will increase insulating difficulties in the antenna circuit.

Many transformers used by amateurs are unsuitable for use with quenched gaps. The voltages in a great many cases are too high. When the spark frequency is high, the quenched gap has been found to operate most efficiently on low voltages which the amateurs cannot use, if they desire to employ the amount of power permitted by law.

The note of a quenched spark transmitter used with 60 cycle current is very low when heard at a distant receiving station. Furthermore, it has been proven by several radio engineers that currents of high frequencies around 1,000 per second will produce the same effect in a telephone receiver as currents, many times as great, at lower frequencies. Therefore, the receiving operator may hear a comparatively weak signal from a low frequency spark transmitter while a signal from a high frequency spark will be heard much louder, even if the received energy from both transmitters are the same. For this reason, a high pitched note has a great advantage over a low pitched note; and in some cases, a higher spark frequency will completely drown out a low pitched spark, simply because the telephone receiver is less sensitive to a low note than to a high one.

It is more difficult to receive a low pitched note through atmospheric disturbances. The higher pitched note of a non-synchronous rotary gap can be read with much greater ease; but it cannot be obtained from a 60 cycle quenched gap.

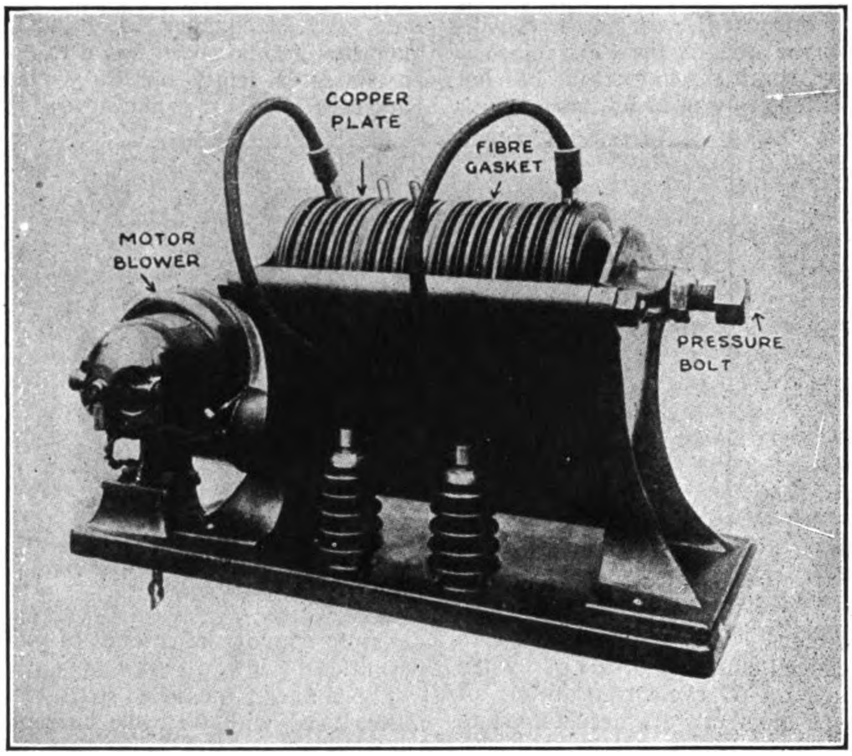
CARL DIETSCH, *Ohio.*

Third Prize—The Quenched Spark Gap and the 60 Cycle Transmitter

THE post-war restrictions imposed upon amateurs regarding power input will require the amateur to strive with increasing zeal to gain the highest possible efficiency out of his apparatus. The quenched gap, possessing as it positively does, 25 per cent greater efficiency than any other form of gap, will be used by the amateur to a greater extent than heretofore, if he is willing to sacrifice the spark note.

As is well known, 60 cycle current is not favored for signaling, due to its low frequency and unmusical pitch; the quenched gap will not improve that pitch. Reception is more difficult through static interference as compared with the more musical sparks of higher frequency and the reception of rapidly transmitted signals with low frequencies becomes rather difficult at great distances. This accounts for the popularity of the non-synchronous rotary gap, in which the spark discharges occur at the rate of 200 or 300 per second along the initial 60 cycle alternating current curve. But during the times of favorable atmospheric conditions and times when the ether is free from interference from other stations, as in midnight hours, very long distance work should be accomplished with a well balanced quenched spark transmitting set using 60 cycle alternating current. Such a transmitter will probably have a greater range under those conditions than one employing the rotary gap.

The superiority of the quenched gap is recognized by the commercial companies and the U. S. Navy, who use it to the almost entire exclusion of other forms, and the amateurs will profit by following a good example. A lower transformer secondary voltage can be used and the better quenching properties of this gap permits of closer coupling between the closed and open circuits, resulting in greater antenna current per given power input at approved decrement per oscillation. The noiseless qualities of the quenched gap should also be given consideration. A primary reactance may be employed to advantage to regulate the voltage of the primary current to secure synchronous discharges.



A quenched spark gap of improved efficiency

In summing up, we find that practical considerations oppose the electrical efficiency of this combination, but the latter no doubt exceeds the former. At least a greater number of amateurs should experiment along these lines, as intelligent results can be noted only from practical application to long distance work. Possibly the progressive amateur will provide both the rotary non-synchronous and the quenched gap, using each according to conditions.

HUGO L. ESTBERG, *New York*.

The Monthly Service Bulletin of the

National Wireless Association

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

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IMPORTANT NOTICE

All restrictions upon the use of wireless receiving stations, other than those used for commercial traffic, were removed on April 15th. The order applied to amateur, technical, experimental, and other stations. Restrictions on transmitting stations of all types remain in effect.

New England Gets Started

THE first post-bellum meeting of the New England Amateur Wireless Association was held at the Everett High School on February 13, with an attendance of about seventy-five. G. R. Entwistle presided.

A very interesting talk was given by Arthur Batcheller, New England Radio Inspector.

All amateur licenses both "operator" and "station" have been automatically canceled, and when stations are licensed again, new call letters will be assigned. This step is necessary to avoid confusion.

In order to secure a first grade amateur license one must be able to both send and receive not less than ten words a minute, and must also pass a technical examination.

The radio inspectors will visit the principal cities at certain periods notifying holders of these licenses two or three weeks beforehand. These men will be expected to appear and take an examination for a first grade license. Those who do not appear or advise the inspector of their inability to do so, will be regarded as no longer interested and their licenses will be canceled.

The law regarding interference will be as strictly enforced among amateur stations as it now is among commercial stations.

The fact that the majority of New England's 2,500 licensed amateurs enlisted, speaks strongly in favor of continuing amateur radio. These men were enabled to take up their duties without special training, thereby saving the government a vast amount of time, which was at such a premium in those strenuous days when every second counted. A committee was appointed to secure permanent quarters for the club.

The association would like to hear from its old members, also from those interested in becoming members. Communications should be addressed to the secretary, Mr. P. W. Pratt, 100 Harvard St., Everett, Mass.

Until further notice a meeting will be held once every two weeks.

Suggestion for Prize Contest, June Issue Wireless Age

We will pay the usual prizes of $10, $5 and $3, in addition to our regular space rates, to the three contributors who send us the best manuscripts on the following subject:

"To what extent do you believe that wireless telephony will take the place of wireless telegraphy in amateur communications?"

Death of Harry V. Roome

Amateur wireless lost an ardent supporter and generous co-worker by the death of Corporal Harry V. Roome of Los Angeles. According to word received by his mother the young soldier died September 30 of gunshot wound and pneumonia.

Corporal Roome was called in the first Selective Service summons and went to Camp Lewis, where he was engaged as wireless instructor. Later he went to France and saw active service in the Signal Corps. The last letter written by him was dated September 15. Corporal Roome was a graduate of the University of Southern California.

A Voice From the Rhine

NOW that hostilities have ceased and peace is in sight, it is urged that amateur stations be permitted to reopen immediately. The most important reason is, that it trains the young amateur for war-work as was clearly shown in the past two years. While we do not expect another war to follow immediately, this is an age when preparedness is an important factor and the United States should never be caught again so wholly unprepared to defend the rights of her people. I was a radio operator in the Army throughout the recent conflict and it has been a matter of keen interest to me to note how well the former amateur played his part and how comparatively inefficient was the man without any previous wireless experience. Practically all the former commercial operators were needed at their old positions and it was up to the amateur to play the leading rôle which he did in every radio organization I have come in contact with.

Now as to the commercial side of the argument, it is evident that with the improvements that have been introduced of late, radio will become an important rival to the wire lines. This expansion will require operators which can only be obtained in sufficient numbers from the ranks of the amateurs. It is a fact that our best commercial operators today were formerly amateurs.

Then the shipping trade resulting from the war is going to be materially increased and every ship will require one or two operators. There are many former wireless "bugs" that with a little brushing up on their amateur practice could fill any of these positions. So it would be much better to give these men a chance than to fill these positions with so-called operators picked up hit and miss regardless of their qualifications.

There is yet another phase to the question. Radio makes an interesting diversion for the high school boys. Not only do they get many hours of interesting play out of wireless experimenting, but the technical education they thus obtain is of inestimable value. Every amateur must have an inkling of the theory of radio which of course, involves a knowledge of electricity. Other branches of electrical work offers many opportunities to young men, so that even if the amateur never intends to follow wireless as a profession, he has secured a store of electrical knowledge which would serve him equally well in many other lines.

Any one of these reasons alone would justify the government to lift the ban on amateur stations and to re-issue licenses, which I believe will be done as soon as a permanent peace becomes more certain and the pressure of other measures allows the question to be acted upon.

In respect to power input, one kilowatt is sufficient, but stations should be allowed to use a longer wave length. The primary reason why they were before limited to so short a wave length was to eliminate interference with commercial stations that were working on slightly longer wave lengths. Nearly all the newly constructed commercial stations are operating on long wave lengths and it must follow that all stations will change to the longer wave. This should allow the amateur to use at least 600 meters because a 1 kw. station will work most efficiently between 400 and 600 meters.

PVT. HOMER G. JORDAN—*A. E. F. Germany.*

For Those Who Sent the "Age" Overseas

TO THE EDITOR:—Many, many thanks for printing my letter requesting recent issues of THE WIRELESS AGE. I was surely remembered by many of the old boys and received over 20 copies, which I sent to radio men over here. I wish I was a writer; I would surely give you a lot of dope on how wireless was used in the war. I have studied all methods of communication. I have seen how the English, French and the Germans do it. I even tried hooking an aerial, consisting of six wires, to the balloon basket 2,000 feet high. No, don't laugh! It got results. The cable from the balloon to the winch makes a wonderful aerial.

It was great to hear all the broad wave sets in a sector. Talk about the amateurs on a busy night! They had nothing on this. You see, every company has a small transmitting set such as the S.C.R. 54. It has a broad wave and when about 30 of these get agoing, you know what happens. . . . Get my drift?

Wishing big success to the best radio magazine in the world—THE WIRELESS AGE—I am,

JOSEPH E. ENGSTROM (2 A. S. O.)
24 Balloon Co., Air Service
St. Mihiel, France.

Marconi and Fleming Support British Amateurs

MARCONI, inventor of wireless has again proved himself the amateur's friend. In the Wireless World, of London, appear his opposition views to proposed legislation in Great Britain which would prevent amateurs experimenting with wireless telegraphy. "I wish to state that, in my opinion, to follow such a course would be a mistaken policy," says Mr. Marconi. "It should be borne in mind that in many or, perhaps, in all branches of radiotelegraphy finality has by no means been reached, and I consider that the existence of a body of independent and often enthusiastic amateurs constitutes a valuable asset towards the further development of wireless telegraphy. It is wise also to remember that had it not been for amateurs wireless telegraphy as a great world-fact might not have existed at all. In the United States, for example, a great deal of the development and progress of wireless telegraphy is due to the efforts of amateurs.

"I think, therefore, that the suppression of the work of those amateurs who are interested in wireless telegraphy would be against the public interest."

Dr. J. A. Fleming, inventor of the famous Fleming valve, also makes a strong plea for the amateur:

"Now that the war is happily ended we ought as soon as possible to be freed from certain shackles of bureaucratic control and from any restrictions which were essential for national safety during the progress of the struggle. One of these is the permission under license to conduct research in radiotelegraphy and telephony. At the outbreak of the war all private and university radio stations were dismantled and non-official research stopped. The question then arises—how soon will these restrictions be removed? It is a matter of common knowledge that a large part of the important inventions in connection with wireless telegraphy have been the result of amateur work and private research, and not the outcome of official brains or the handiwork of military or naval men. In fact we may say that wireless telegraphy itself in its inception was an amateur product. At the time when Senatore Marconi first made known his epoch-making inventions the official telegraphists of the General Post Office had been working for years and spending large sums of public money in trying to develop and exploit the magnetic-induction and earth-conduction methods of wireless telegraphy of very limited application, but, apart from certain pioneer work by Admiral Sir Henry Jackson, they did not succeed in utilizing electro-magnetic waves for this purpose until Mr. Marconi showed them how to do it.

"Then, again, numerous important inventions such as the crystal detectors, the oscillation valve, the three-electrode valve, the electric arc generator, the high-frequency alternator-directive radiotelegraphy, beat reception, all the important uses of the thermionic detector, and much work on the study of atmospheric stray waves, has been due to private or amateur expert work, and not to official electricians in the General Post Office or the Army or Navy. If, then, full opportunities for such non-official work and research are not soon restored, there is no question that the progress of the art of radiotelegraphy and telephony will be greatly hindered.

"In an article published by me just eighteen years ago in The Nineteenth Century and After (February, 1901) entitled 'Official Obstruction of Electrical Progress,' I pointed out how much of all electrical discovery and invention has been due to amateur work, including in that term teachers and private investigators of all kinds.

"The action of Government officials has been in most cases to hinder and not help progress. As a rule the most effective method of afflicting any department of applied science with lethargy is to constitute it a Government monopoly."

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.

R. R., Wapinitia, Ore.:

Ques. (1)—Which is the most efficient, an open core transformer or a closed core transformer, both having the same power input?

Ans. (1)—If properly designed, they are equally efficient, but the open core transformer is more expensive to construct, because it requires more material than the closed core transformer for a given power input.

Ques. (2)—What would be the wave length of an 8 wire antenna, 60 feet in length, 38 feet in height at one end and 43 feet in height at the other end?

Ans. (2)—Approximately 135 meters.

A. P., Winthrop, Mass.:

The first receiving set you describe has a range of wave lengths up to 2,000 meters, the second set will respond up to 3,500 meters and the third set up to wave lengths between 6,000 and 8,000 meters. You will require loading inductances in the primary and secondary circuits of the second set to receive the longer wave lengths radiated by high power stations. It is difficult to conjecture your receiving range unless we know the type of oscillation detector you employ.

A vacuum tube regenerative set using a single bulb, will permit reception over very great distances provided the apparatus is correctly designed and an aerial of fair proportions is employed.

H. R., St. Augustine, Fla.:
If you can procure a vibrator that can handle the primary currents of four induction coils, we would suggest that the primaries be connected in parallel, making sure that the current for all four coils passes through the vibrator. The secondaries may be connected in series or in parallel, depending upon the condenser capacity employed.

* * *

A. W. J., Warren, Pa.:
Pages 281 and 282 of the text-book "Practical Wireless Telegraphy," give complete dimensions of a long wave receiving set. The dimensions of the regenerative coupler are approximately those used for a 3,000 meter tuner, that is, the secondary coil may be about 5½ inches in length, 4 inches in diameter wound with No. 26 S. S. C. wire and the primary of similar length, but about 3½ inches in diameter wound with No. 26 S. S. C. wire.

The variometer type of coupler described in your third query will respond to wave lengths up to 700 meters.

The variometer mentioned in the first query should be wound with No. 28 wire in order that the tuner may respond to 3,000 meters. * * *

C. F., Jersey City, N. J.:
The correct number of plates for the condenser mentioned is best determined by experiment. For one thing, inasmuch as you do not intend to place glass between the conducting plates, you will have to space the plates sufficiently to prevent the transformer discharging between them. With a 20,000 volt transformer, two banks in series are required. The capacity should not exceed .008 mfd. and a dozen of the plates you mention connected in parallel with two sets in series should give the proper capacity. * * *

C. K. U., Ancaster, Ont., Canada:
If the receiving station to which you intend to transmit possesses a thoroughly sensitive oscillation detector, you should have no difficulty in covering a range of 10 miles with a 2-inch or 3-inch spark coil.

The poles to support the antenna need not be more than 30 feet in height. They should be spaced about 100 feet. Four copper wires spaced 2½ feet apart will be satisfactory for the flat top portion of the antenna. Either hard drawn or stranded copper wire may be employed.

The lead-in wire does not necessarily have to be placed in a vertical position, but it should be run as directly as possible to the station house. A complete transmitting and receiving apparatus to cover the distances you require should not cost more than $20 to $25.

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J. A. B., Annapolis, Md.:
The filament current of various types of vacuum tubes varies with the construction. Some tubes require an ampere or an ampere and a half, while others will operate with ¼ or ½ ampere in the filament circuit.

Replying to your second query, the inductances in the X circuit of the Weagant receiver employs the same size wire used in the secondary circuit, although it is not strictly essential that the same size wire be employed.

Regarding the control of the plate voltage in the vacuum tube detector: To prolong the life of the plate battery, the most satisfactory method of controlling the voltage is to connect the cells to a multi-point switch varying the applied E.M.F. by a cell at a time. Either a series resistance or a shunt resistance may be employed. The shunt resistance should be approximately 3,000 ohms while the series resistance may have to be considerably greater, depending upon the internal resistance of the tube. Most amateurs prefer the cell by cell adjustment of the plate voltage.

C. B., Union, Ore.:
Any of the advertisers in THE WIRELESS AGE can supply you with raw material for constructing a wireless transmitter and receiver. Various types of cabinet receivers have been described in past issues of THE WIRELESS AGE. The set designed by Fearing Pratt in the April issue of the WIRELESS AGE consists of three receiving sets and you can select the one most suited for reception in your district.

The text-book "How to Conduct a Radio Club" gives dimensions of receiving tuners for various ranges of wave length. The dimensions of the coupler depend upon the wave lengths you intend to receive.

* * *

D. C., Ann Arbor, Mich.:
We presume that station licenses will be issued to amateurs just as soon as peace articles are signed. Experimenters are now permitted to operate their receiving sets, but they cannot use their transmitters until the ban is lifted.

* * *

F. S. F., Chicago, Ill.:
In a forthcoming issue of THE WIRELESS AGE, there will appear a complete description of a vacuum tube transmitting and receiving set which employs one bulb for both purposes. Dimensions and other data for construction will be given.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912.

Of THE WIRELESS AGE, published monthly at New York, N. Y., for April 1, 1919.
State of New York, } ss.
County of New York. }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared E. J. Nally, who, having been duly sworn according to law, deposes and says that he is the President of the Wireless Press, Inc., publisher of THE WIRELESS AGE, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:
Publisher, Wireless Press, Inc., 25 Elm St., New York, N. Y.
Editor, J. Andrew White, 25 Elm St., New York, N. Y.
Managing Editor, None.
Business Manager, Alonzo Fogal, Jr., 25 Elm St., New York, N. Y.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)
Wireless Press, Inc., 25 Elm St., New York, N. Y.
E. J. Nally (851 shares), 233 Broadway, New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)
None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

E. J. NALLY,
President.

Sworn to and subscribed before me this fourth day of April, 1919.
(Seal.) M. H. PAYNE.
(My commission expires March 30, 1920.)