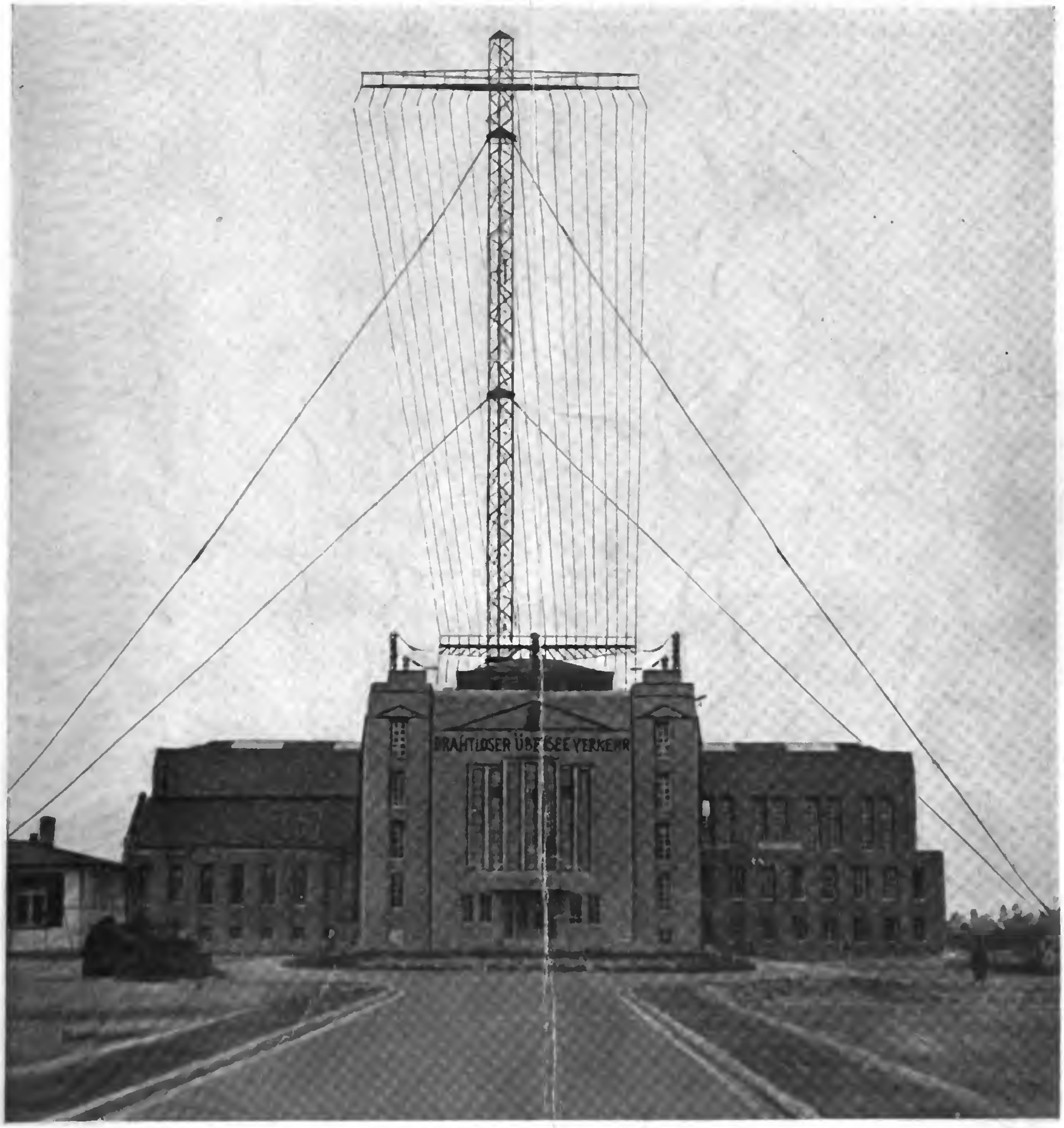
December, 1919

20 Cents

The WIRELESS AGE

Volume 7

Number 3



A close-up of "POZ" the German Station at Nauen

"NSS"—The Annapolis Station

A complete description of the Navy's most powerful wireless plant

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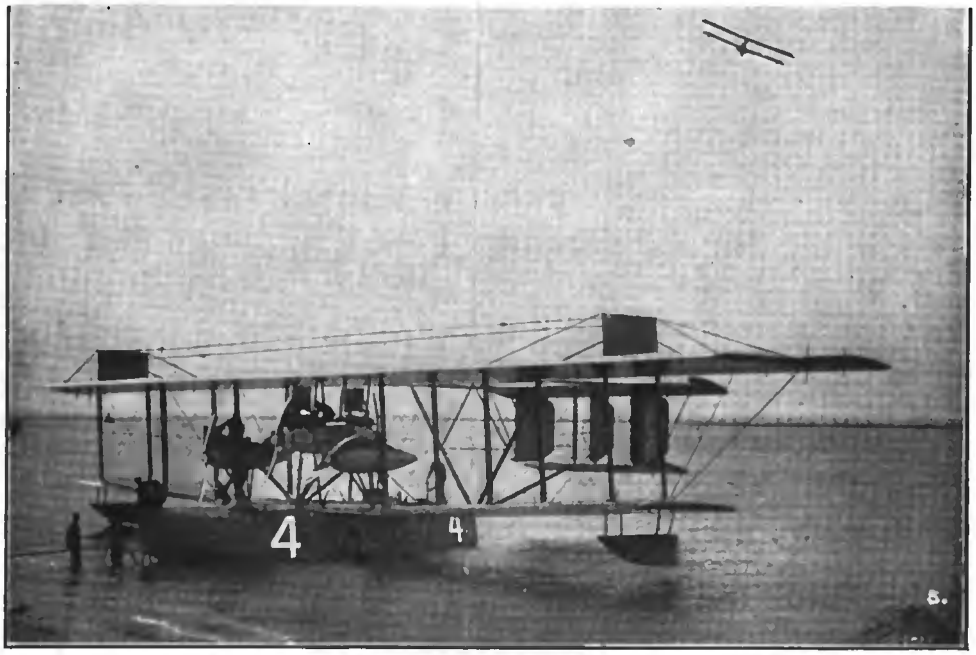
Extract from New York World, June 3, 1919.



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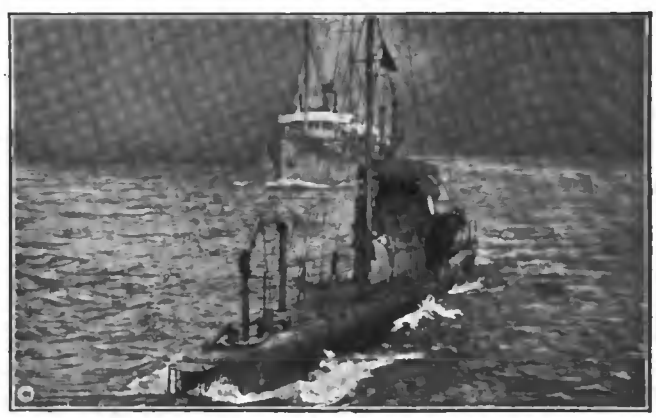

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The Wireless Age

Edited by J. ANDREW WHITE

Vol. 7 — No. 3

Contents for December, 1919

Index of Equipment

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

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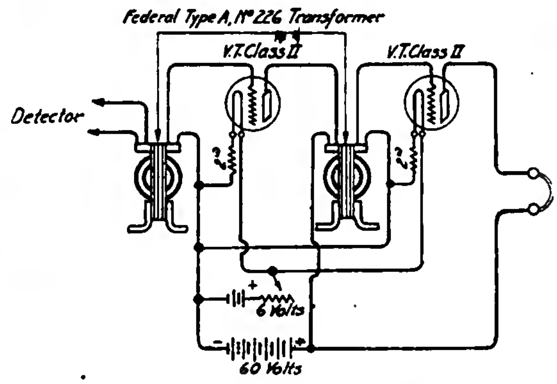

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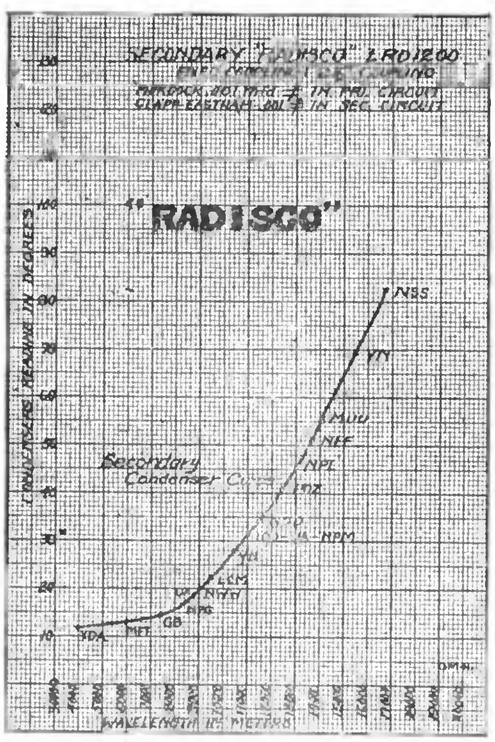

shows the performance of "RADISCO" long-wave coils used at Brookline, Mass., with a short amateur antenna. All the stations noted were received in several hours time—and but one tube was used.

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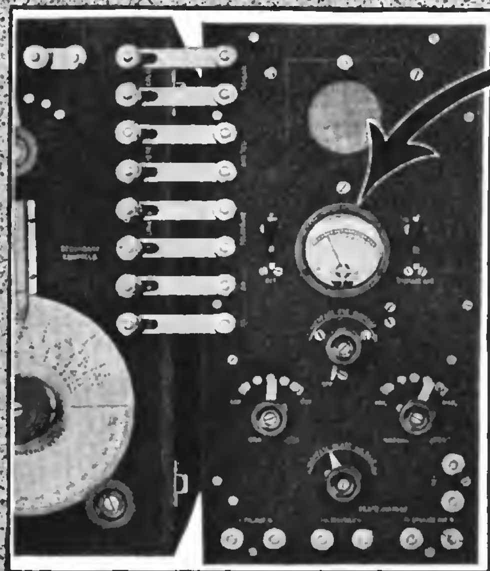

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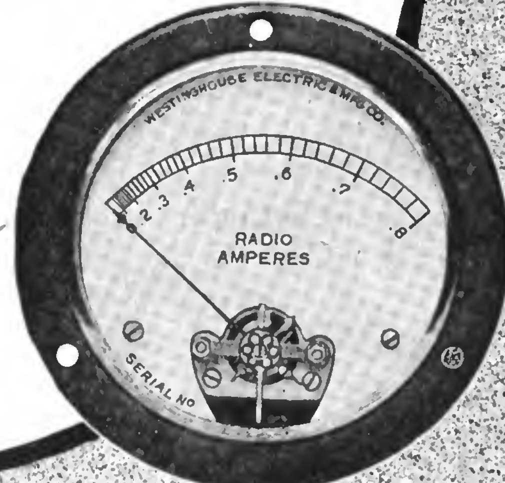

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Vol. 7. No. 3. December, 1919

THE WIRELESS AGE

WORLD WIDE WIRELESS

Wireless to Improve the Aerial Mail Service

THE Aerial Mail Service has developed a most powerful loop radio for communication of mail planes and their guidance through all sorts of weather, even fog. This equipment is now being installed on the new mail planes and landing fields at College Park, Newark, and Bellefonte, Pa.

The radio set has an unusual range for sending. Its possibilities have not been fully determined. Instead of requiring masts from 200 to 500 feet high, the aerial wires are being raised on masts only 23 feet high.

Included in the equipment is a field marking radio device, which enables a pilot to steer exactly for the center of his landing field, although it may be invisible and obscured by clouds, rain, snow or fog.

Fog is the aviator's most dangerous enemy. A majority of crashes and bad landings are caused solely by the inability of the pilot to determine his position and the location of a suitable landing place. A new compass has been devised and put in service on the mail planes, but one of the most important contributions to aviation being worked out by the aerial mail service, with every prospect of success, is a non-magnetic and non-gyroscopic compass which will overcome the unreliability of the magnetic compass caused by vibration and other disturbing features of an airplane in motion.

Greek Ships Equipped With Wireless

GREECE has required radio equipment on all cargo ships of 1,000 or more tons dead weight capacity and on all cargo ships of 1,000 or more tons.

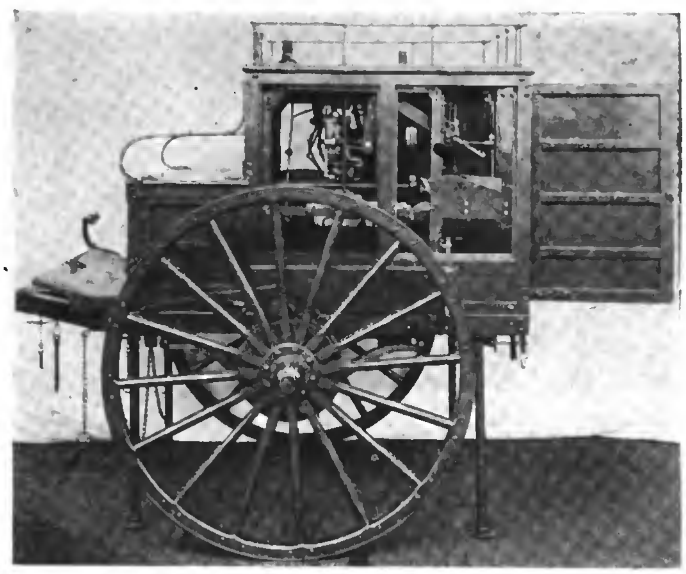
Dr. Alexanderson Reviews Recent Radio Developments

DR. E. F. W. ALEXANDERSON, consulting engineer for the General Electric Company, recently addressed the Schenectady section of the American Institute of Electrical Engineers on radio development.

"As free as the air" is no longer a true simile, Dr. Alexanderson said, because it will soon be as crowded as Fifth Avenue. Only 10,000 to 20,000 meter length wireless waves can be used for inter-oceanic communication. Under present conditions there is room in this range for about 12 stations, of which five are already in use. But, because some of these existing stations have been sending out irregular waves it has been impossible to use the maximum number of stations. By using the new alternator invented by Dr. Alexanderson, it is possible to run seven automobiles, as it were abreast in the space formerly taken by one automobile, because seven messages may be made to keep their own path so that messages can be placed within one per cent of each other, and thus seven times as many stations can be placed within the world as was formerly possible.

It is also possible to send more than one message on the same wave length due to the invention of the "barrage receiver" which cuts out all messages but those from the direction in which one wishes to receive a message. To get these signals pure, a special alternator is driven by a direct alternating current motor, whose speed is kept constant to within 1-10 of 1 per cent by means of special control equipment. The speed with which the messages can be sent has been increased from 20 words a minute to as high as 500, with 100 being a good average.

The result of all of these improvements has been to open up possibilities of communication facilities 125 times greater than those now existing.



Wireless cart of a greatly improved type designed for the Brazilian army by Marconi engineers

Marconi Fund for Italian War Relief

IN connection with the general work of the Italian War Relief Fund of America, a special fund in honor of Marconi is being raised by an electrical committee of which the members are T. C. Martin, chairman, Dr. Elihu Thomson and J. W. Lieb. Considerable success has attended this laudable effort and the Marconi Fund has already reached over $3,500, and a first instalment of $2,500 has been forwarded to Senator Marconi in Rome.

In view of the fact that sore distress in Italy deepens as the winter advances it is believed that many others in the electrical field, as well as outside it, would like to embrace this opportunity presented by the special fund and the Committee therefore renews its plea for aid and co-operation.

Each subscription is accompanied by an autograph card, with the object of assembling all these cards later in a memorial album to be delivered to Mr. Marconi. Such cards can be obtained from the Committee at 29 West 39th street, New York City.

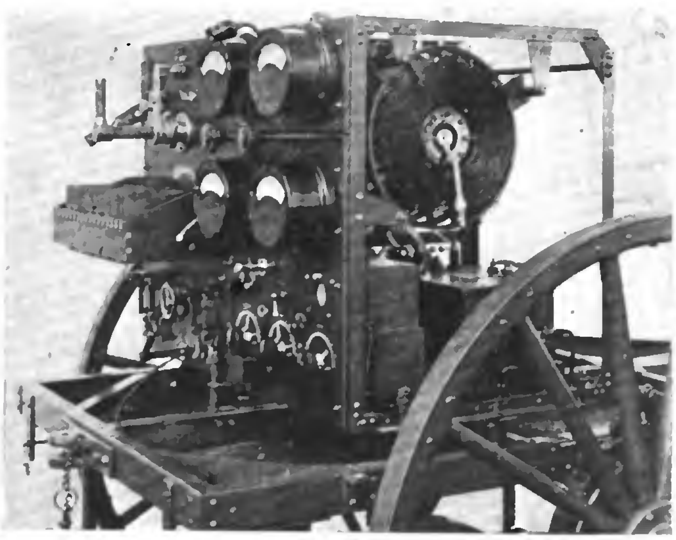
Spanish Station Being Improved to Reach America

IMPROVEMENTS are being made to their important Spanish radio-telegraphic station at Carabanchel. four miles from Madrid, with a view to opening wireless communications with America if possible. This station was used, it is said, to maintain communications with Germany during the war.

Ship Maintains Wireless Communication Across Atlantic

THE distinction of having been the first trans-Atlantic steamship to maintain wireless communication with England during the entire voyage westward has been made by the Cunard Line vessel, Royal George. A long message was received from the Marconi station at Cornwall when the ship was 150 miles from Halifax.

A new valve amplifier, which doubles the distance at which messages can be received, was used on a passenger steamship for the first time. British ships were equipped with the apparatus during the war.



Interior view of the American-made signal corps radio cart equipment designed and built by Marconi for army service in Brazil

Canadian-Japanese Wireless Communication Being Effected

CONSTRUCTION of a high powered wireless station, which when completed will be the most powerful radio depot in the British Empire, is proposed for the vicinity of Vancouver, B. C., by the Canadian Marconi Wireless Company.

The station, which will cost, it is estimated, in the neighborhood of $2,000,000, is designed to handle commercial business between Canada and the Orient, and a station of like power and cost will be built in Japan. Negotiations are being carried on simultaneously with the Governments of Canada and Japan for licenses to construct and operate the two stations necessary to establish direct communication across the Pacific.

Long-Distance Wireless to Ships at Sea

MARCONI'S Wireless Telegraph Company, London, announce that long-distance messages can again be accepted for transmission through their high-power wireless station at Poldhu in Cornwall to ships which are not within range of any other British coast station. The Poldhu station communicates to ships at night only and its range is about 1,500 miles.

American-Japanese Direct Wireless Service to Open

THE new high power Japanese wireless station which will communicate directly with a radio station on the Pacific coast of the United States, will be completed soon. Trial exchange of messages will at once be made with the American station and if satisfactory results are obtained the radio station will be opened to the public for the acceptance of messages.

Construction of the Japanese station was started in 1918 and the total expenditure has been about $360,000. The sending station is located at Tomickamura, a village in the prefecture of Fukushima, about a hundred miles north of Tokio.

Norway's Stavanger High Power Station Opened for Service

THE opening of the high power radio station on the western coast of Norway, near the city of Stavanger has been accomplished and is regarded throughout Norway as marking a new epoch in the communication service between northern Europe and the United States.

The Stavanger radio, which has been ready for business since a short time after the war broke out, but has not been opened until now, is the biggest radio plant in Northern Europe, and was built by the Norwegian Government in co-operation with the Marconi Company. It is expected to handle a great deal of the business correspondence between America and the countries in Northern Europe, as the rate is one-third cheaper than the rates for cables.

Scandinavian commercial interests in the United States have during the war increased to a very large extent, and the radio service is, therefore, greeted with the greatest satisfaction in business circles where correspondence with the United States has been hampered in various ways. The Stavanger station is able to handle unlimited traffic both ways, thereby establishing a new link between the countries of northern Europe and United States.

Consul General of Norway, Christopher Ravn, New York, says: "The long expected and now at last opened action of our wireless will be greeted with joy by all, as the wireless will make Norway's connection with America closer and more reliable, and also forward both countries' business transactions."

Sweden's Karlsborg Station Soon Ready

A STOCKHOLM dispatch received here announces that the Karlsborg radio station, the largest in Sweden, will soon establish regular communication with the United States upon the completion of a test with an American station on the Atlantic coast. The Swedish wireless plant already has established service with many countries, including England and Germany.

England Regulates Aircraft Radio

THE Air Ministry in London makes the following announcement:

The form of license to be granted for the use of wireless to and from aircraft, and the conditions under which such licenses will be granted, are under consideration. In the meantime, pending the issue of the license by the Post Master General, temporary provisional authority for the installation and use of wireless apparatus in aircraft can be obtained, in approved cases, by application to the Secretary of the Post Office.

For the present the wave length suggested for wireless

Telephony is 480 meters. This is the wave length which the existing Air Ministry W/T Stations at present employ for work with aircraft.

For the benefit of designers and others interested it may be said that the Post Master General's license when available, will probably contain provisions to the following effect:

The sending apparatus installed at any aircraft station shall be constructed so as to be capable of using waves of 600 meters interrupted continuous wave, and 900 meters continuous wave; such of the following wave lengths, namely, 220, 300, 450 and 800 meters interrupted continuous wave, and 200-550 meters, 650-950 meters, 200-3000 meters continuous wave may also be used for transmission as are authorized in writing by the Post Master General.

The use of the wave of 600 meters (hereinafter referred to as the "air-craft-ship" wave) shall be confined to the use of the system known as "Interrupted Undamped Wave or Tonic Train," or I.C.W., and the use of 900 meters hereinafter referred to as the "Aircraft Normal Wave," shall be used only for continuous damped waves or wireless telephony.

Should an aircraft station be also fitted with a supplementary installation on long continuous waves, such installation shall be so constructed as to be capable of using the wave length of 2,400 meters.

The range of wave lengths for which the receiving apparatus may be constructed is not limited, but the apparatus must be capable of receiving on 600 meters and 900 meters, and on 2,400 meters when a transmitter working on this latter wave length is installed; it must also be made to embrace any other wave length on which a transmitter installed has been authorized to work.

Australians Plan World Wireless

AN offer has been made to the Australian Government to provide a permanent direct wireless commercial service between Australia and the rest of the world and it is now being negotiated, according to the report submitted by Sir Thomas Hughes, chairman of the Amalgamated Wireless Australasia, Ltd.

Sir Thomas points out that as a result of successful experiments carried out by the managing director of the concern last year, when wireless messages were received in Sydney without relay from the Marconi company's transatlantic station in Wales, a service can be established, including all classes of messages—code, plain language, deferred and press—at one-third less than existing cable rates.

"There has been some delay in this matter," Sir Thomas adds, "because under the wireless telegraphy regulations it is necessary to have a license to erect and operate wireless stations. Negotiations for this license are to be followed up and it is hoped that our Government will decide the matter without undue delay, so that erection of stations can be proceeded with.

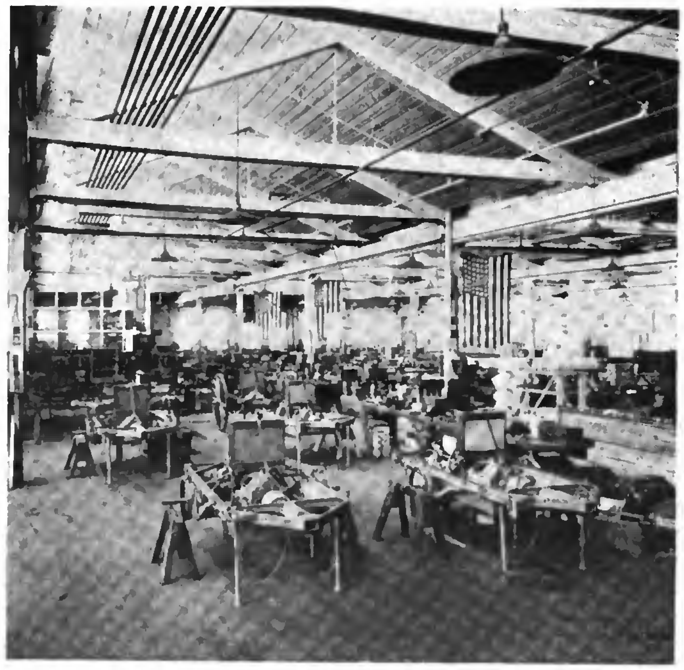
"It would be fatal to attempt to combine a naval service with a commercial service. If a naval service is needed it must be quite distinct, and it should be conducted on purely naval lines. By an attempt to combine the two we would destroy all possibility of efficiency on either side.

"The commercial service will be successful and will be capable of expansion to provide communication with almost every part of the world so long as uniform apparatus and organization are employed at all stations. There is no reason why several stations, if required for different purposes, should not be erected and worked simultaneously in Australia without mutual interference. One great company is reported to have decided to spend about $15,000,000 in improving its connections with Australia."

High Speed Radio Across the Pacific

EXCHANGE of press despatches and commercial messages by radio between California and the Hawaiian Islands, Guam, the Philippines and Japan on a much more extensive scale will become possible when arrangements recently completed by the Government become effective about the first of the year.

Through the use of modern high power, high speed operating equipment it is estimated that it will be possible to transmit and receive more than one hundred thousand words a day between Hawaii and the Philippines; two hundred thousand words a day between San Francisco and San Diego and Hawaii, and about one thousand words a day on a slow speed circuit between Hawaii and Japan. The Hawaii-Japan circuit, operating under an arrangement with the Japanese government, will be available only nine hours a day.



View of the assembly room of the Marconi factory showing the vast quantities of army wireless equipment being manufactured for South America

Rates on press despatches over the new radio circuits will be low, insuring, in the view of officials, a widespread exchange of news between the United States and the Orient and American insular possessions in the Pacific. The rate decided on is six cents a word between California stations and Manila, and three cents a word to Hawaii.

The new arrangement, which will be open to routine commercial business, is expected by officials to aid greatly also in the building up of trade by American interests with Hawaii, Guam and the East.

Mexican Border Patrol Equipped With Wireless

THE Mexican border line within the jurisdiction of the Western Department of the Army is now completely equipped with wireless telephone sending apparatus that will reach an Army airplane at any place along the border.

Colonel J. E. Hemphill, chief signal officer of the Western Department, will inspect the new equipment. Four sending stations were installed, each with a radius of 100 miles. Additional stations and possibly more powerful equipment may be installed as a result of Colonel Hemphill's visit.

NSS—The Annapolis Radio Station

The Arc Radio Transmitter—General Description

(Photos by courtesy of Navy Department)

THE Annapolis radio station is said by the Navy to be the most powerful in the United States. It was constructed by the Navy Department and is one of four high power stations which have been operated under distant control from a main station located in Washington. By means of relay, messages are transmitted through these stations by operators seated at four small tables in the Washington office of the Navy Department. Official messages were handled by Annapolis in large volume during the war, thus relieving the congestion on the trans-oceanic cables.

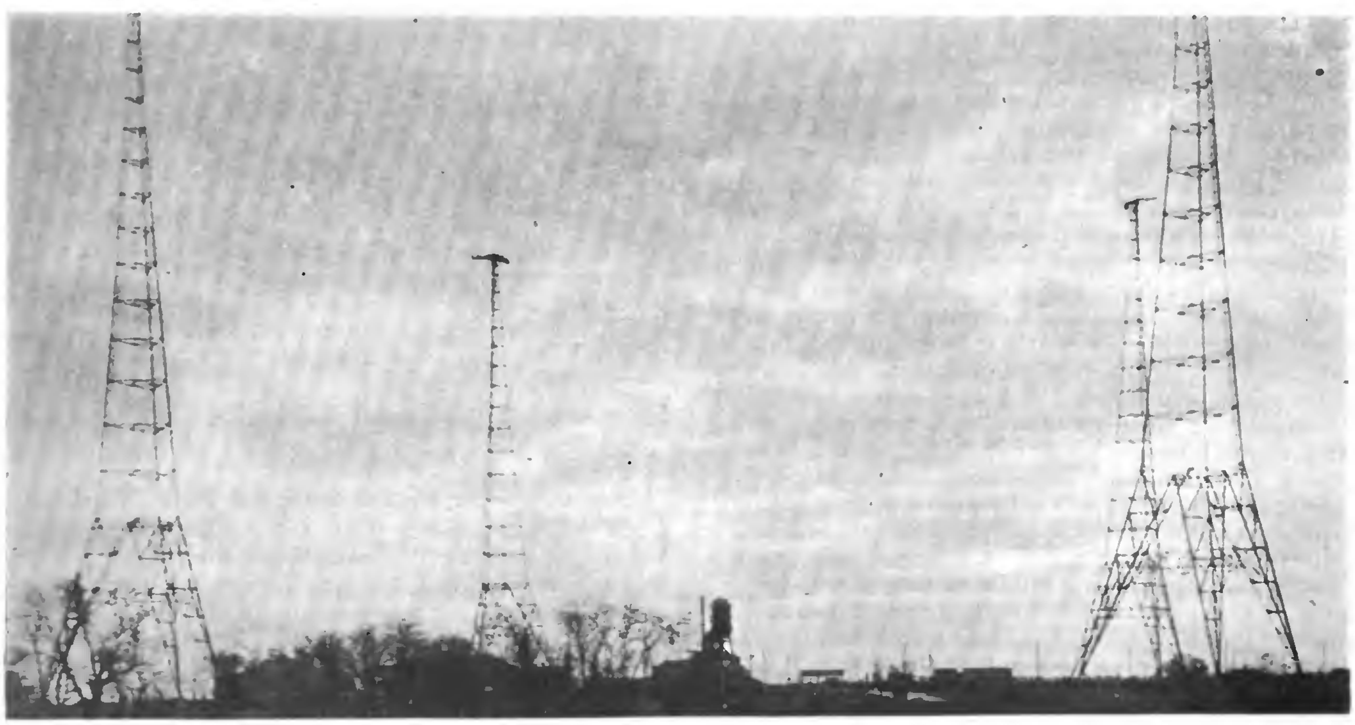
The high power arc transmitter is based upon Poulsen's method of obtaining high frequency oscillations by means of an electric arc burning in an atmosphere containing hydrogen and in a strong transverse magnetic field. The equipment consists of the following main units:

A source of direct current; an arc converter; an antenna loading inductor; an antenna and ground system; a signaling device and auxiliary and control apparatus.

The circuits employed for the set equipped with the coupled compensation method of signaling are outlined in figure 1. The electrodes of the arc converter are enclosed in a water cooled bronze chamber. To this there is supplied either a gas containing hydrogen or a liquid hydrocarbon which decomposes in the intense heat of the arc and releases hydrogen. The arc electrodes are placed between the poles of a strong electromagnet, whose winding is in series in the direct current leads to the arc, and which is therefore energized whenever the arc is in operation. When the arc is started by bringing the electrodes together and then drawing them slowly apart, a direct current arc is formed which burns in an atmosphere containing hydrogen and in a strong transverse magnetic field. This arc is shunted by a circuit containing inductance and capacitance connected in series. The capacitance may be considered as concentrated in the electrostatic capacity of the antenna to earth (the antenna and earth acting as the two plates of a large air condenser). The inductance of the circuit may be considered as concentrated in the antenna loading inductor. Under these conditions there will be superimposed upon the direct current arc a high frequency alternating current which flows in the circuit: arc, loading inductor, antenna, and earth. The arc converts the power supplied by the direct current generator into radio frequency energy with undamped current in the antenna circuit. The choking effect of the arc series field winding prevents the flow of radio frequency current from the arc back into the power machinery.

The frequency of the undamped current in the antenna circuit depends upon the inductance and capacitance of this circuit. The frequency and therefore the wavelength may be altered by changing the value of either the inductance or the capacitance. Since the capacitance is furnished by the antenna and therefore fixed, the inductance is made variable in order to permit changes in wavelength.

When the contacts of the signaling key are closed, the coupled compensation key loop becomes the short-circuited secondary winding of an air core transformer of which the antenna loading inductor is the primary. By virtue of transformer action and mutual inductance between the short-circuited winding and the main loading inductor, the inductance of the antenna circuit is varied and signaling is accomplished by the compensation method. When the signaling key is closed, the emitted wave is of shorter length than it is with the key open. The receiving set is tuned to receive the shorter wave and therefore signals are heard only when the key is closed.



The four towers of Annapolis forming a square within which the aerial wires are strung. A feature of the gigantic antenna is the provision for melting ice from the wires by current supplied from the 400-kw. generators

A general view of the Annapolis station buildings, taken from one of the towers

The Annapolis High Power Radio Station is equipped with duplicate power machinery and duplicate arc converters, permitting practically continuous operation. Power is supplied by a 3-phase, 25-cycle alternating current source at 2,200 volts. The main pieces of equipment may be summarized as follows: Two 400-kw. motor generators, supplying direct current for the arc converters; two oil switches, through which power is supplied to the motor generators; two automatic starting panels for the motor generators; two 3-kw. motor generators supplying 125 v. direct current for operation of control circuits and arc auxiliaries; a switchboard, two arc converters, two benchboards for control of the arc converters, an arc transfer panel, antenna loading inductor, a combined wave changer and send-ground-receive switch, a signaling system and a set of switches for melting ice from the antenna.

Either of the two 400-kw. motor generators may be used to supply direct current to either of the arc converters. When one of these is in use, the other is entirely disconnected. This makes it possible to clean or repair either arc or either motor generator while the other is in operation. The arc transfer panel carries the necessary switches for transferring all the electrical connections from one arc converter to the other. A benchboard located at each arc converter carries all the necessary apparatus for the complete electrical remote control of the station equipment.

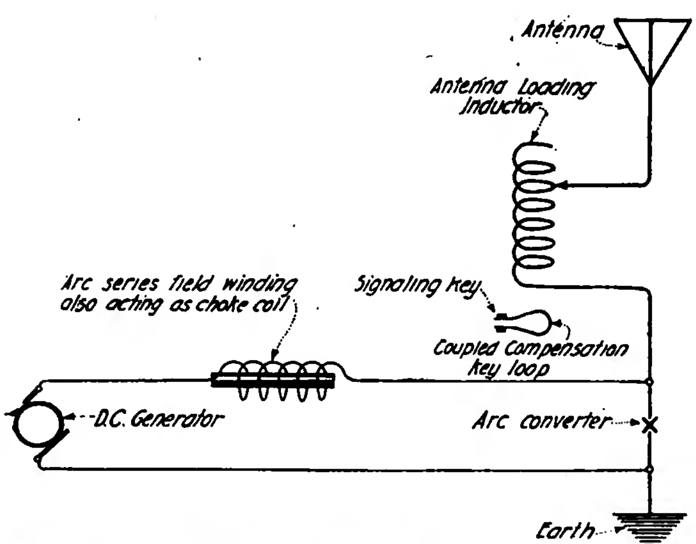
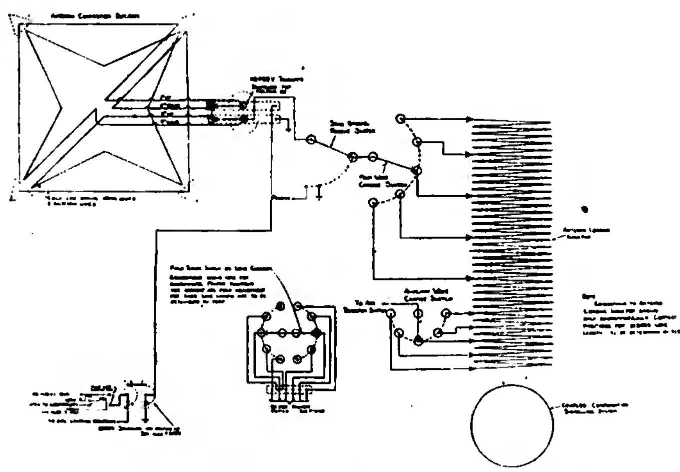


Figure 1—Arc transmitter with coupled compensation method of signaling. The arc flame burns in an atmosphere containing hydrogen and in a transverse magnetic field set up by the arc series field winding



Wiring diagram of the circuits of the Annapolis station

The motors of the 400-kw. motor generators are supplied with power from the 2,200-v., 3-phase, 25-cycle bus through oil switches and automatic starting panels. The oil switches are provided with overload protection and the automatic starting panels have no voltage protection.

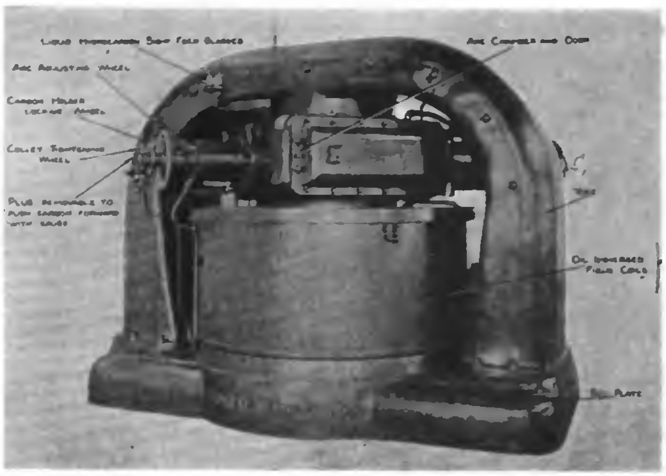
Overload protection for the 400-kw. generators is provided by relays which operate in connection with the contractors through which current is supplied to the arc converters, the contractors serving as circuit breakers between the arc converters and the motor generators.

Either of the 3-kw. motor generators may be used to supply 125-volt direct current for operation of the station control circuits and arc auxiliaries. These machines may be operated in parallel if desired.

For melting ice from the wires of the antenna, the two 400-kw. generators connected in parallel are used. A set of switches is provided for making the necessary connections.

Mounted on the same base with each of the 400-kw., 1,430-volt direct current generators are 600-hp., 2,200-volt, 3-phase, 25-cycle induction motors which drive the power units. Excitation for the generator is provided by a 3-kw., 125-volt overhung exciter. In operation, the voltage of the generator is regulated by an exciter field rheostat upon the arc control benchboard; this rheostat controls the voltage of the exciter, which in turn regulates the voltage of the main generator. Both an exciter field rheostat and a rheostat for the field of the generator itself are provided upon the main switchboard. The induction motor is of the wound rotor type.

Automatic starting panels are provided for the motor generators. These panels have no voltage protection.



The 350-kw. arc converter of the closed magnetic circuit type

Overload protection is provided by relays on the oil switches through which power for the motor generators is supplied. Each starting panel is provided with three push button stations for starting and stopping its motor generator. One push button station is located upon each arc control benchboard, permitting either motor generator to be started or stopped by the arc engineer from his position at either arc. The other push button is located upon the automatic starting panel itself. A transfer switch provides for either local or remote control.

The switchboard for the station consists of ten panels; one for each motor generator oil switch; one for the two 3-kw., 125-volt direct current generators; another is a 6-circuit, 125-volt direct current distribution panel; the fifth is a contactor panel through which current is supplied to the arc converters; then there are two panels for the control of both 400-kw. generators and three panels for the control of the station signaling system.

Each of the panels for the two 400-kw. generators carries two remote manually controlled lever switches through which the generator is connected to the 1430-volt direct-current bus. Each also carries an ammeter and a voltmeter indicating the current and voltage of the generator, an overload relay for opening the proper contactor and disconnecting the generator in case of overload, a generator field rheostat, an exciter field rheostat and an exciter field switch.

The contactor panel carries four contactors for shorting out the arc series starting resistance, and two small contactors for reducing the excitation of the 400-kw. generators whenever either main line contactor is opened by its overload relay. Two high voltage main line contactors are mounted behind the switchboard upon a pipe frame. One of these acts as an arc main line contactor and serves to connect the arc to the positive 1430-volt direct-current bus. The other serves as a bus contactor and connects together the positive switches of the two 400-kw. generators. The positive bus contactor serves to protect either motor generator in case the main line switches of the other are closed when the generator is not running, or in case an attempt is made to connect the two generators in parallel without equalizing their voltage.

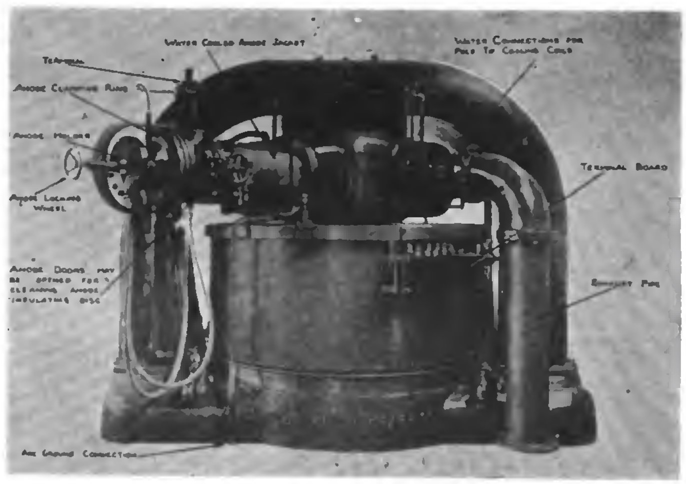
The arc main line contactor and the four arc starting resistance contactors are operated by the arc drum controller upon the benchboard. A switch on the arc transfer panel transfers the control of these contractors to the benchboard of the arc which is in use. In starting the arc, the controller first closes the arc main line contactor and then the four starting resistance contactors one at a time.

The two small contactors for the generator fields are both normally closed at all times and are opened only in case of an overload upon the generator whose fields they supply. When either of these opens, resistance is inserted in the field circuit of the generator, thereby reducing its voltage.

The two arc converters are exactly alike. Each has a normal rating of 350 kilowatts, a maximum rating of 400 amperes radio frequency current in the antenna, and a maximum direct current voltage of 1500.

The 350-kw. arc converter is of the closed magnetic circuit type. The magnetic circuit consists of a bedplate, a yoke, a lower pole, and an upper pole. The field winding is placed around the lower pole and the magnetic circuit is closed through the bedplate and yoke. The pole tips are designed to give maximum flux in the air gap between them.

The field winding consists of 15 flat pancake coils which are wound with copper strip. These are immersed in oil, giving good insulation and facilitating cooling. The six upper coils serve as a choke to prevent the flow of radio frequency current from the arc into the direct current power circuits. The remaining nine coils are used for adjustment of the strength of the magnetic field, and are provided with a series of connections by means of which any or all of them may be short-circuited. When the arc is operating on relatively short waves, a strong magnetic field is required and all of the coils are needed. On the longer waves better operation is obtained with a weaker magnetic field, and a portion of the winding must be short-circuited. A switch is provided on the wave



View of the reverse side of the Annapolis arc converter

changer for accomplishing this, and after the station is once adjusted for a given set of wave lengths no further adjustments are necessary during ordinary operation. The wave changer automatically tunes or adjusts the magnetic field to the proper strength for the wave length in use.

The field coils are enclosed in a steel tank, which is filled with transformer oil. The cover of this tank is made of brass in order that it may not furnish a return circuit for the flux of the magnet pole.

The heat storage capacity of the coils, oil and tank is sufficient for full load operation of the arc for several hours. For continuous operation, a motor driven pump is provided to circulate the oil through water cooled coils placed in a concrete pit outside the building. The cooling water from the arc runs through this pit. It is still relatively cool when it leaves the arc and serves to remove heat from the oil.

The arc chamber is a water cooled bronze casting provided with a door on one side. This may be unbolted and opened for inspecting and cleaning the interior. The anode and cathode are bolted to opposite sides of the chamber.

The hydrogen content of the atmosphere in the chamber is provided either by city gas or by liquid hydrocarbon

The two arc converter machines installed in Annapolis station, showing the benchboards from which the engineer controls the whole station

fed drop by drop into the arc. Two tanks, one for kerosene and one for alcohol, are connected with a sight feed drip cup mounted on the yoke of the arc above the chamber. From these cups a common feed pipe leads into the chamber through the upper pole tip. The flow is controlled by needle valves mounted on the side of the arc yolk within easy reach of the operator. The hydrocarbon supply is turned on by two small valves operated by the arc drum controller when it is advanced to position 2.

The cathode or negative electrode of the arc consists of a carbon in a holder, a water cooled sheath which surrounds the holder and removes the heat transmitted to it by the carbon, a mechanism for slowly rotating the carbon and its holder and a means of adjusting the length of the arc gap between the carbon and the copper tip of the anode. The carbon is held in the holder by a split taper collet which is tightened by a small hand wheel called the collet tightening wheel. This construction insures good electrical contact between the carbon and the holder and provides an easy means of making the projecting carbon any desired length. The sheath forms a water jacketed bearing surface within which the holder is rotated. The mechanism for rotating and adjusting the carbon are built as parts of the sheath. A sleeve with jaws which engage similar jaws on the carbon holder is rotated by enclosed worm gears. This sleeve is moved axially to adjust the arc gap by a screw and hand wheel, as shown in an accompanying photograph.

Water for cooling the sheath is supplied by a ¾-inch pipe. After being circulated in the sheath, it goes to the water cooled jacket, which acts as an extension of the chamber and helps keep the cathode cool.

The carbon holder is held in position and locked to the sleeve by a locking wheel and is made removable for renewing the carbon. The carbon may be lengthened without removing the holder from the sheath by unscrewing the plug at the end of the holder, loosening the collet and pushing the carbon forward with the gauge rod provided for this purpose. The carbon may be shortened by simply loosening the collet and turning the adjusting wheel to the right, thereby forcing the carbon against the anode tip and pushing it back in the holder.

The carbon is rotated through enclosed double reduction worm gears by a ¼-h.p., 115-volt direct current motor.

The anode or positive electrode of the arc converter consists of a metal tube with a narrow water cooled copper tip which is renewable; the flame of the arc burns between this copper tip and the carbon electrode of the cathode.

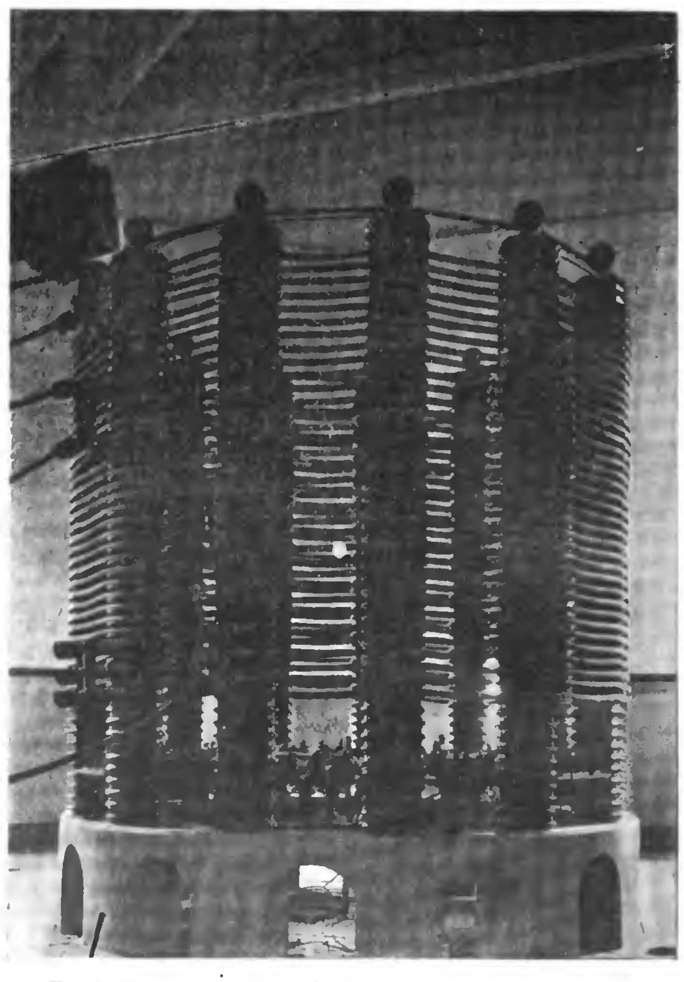
The anode holder is insulated from the frame of the arc converter by a round insulating disc of ebony asbestos. This is placed at the outer end of a water cooled jacket which forms an extension of the chamber. The relatively cool gases in this jacket protect the insulating disc from the heat of the arc flame. The cooling water for the anode is carried to and from it by rubber hose.

It is important that the arc chamber should not be opened after the arc has been in operation until plenty of time has been allowed for the carbon to cool, the chamber is full of combustible gases, which will be ignited by the hot carbon if air is admitted. Two electric Danger signs mounted upon the arc converter which are illuminated whenever the main line contactor is closed and remain lighted after the arc has been shut down until sufficient time has elapsed for the carbon to cool. The lights are controlled by an automatic timing relay.

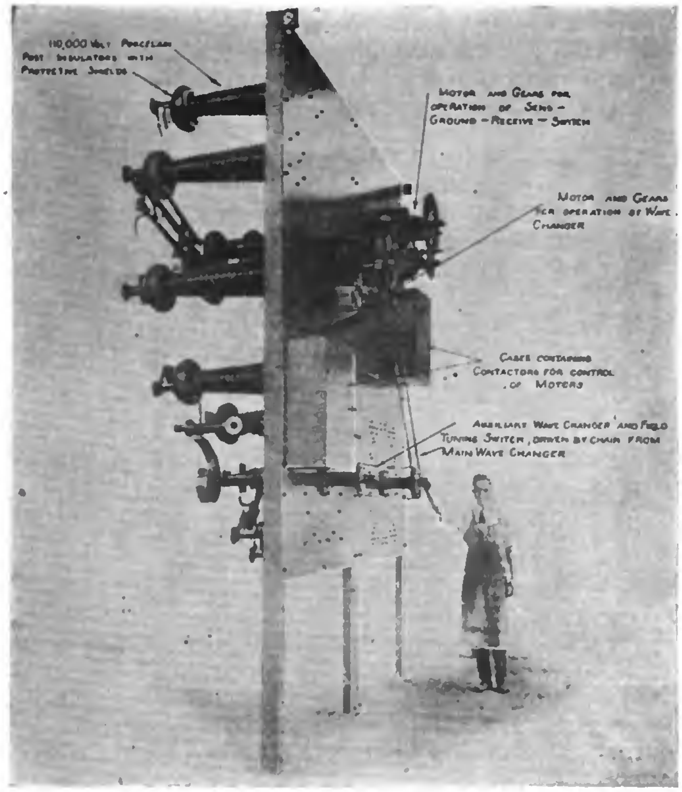
A benchboard located at each arc converter enables the arc engineer to control the whole station from his position at the arc.

The antenna loading inductor is built in the form of a large single layer helix wound with special radio frequency cable upon a series of columns which are made of porcelain rings. Taps are provided for connecting any desired number of turns of this coil in the antenna circuit. Cables connect the proper taps on this loading inductor to the wave changer, which makes the necessary adjustments for five different wavelengths.

The combined wave changer and send-ground-receive switch is a voltage switchboard built with steel panels and



The gigantic helix of the Navy's most powerful wireless station



Combined wave changer and send-receive ground switch with remote electrical control

porcelain post insulators. The send-ground-receive switch occupies one of the four steel panels which compose the board. The main and auxiliary wave changer switches occupy the other three panels. Both the wave changer and the send-ground-receive switch are of the electrical remote control type, and are controlled by drum controllers on the arc benchboard. Each is driven by a ½ H. P., 115-volt, D. C. motor, through double reduction spur gears. Each motor is controlled through contactors by an automatic switch which is inter-connected with the corresponding drum controller.

The wave changer may be set for any one of five wavelengths by turning its controller on the benchboard to the proper position. Similarly, the send-ground-receive switch may be set upon any of its three positions by placing its controller on the desired notch.

For each of its five positions, the wave changer connects in the antenna circuit the proper number of turns of the antenna loading inductor to give the desired wavelength. It also tunes or adjusts the arc magnetic field to give maximum antenna current and steadiest operation of the arc for each of the five wavelengths.

The main switch arm of the wave changer is mounted upon 110,000-volt. porcelain post insulators, and is operated directly by the motor and gears. The auxiliary switch arms are driven by roller chains which connect them with the gear mechanism of the main switch. In operation, the switch arm on the wave changer short-circuits a portion of the arc field winding to give the proper field strength.

In the Annapolis station the coupled compensation method of signaling is employed. A number of relay keys are connected with a loop system which is inductively coupled with the main antenna loading inductor. Two sets of control relays are provided for the operation of the relay keys. One set is used for high speed sending, and the other set for hand sending. For high speed sending, current for the operation of the relay keys is provided by a special 15 kw., 575-volt generator which is driven by a 220-volt induction motor. For hand sending, 125-volt direct current is used. This is furnished by the 3 kw. motor generators which supply current for the station control circuits and arc auxiliaries.

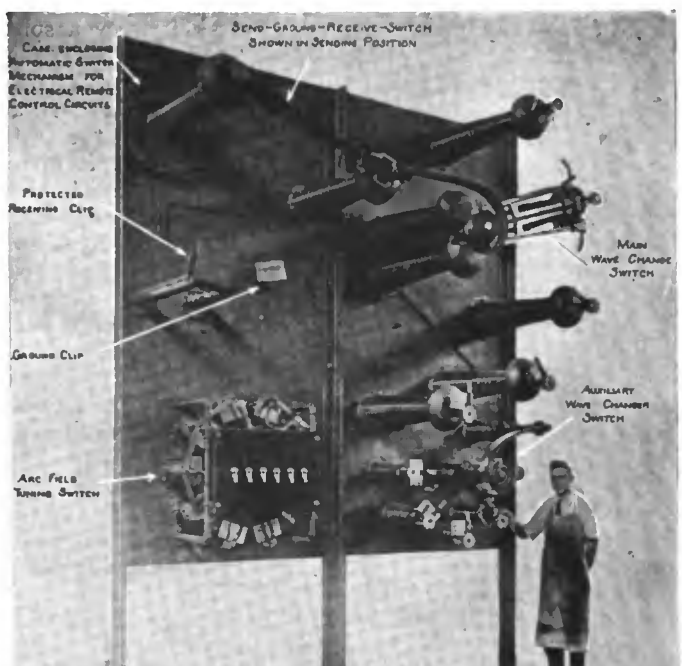
For high speed sending, all of the switches on the transfer panel are thrown toward "high speed sending." The relay keys are then operated in groups of three by 575-volt direct current. Each group of three keys is controlled by one control relay.

The control relays are operated as a group by a master relay using 125-volt direct current. A rheostat behind the switchboard serves to regulate the current which they receive to the value necessary to give the desired speed.

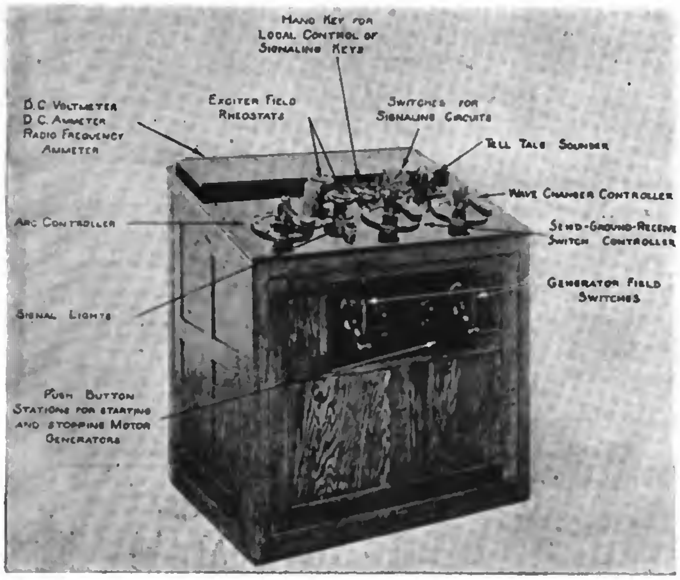
The current which is supplied to the relay keys themselves is regulated by adjusting the spring tension and magnetic air gap of the control relays. A signal light is provided for each control relay, and therefore for each group of three keys. When the keys are operating normally, this signal light burns dimly. In case one of the control relays sticks closed, the signal light burns brightly, indicating that that particular group of three keys is receiving excessive current and its control relay is then adjusted immediately. The signal light goes out in case the control relay sticks open, thereby indicating that that particular group of three keys is not operating.

For hand sending, all of the switches on the relay key transfer panel are thrown toward "hand sending." All the relay keys are then connected in two main groups, each group being operated by one control relay. The relay keys are then operated by 125-volt direct current. This is supplied through a small contactor which closes whenever the main line contactors are closed. This arrangement prevents current being left in the relay key circuits when the arc is not in use. The two control relays used for hand sending are operated by the same master relay which operates the larger group of control relays used for high speed sending.

Cooling water is supplied to the arc converter through a valve operated by the arc drum controller. This valve is opened on the first two notches of the controller and is therefore turned on whenever the controller is advanced for starting the arc.



Send-receive ground switch shown in sending position



Arc control benchboard

The antenna ice melting equipment, by means of which ice may be melted from the wires of the antenna, is operated by a series of switches and utilizes current from the two 400 kw. generators.

During normal operation of the station two switches connect all four of the cables leading down from the antenna loading inductor and thence to the arc. All four of the antenna cables are then connected in parallel, and carry approximately equal amounts of radio frequency current. When it is desired to melt ice from the wires of the antenna, the switches are thrown over to the "ice melting" position, and the four antenna cables are then connected in series. The connections in the antenna itself are such that when the switches are in "ice melting" postion, current will flow through all the various wires of the antenna, heating them and causing the ice to melt.

Circular shields with a large radius of curvature are provided for making connections through the holes in the plate glass antenna entrance windows. The shields furnish charging currents to the glass and prevent corona at high voltage.

The Design of Multi-Stage Vacuum Tube Receiving Circuits

By Lieut. J. Scott-Taggart, M.C.,

Membre de la Société Française des Electriciens

THE present article is intended as an introduction to modern methods of connecting vacuum tubes in cascade for the purpose of receiving wireless signals. Few details regarding such circuits, which are of paramount interest to those engaged in wireless work have been given, and it is proposed to describe some typical practical circuits which have been taken from a complete volume on vacuum tubes by the present author and which will shortly be published by Wireless Press, Ltd., Henrietta Street, London.

plate battery. Another feature of the amplifier design is that all the vacuum tubes used as amplifiers are adjusted to the same operating point. The plates of all the amplifying tubes are given a fixed voltage which is variable if desired. A single rheostat (of about 5 ohms resistance) serves to adjust the filament currents of all the valves simultaneously. Likewise, since all the tubes are of identical construction and carry out the same functions, a single potentiometer to control simultaneously the grid potentials of all the amplifying vacuum tubes

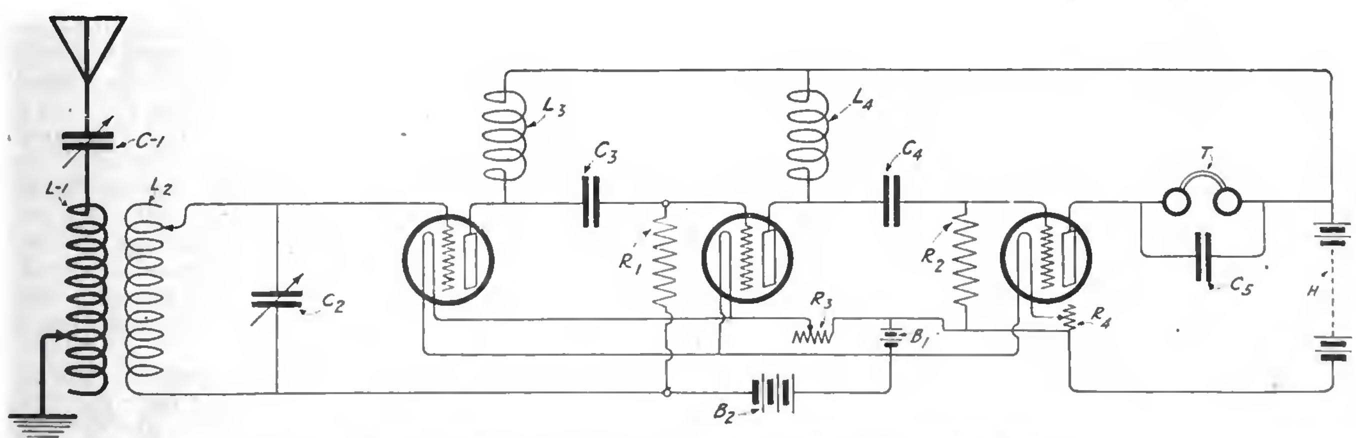


Figure 1—A three-stage amplifier with aperiodic auto-transformer coupling arrangement

All the following circuits possess one common filament battery and one plate battery. A single plate battery may be used provided that its resistance is negligible. The stipulation is that there shall be no resistance common to the plate circuits of several tubes. The voltage applied to the plates of the vacuum tubes is consequently best varied by means of tappings off the battery, and not by means of a variable high resistance in series with the

can be used. This potential is preferably negative and in the neighborhood of 2 volts.

Cascade amplifiers may roughly be divided into four classes.

(1) High frequency amplifier-detectors, which use several tubes as oscillation amplifiers and a final tube as a detector.

(2) Amplifiers similar to the above, in which the de-

tector valve is followed by one or more stages of low-frequency amplification.

(3) Amplifiers in which the first vacuum valve acts as a detector, the succeeding tubes operating as low-frequency amplifiers.

(4) Amplifiers in which the oscillations are magnified by a number of tubes and then rectified, the rectified pulses being now led back to one of the preceding tubes and re-amplified by the system at low frequency.

Each of the above four types may be provided with arrangements for producing regenerative amplification or self-oscillation (the latter for continuous-wave reception). Here again the amplifiers may be modified by different methods of obtaining regeneration such as:

(1) The use of magnetic couplings, direct or indirect

(2) The use of capacitative coupling.

(3) Whether it is for general reception on a wide range of wavelengths or only on one wavelength.

(4) Whether the apparatus is to allow of many adjustments or as few as possible.

(5) Whether it is for experimental or commercial work.

(6) The degree of amplification desired.

(7) Whether loud signals or weaker signals with less interference are desired.

(8) Whether the circuit is intended for the reception of weak or strong signals.

(9) Whether the circuit is to be used for the reception of continuous waves or not.

(10) Whether the amplifier is to be used for the reception of short waves or long waves.

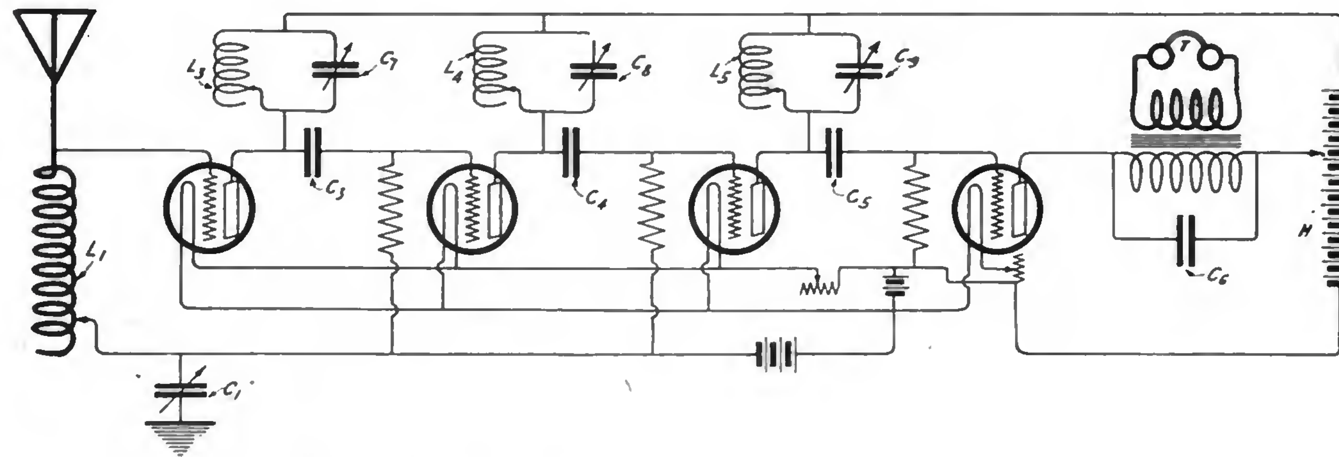


Figure 2—Four-stage amplifier-detector with tuned intermediary auto-transformer

(3) The use of resistance or conductive coupling.

Another matter of utmost importance in the design of multi-stage amplifiers is the means to be adopted for coupling the output circuit of one tube to the input circuit of the next. One or other of the following methods is usually used:

1. (a) Aperiodic air-core auto-transformers.
   (b) Tuned air-core auto-transformers.
   (c) Air-core auto transformers with aperiodic plate circuit and tuned grid circuit (or vice versa).
2. (a) Aperiodic air-core oscillation transformers.
   (b) Oscillation transformers having aperiodic plate circuit and tuned grid circuit (or vice versa).
   (c) Completely tuned air-core oscillation transformers.
3. Use of coupling resistances.
4. Employment of impedance coil couplings.
5. (a) Aperiodic iron-core auto-transformers of fixed ratio.
   (b) Similar transformers with step-up ratio.
   (c) Above transformers resonated to give frequencies.
6. (a) Aperiodic step-up iron core transformers.
   (b) Tuned iron-core transformers for low frequency amplification.
7. Iron-core transformers as described in classes 5 and 6, but designed for high frequencies.

Each of these systems of couplings has its advantages and disadvantages. The complicated circuit, while giving excellent results in the hands of an expert, is obviously unsuitable for use by the average operator. The design of amplifier chosen will depend on the following conditions:

(1) Whether the apparatus is to be handled by an expert or an inexperienced operator.

(2) Whether it is to be portable or not.

These questions must first be answered before commencing the design of a multi-stage vacuum tube receiving circuit. It is now proposed to describe typical amplifiers of each of the seven classes and to show some of the various modifications which are possible. Each of the above ten questions should be applied to the circuit under discussion. By doing this a suitable circuit is evolved having just those characteristics and modifications which are necessary to make it carry out the duties required of it. Figure 1 shows a three-stage amplifier having aperiodic inductances L-3 and L-4 connected as shown. The received oscillations are amplified by the first tube, the magnified high frequency current flowing via L-3 and the plate battery H. The oscillating potentials at the foot of L-3 are communicated to the grid of the second tube through the condenser C-3 of about .0003 mfd. capacity. If the condenser C-3 was omitted, the potential of H would give the grid of the second vacuum tube a high and undesirable positive potential. The second vacuum tube now amplifies the oscillations a second time, the magnified potentials at the foot of L-4 being communicated through C-4 to the grid of the third tube, which is arranged to act as a detector, the telephone T being connected in the plate circuit.

The first two tubes act as oscillation amplifiers and are arranged to work on straight portions of their plate and grid current curves. Their grid potentials are the same and are given a suitable negative value by means of the battery H-2, consisting of one or two cells. The second grid receives its potential through the resistance R-1 of from 2 to 5 megohms. Since the grid is negative there is practically no grid current. Consequently there is no fall in potential across R-1 in spite of its high resistance. This use of the resistance R-1 and battery B-2 is very useful in all amplifiers using auto-transformer, resistance or impedance couplings.

The rheostat R-3 (of about 5 ohms resistance) is used to vary the current supplied by the accumulator B-1 to the filaments of the two amplifying tubes. A separate rheostat R-4 is used to vary the filament current of the detector valve which requires a different adjustment to that of the amplifying tubes. The resistance R-2, having about the same value as R-1, acts in a manner similar to the leak across a leaky grid condenser. It prevents an excessive negative charge from building up on the grid of the third valve. The foot of R-2 might, if desired, be connected to the negative side of B-1. If instead of desiring to use grid current rectification it were desired to work on one of the bends of the plate current curve it would be possible to include a potentiometer between the foot of R-2 and the battery B-1. A suitable operating point on the saturation bend may, however, be most easily obtained in a circuit similar to figure 1 by adjusting R-4. (J. Scott-Taggart "On Valve Characteristic Curves and Their Application in Radiotelegraphy," WIRELESS WORLD, Sept., 1918).

The inductances L-3 and L-4 should have a natural wavelength less than the wavelength to be received. If the range of wavelengths to be received is wide, tappings may be taken from L-3 and L-4.

Figure 2 shows a modification of the figure 1 circuit. Four vacuum tubes are shown in use. The first three act as amplifiers and the last as a detector. The intermediary inductances L-3, L-4 and L-5 are tuned by the aid of variable condensers C-7, C-8 and C-9. The circuit as it stands is capable of much finer tuning than figure 1, each plate oscillatory circuit requiring to be tuned to the incoming waves, whereas the figure 1 circuit will respond to a wide range of wavelengths without adjustments of the amplifier circuits. In the plate circuit of the last valve is the primary of the step-down telephone transformer. Across this winding is connected a condenser C-6, which, like C-5 of figure 1, allows the passage of the comparatively strong high frequency component of the rectified current in the plate circuit without injuring the windings. Another feature is the use of a separate tapping, which allows the plate voltage of the detector valve to be independently regulated.

(To be continued.)

Some Recent Developments in Radio Transmitters

By Morton W. Sterns

DUE to the impetus of the war many and various were the types of transmitters that were developed. Of these many have been described in current periodicals, but nothing at all has been published, to the writer's knowledge, on a very interesting phase of the subject, viz.: the utilization of direct current for transmission without the use of vacuum tubes, Chaffee gaps, arcs, etc.

As is well known, at the outbreak of the war the government asked for samples of transmitters of various kinds, mainly for aeroplane use, giving only very general specifications as to space, weight, antenna capacity, etc., and allowing the various manufacturers to use their own judgment as to type. From the original samples thus produced the present types were developed, which incorporate also the changes found advisable in service.

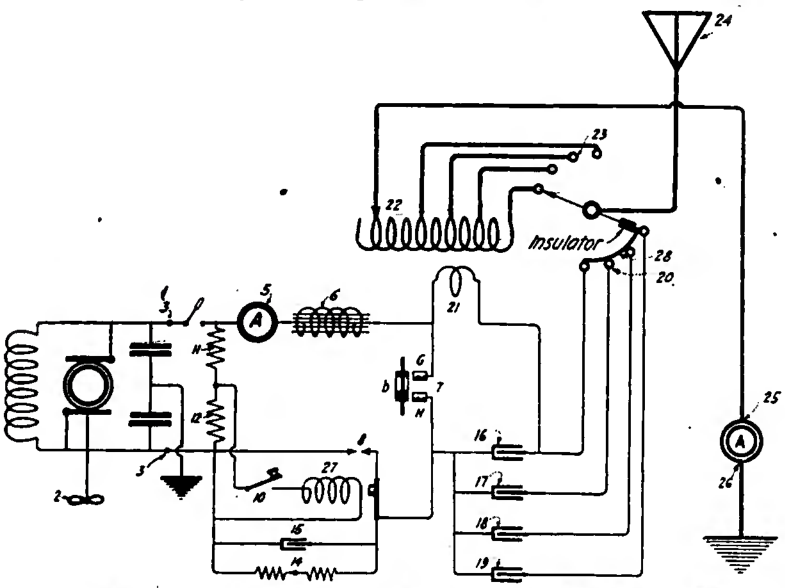


Figure 1—Wiring diagram for airplane radio buzzer set design by Sperry Gyroscope Co.

Among the sets submitted was a direct current buzzer set manufactured by the Sperry Gyroscope Company, illustrated in figure 3. From this original sample a rather complete line of buzzer transmitters of various powers and for various conditions were developed.

It may not be amiss to look into the advantages of the buzzer type transmitter. First, it is very simple in construction and is easy to manipulate; second, it eliminates the use of high potentials, thus simplifying insulation problems; third, it is fairly efficient—ranking quite well with other types of sets; fourth, its extreme simplicity makes it very easy to understand and operate.

A schematic wiring diagram of the buzzer transmitter in its simplest form is shown in figure 2.

To follow its operation imagine the key to be depressed, the current will then flow from the direct current source through the choke coil into the movable spring D, to the stationary contact C and thence back to the source. When current traverses the choke coil winding it becomes a powerful magnet and attracts the iron armature on the movable spring D, which moves over toward the magnet core and opens the circuit at the contacts C, D. Immediately the current ceases to flow in the electro-magnet (choke coil), and, since the magnet

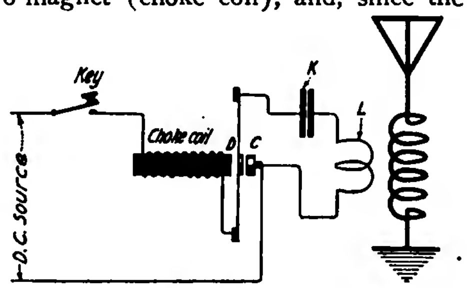


Figure 2—Schematic wiring diagram of the buzzer transmitter

no longer attracts the armature of D, the movable spring D returns to its normal position, due to the bending force it was under. This immediately causes current to flow again in the magnet winding, and the same cycle of operation takes place as long as the key remains depressed.

When the magnet coil causes the circuit to be broken at the contacts C, D, an excessive instantaneous voltage is produced across the gap C, D, due to the inductive kick of the choke coil, and this voltage charges the condenser K in the high frequency circuit CDKL, which in turn discharges across the now open gap and sets up highly damped oscillations in the circuit CDKL and impulses the closely coupled antenna circuit into oscillation at whatever frequency it happens to be tuned to.

If L be the inductance of the coil in henries and I be the current flowing through the coil in amperes, then the voltage across the coil at the instant the current is broken is equal $\frac{1}{2} LI^2$, and this voltage is also effective across the gap CD and tends to charge the condenser K.

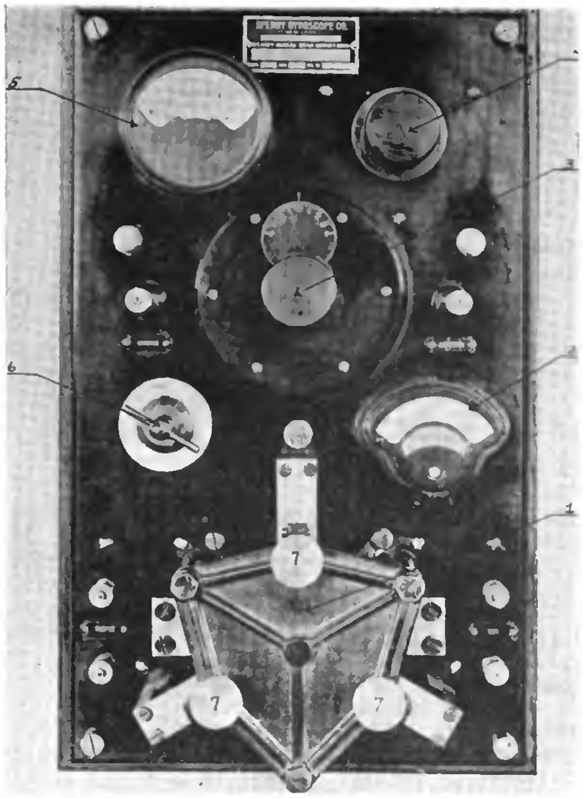


Figure 3—Front view of 500-watt, 500-volt buzzer transmitter

Since the energy stored in the condenser is equal to ½ CE^2 it is seen that in order to get maximum output we must use the largest capacity condenser consistent with the wavelength. Using a large capacity condenser fulfills two necessary conditions simultaneously, viz., the elimination of sparking at the contacts C, D and causing a preponderance of capacity with only enough inductance in the high frequency circuit CDKL to efficiently transfer the energy from primary to secondary. This is the ideal condition for an oscillation circuit to rapidly damp out after one or two oscillations and impulse a secondary circuit.

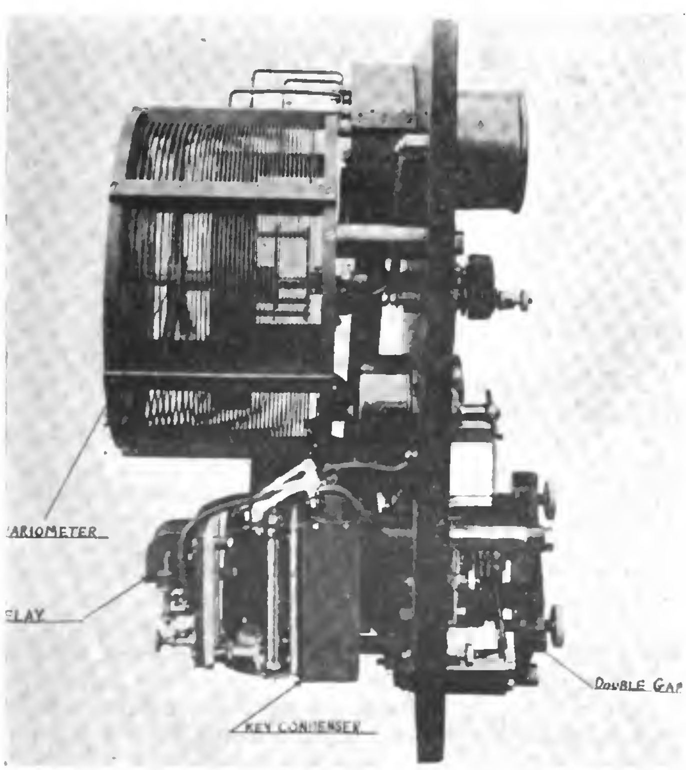


Figure 4—Side view of figure 3, showing arrangement of instruments

The radiation produced by the larger type sets, to be described and illustrated in figure 3, have a rather low note and the wave characteristic is somewhat between a pure undamped wave and a damped wave, so that a receiver of either the usual crystal type or the heterodyne receiver could not get the maximum audibility from its signals. However, since the radiation was good, and since excess of energy existed to work with this slight disadvantage, it was felt it could be overcome. After some experimentation I discovered that by placing a rotary chopper on the antenna circuit I could modulate the emitted envelope and produce notes of absolute purity which, while decreasing the radiation slightly, greatly increased the working range due to its absolute tone characteristics. The note could be varied at the will of the operator by simply changing the speed of the chopper motor, which controlled the rapidity of interruption. It is interesting to note that the use of the chopper was not needed on low power sets.

The oscillations produced by this type of set are almost of the impact excitation type, and to change the wavelength of the emitted wave for ranges of a few hundred meters, the primary may be set at one wave and

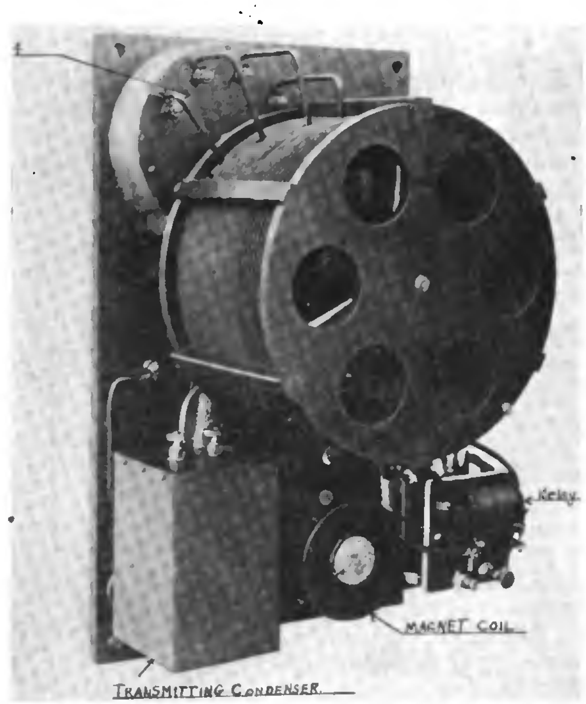


Figure 5—Rear view of figure 3, showing the helix, relay key, coil and condenser

the inductance in the open circuit may be varied. For large ranges of wavelength, such as is shown in figure 10, where seven wavelengths varying from 600 to 2,400 meters are used, it is policy to vary the capacity of the primary condenser for every two or three wavelengths, although the maximum radiation is seldom produced when the primary and secondary circuits are in tune.

A brief description of the three standard type buzzer transmitters manufactured by the Sperry Gyroscope Company will now be given.

Referring to figure 10 we see a very small type 75-watt set which operates on 110 volts D. C. Its dimensions are approximately 7 x 12 x 5 inches, and the whole outfit can be readily held in one hand. It was originally designed for airplane use, but eventually an even more compact set of the same type was developed and these first sets were installed on small boats.

On a submarine chaser antenna these sets give a radiation of about 2 amperes on all wave lengths. On a 250-foot trailing wire from an airplane a radiation of 1.25

amperes was obtained and a very strong signal was obtained at a distance of 18 miles.

Referring to figure 10, the wave changer appears at the top of the panel. This wave changer allows a selection of seven wavelengths between 600 and 2,400 meters to be rapidly made. Under the bakelite button at the switch centre is a fan contact which automatically connects in various values of the primary condenser as explained above. Underneath is the antenna and ground binding posts and the hot wire radiation ammeter. Below the ammeter is the buzzer gap which is constructed somewhat after the fashion described in my article in the July WIRELESS AGE. The arrow points to the vibrating contact. The top of the stationary contact can be seen extending from its casting and shows the method of adjustment. At the bottom of the panel are the terminals for the supply and key. In the rear of the panel behind the wave changer are mounted the pan-cake oscillation transformers wound with large size litzendraht and tapped for the various wavelengths. The primary consists of about three turns. The key and oscillation condensers are mounted in one case behind the ammeter and naturally the magnet coil is mounted behind the gap casting.

The front view of the original type of buzzer transmitter submitted to the government at the outbreak of war is shown in figure 3. This type of equipment was manufactured in large quantities and furnished to both the Navy and Signal Corps. It is a 500-watt 500-volt set and furnishes a radiation of 4.5 to 5 amperes on a 300-foot trailing antenna as used on airplanes.

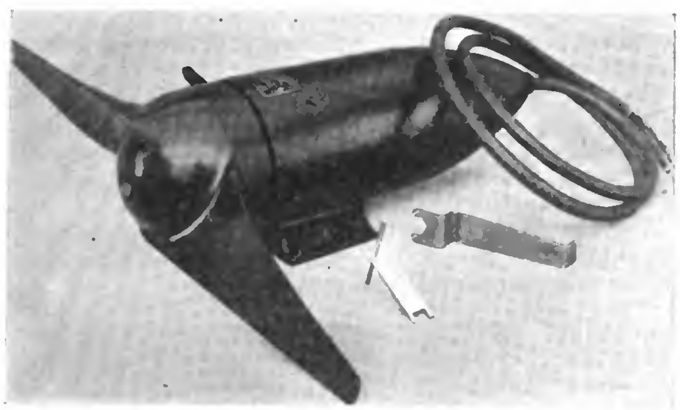


Figure 6—Wind driven generator equipped with self-regulating propeller blades

While these sets were designed primarily for airplane use they were eventually used for ground telegraphy and on training planes, being superseded by more compact types for airplane use.

Referring to figure 3, the hot wire radiation is shown at 5, while 4 shows the wave changer which has the four standard navy waves, namely, 300-378-476-600 meters. Number 3 indicates the antenna variometer adjustment, which allows the wave to be corrected for changes in antenna capacity due to flying low or having part of the antenna reeled in. The scale above the adjustment knob shows the number of turns added or subtracted from the antenna circuit. A total variation of 25 meters is possible with the variometer. Another view of the variometer and a side view of the set is shown in figure 4.

On either side of the variometer handle are mounted the insulated binding posts for antenna and ground.

The main switch which turns the power on or off is shown at 6, while number 2 represents the direct current ammeter in the power circuit.

Number one is the gap, showing the adjusting screws 7. On either side of the gap are the supply and key terminals.

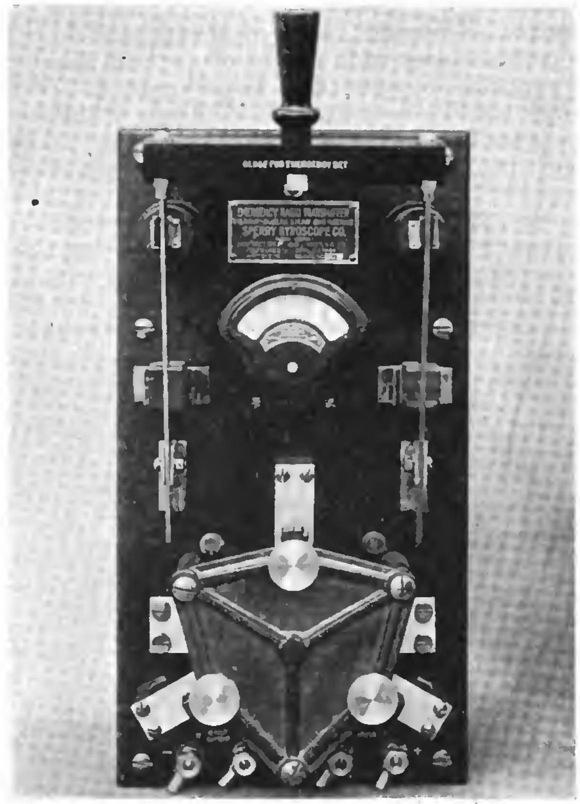


Figure 7—Front view of the emergency radio transmitter

Figures 4 and 5 show a side and three quarter view of the set and give details of the various condensers, helix and relay key.

Figure 6 shows the 500-watt 500-volt wind driven generator furnished with the set, also the necessary wrenches for dissembling the generator. This illustration shows the original type fan with a manually operated brake to approximate constant speed regardless of the maneuvers of the airplane. As is well known, if the plane takes a nose dive the generator speeds up and develops such an excessive potential that damage may ensue. For this reason most of the sets are equipped with self-regulating fans. When the speed of the airplane increases and consequently the speed of the generator, a centrifugal regu-

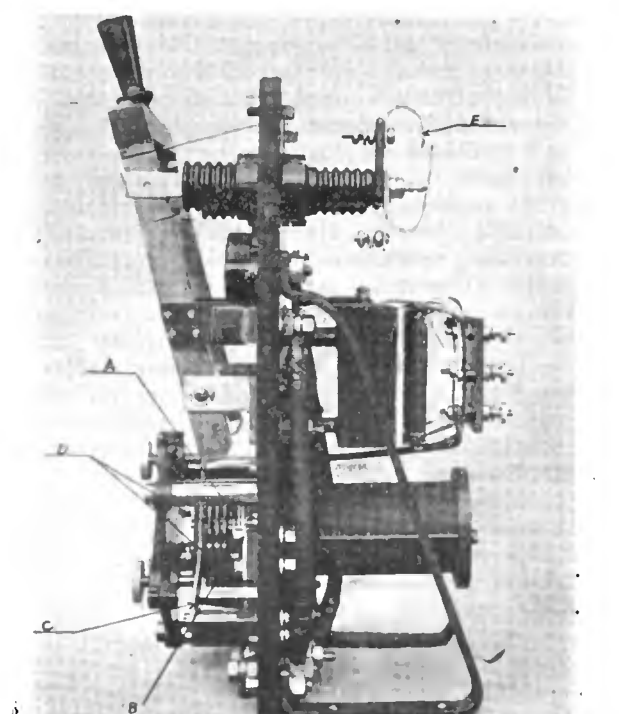


Figure 8—Side view of the emergency set designed for use on shipboard

lator flies out and automatically alters the pitch of the fan blades. Thus the speed of the generator is kept fairly constant over wide ranges of airplane speed.

All controls are fitted with large knobs to permit of their operation by the heavy-gloved hands of the aviator. All parts are fastened so as not to loosen under vibration. The switches must all be pulled out to turn and cannot be moved by vibration.

The key, mounted on an insulated piece with a strap for fastening on the leg of the operator, is fitted with a large button to allow the operator to work it with gloves on.

In order not to put the full potential of 500 volts on the

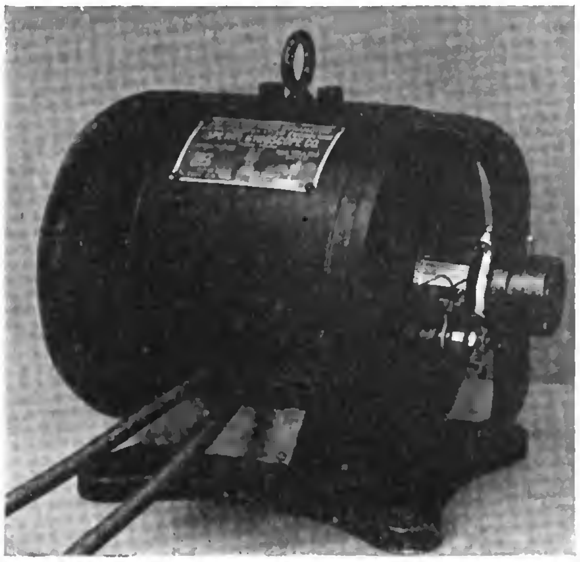


Figure 9—Two-pole semi-enclosed dynamotor which operates on a 6-volt storage battery

leg of the operator two resistances Nos. 11 and 12 are connected across the line and the fall of potential across resistance 12 in diagram B, which is equal to about 100 volts, operates the relay. Thus if the insulation of the key should break down there would never be more than 100 volts near the operator and his glove would protect him from that.

Referring to figure 1, No. 2 represents the air driven shunt wound generator. No. 3 shows the kick-back preventer condensers, 4 the main switch, 5 the D.C. ammeter, 6 the magnet coil, 7 the double buzzer gap to be described later and 8 the relay contacts that break the main 500-volt current. Number 10 shows the hand key, while 27 is the relay winding. Numbers 14 and 15 are the resistance and condenser connected across the relay contacts 8 to absorb the spark at the relay break.

A description of the high frequency circuit follows: Number 21 is the single turn primary inside the helix. It is shown in figure 4. Numbers 16, 17, 18 and 19 are the transmitting condensers, with a value of .12 M.F. on 600 meters. The wave changer is shown at 28 where the primary and secondary circuits are varied simultaneously from the one knob, the two circuits being insulated. The taps in the secondary circuit are fully shown in figures 4 and 5.

We will now take up the construction of the spark gap 7 which is in reality two gaps in series but arranged to open simultaneously.

The oscillating member of the gap consists of a copper disc 7b faced heavily with silver. This copper block is carried in a recess of the cooling block. The whole is mounted on a flat spring which is actuated by the electro magnet. A soft iron disc serves the double purpose of acting as an armature for the magnet and as a nut for clamping in position the oscillating gap.

The stationary gap is divided, forming two insulated electrodes, 7g and 7h. The current thus enters through terminal 7g, passes across the gap toward the panel, then down through the vibrating electrode, back across the gap in the opposite direction, and out of the terminal 7h.

One of the essential requirements of this type of gap is that the surfaces be parallel, and in order to make this parallelism a matter of easy adjustment the construction shown was used.

The stationary gaps are mounted on and insulated from an inverted Y spring carried on high standards. Now on each prong of the Y, midway between the centre and the supports, an adjusting screw, 7, figure 3, bears. By turning down any one of these screws, the face of the stationary gap will be tilted down in that direction. By turning down all the screws equally, the entire stationary gap may be moved into contact with the vibrating gap. The pressure of this contact determines the power input. This construction is fairly well shown in figure 8.

Here A is the vibrating contact 7b, B is the vibrating spring. D shows the stationary gaps 7g and 7h. C is the inverted Y spring.

The size of this airplane set is 12 inches wide, 20 inches high and 10¼ inches deep. Its weight is approximately 50 pounds.

The Sperry Type CS 494 Emergency Radio Transmitter is designed for use on shipboard, as an emergency set, when power from the main supply is cut off.

It operates on a 6-volt storage battery through the medium of the dynamotor which delivers 400 volts D. C. to the transmitter. Figures 7 and 8 show the transmitter, while figure 9 shows the dynamotor.

The transmitter is of the vibrating gap type with a capacity of 200 watts continuous sending. It is mounted on a bakelite panel 9½ inches wide by 20 inches high. The panel also carries all terminals, binding posts, the key condenser, resistances, a line ammeter and switching mechanism.

The dynamotor is a two pole, semi-enclosed machine operating as a motor from a 6-volt storage battery, and delivering 400 volts direct current to the transmitter. The machine is entirely fitted with ball-bearings and has an output capacity of 200 watts.

There are over 250 of these transmitters in use on various ships of the navy today—being installed on practically all the battleships and destroyers.

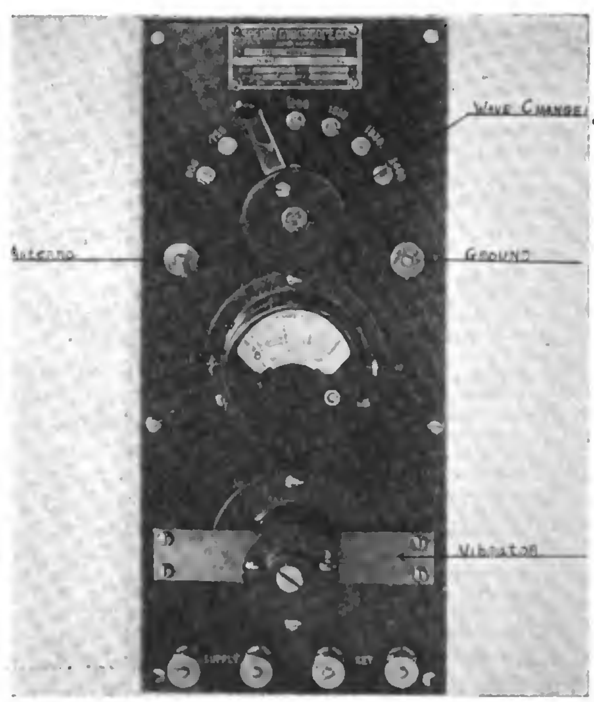


Figure 10—Small type 75-watt buzzer transmitter

This transmitter is intended for emergency use and operates in conjunction with the standard wave-changer of the main radio set and its condenser.

Radio Frequency Interference Balance

THE effect of static disturbances upon a receiving system may be likened to that of a blow upon a tuning fork. Characteristic damped oscillations of the natural frequency of the system are set up therein and these cannot be tuned out as can persistent or sustained oscillations of a definite periodicity from a foreign station. In the present arrangement no attempt is made to tune out the interference known as "static" but an auxiliary system is provided whose function is, in co-operation with the receiving system, to balance out or neutralize static disturbance with respect to the receiving device. The auxiliary system is tuned and is therefore unresponsive to the continuous waves it is desired to receive. The natural oscillations excited by static disturbance in the receiving and auxiliary systems are therefore of different frequencies. For this reason a frequency converting device is provided to convert the frequency of the oscillations in the auxiliary system to the same frequency as that of the oscillations in the receiving system and differentially combine the resultant oscillations with respect to the receiving device. A further feature of the idea consists in providing an auxiliary system whose characteristic damping factor is the same as that of the receiving system. The arrangement is best understood by reference to figures 1, 2 and 3, which are diagrams illustrative of three forms of wireless receiving systems embodying the invention. Referring to figure 1, a pair of receiving antennae are provided, antenna 1 being tuned to the receiving frequency and antenna 2 being tuned to a frequency differing sufficiently therefrom to render it unresponsive to the receiving frequency. Coupled to antenna 1 by a transformer is an oscillation circuit tuned to the receiving frequency and working into the input side of a vacuum tube amplifier of the usual construction. Similarly, antenna 2 is connected by means of a transformer to an oscillation circuit tuned to the same frequency as its antenna and working into the input side of a second vacuum tube amplifier. A frequency transformer 9, of the Goldschmidt type is provided, this transformer comprising a rotor winding 10, and stator and field windings 11 and 12, winding 11 being included in the output circuit of amplifier 8. The rotor winding is connected to the input side of a modulator whose output circuit works through a transformer into an oscillation circuit connected to the input side of a vacuum tube detector in the output circuit of which is a receiving telephone.

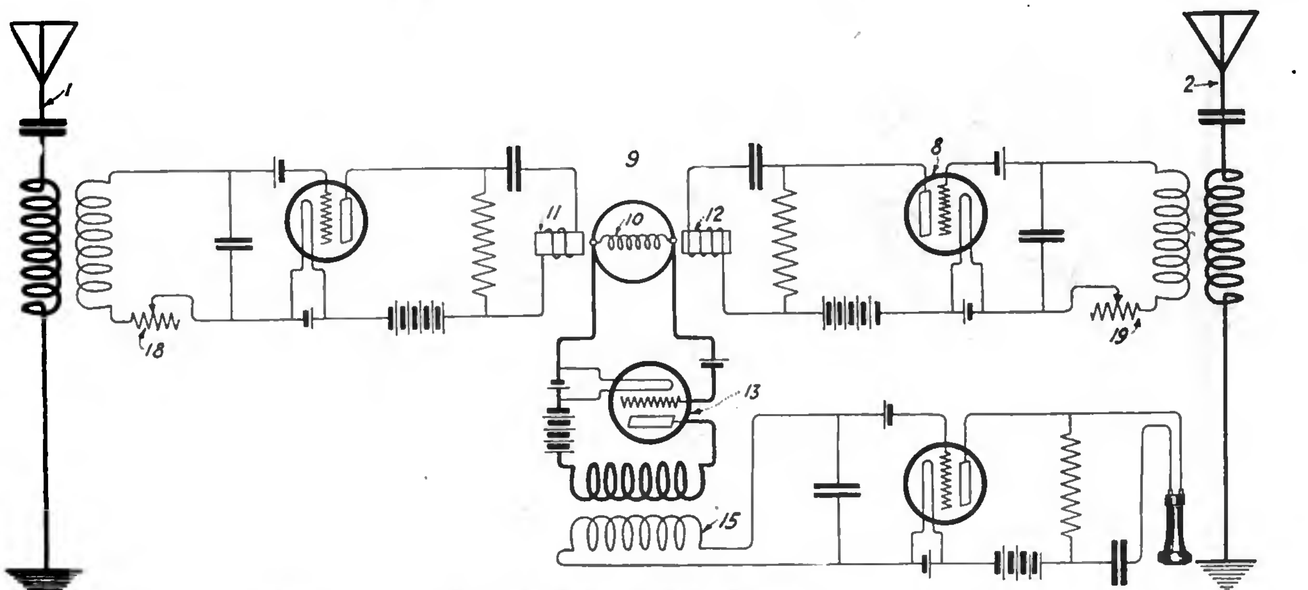


Figure 1—Diagram of a receiving system having two antennae used to neutralize static disturbances

The frequency transformer above referred to is so constructed that its rotor winding may be rotated at a speed such as to give an alternating frequency n. If then, a frequency N be impressed upon its stationary winding 11, it may be shown that two frequencies $N+n$ and $N-n$ will appear in the rotor circuit while if a frequency N_1 be impressed on winding 12, frequency N_1+n and N_1-n will appear in the rotor circuit.

Suppose a static disturbance affects both antennae and that these antennae are resonant to frequencies N and N_1 respectively. Antenna 1 will oscillate at frequency N and impress oscillations of the same frequency upon its oscillation circuit, these oscillations being amplified by the amplifier and impressed in the field winding 11. At the same time antenna 2 oscillates at frequency N_1 and impresses this frequency upon its oscillation circuit, these oscillations being amplified by the connected amplifier and impressed upon the field winding 12. If now the rotor be rotated at an alternating frequency n, so chosen as to be equal to $\frac{1}{2}(N-N)$ three frequencies will appear in the output circuit, namely $N+n$, $N-n=N_1+n$ and N_1-n. These frequencies are amplified by amplifier 13 and impressed upon oscillation circuit 15 which is tuned to frequency $N-n=N_1+n$ so that this frequency is brought out and frequencies $N+n$ and N_1-n are suppressed. The circuits may be so adjusted that the oscillations from both antennae are impressed upon their respective stator windings in such a manner as to appear in the rotor circuit in opposite phase relation, while by suitable adjustment of their respective amplifiers the oscillations may be given the same amplitude, and by means of variable resistances, the same decrement. Being converted to the same frequency by the frequency transformer it is obvious that the two sets of oscillations will then neutralize each other and that no oscillations will appear in the oscillation circuit and no effect will be produced on the detector or the receiving instrument. If, however, signals of a frequency N are received the antenna 2 is substantially unaffected while the antenna 1 being resonant to this frequency impresses said frequency through the amplifier upon field winding 11. As a result, frequencies $N+n$ and $N-n$ appear in the rotor circuit and are amplified by amplifier 13. The oscillation circuit suppresses the frequency $N+n$ while frequency $N-n$ is impressed on the detector and gives a signal in the receiving instrument. It is obvious that the rotor circuit may be tuned to the desired frequency $N-n=N_1+n$ so that the undesired frequencies N+n and N_1—n are suppressed before amplification by amplifier 13, in which case the oscillation circuit 15 would be unnecessary. It will further be noted that by the provision of resistances 18 and 19, the auxiliary circuits, including antenna 2 and associated circuit may be adjusted so as to have the same damping factor as the receiving circuits so that static disturbances produce oscillations of the same damping in both sets of circuits.

Another arrangement is illustrated in figure 2 in which an antenna is provided having two branches, branch 21 being resonant to receiving frequency N and branch 22 being resonant to a different frequency N. Branch 21 is coupled through a transformer 23 to an oscillation circuit tuned to frequency N+n and N—n are suppressed and only frequency N—n=N_1+n is impressed on detector 37. As the circuits are adjusted so that oscillations of frequency N—n and N_1+n are impressed upon oscillation circuit 36 in opposite phase relation and with equal amplitude, no effect is produced upon the detector or receiving instrument. If, however, signals of frequency N are impressed upon the antenna system, only branch 21 resonates and oscillations of frequency N+n and N—n are impressed on the oscillation circuit, the former being suppressed and the latter acting through the detector to produce a signal in the receiving instrument.

A still further modification is illustrated in figure 3, in which an antenna is provided with two branches

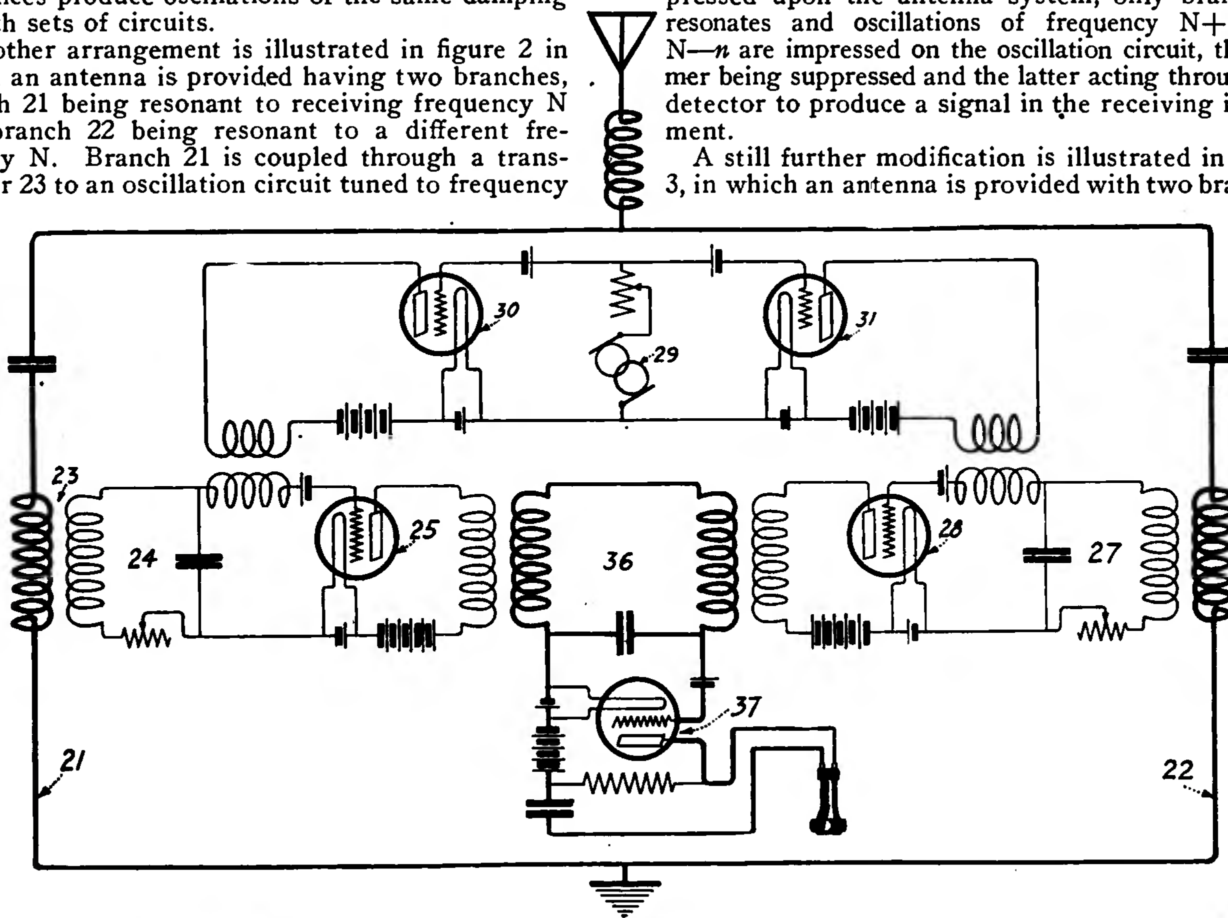


Figure 2—Diagram of a system having one antenna with two branches resonant to different frequencies

N and connected to the input side of a vacuum tube modulator. Similarly branch 22 is coupled through a transformer to an oscillation circuit tuned to frequency N_1 and working into the input side of a vacuum tube modulator. A generator 29 of frequency n is connected to the input side of vacuum tubes 30 and 21, whose output circuits are connected through transformers to the input circuits of modulators 25 and 28 respectively. These vacuum tubes prevent any reaction from the input of the modulators back into the generator. The output circuits of modulators 25 and 28 work through transformers into an oscillation circuit 36 tuned to frequency N—n=N_1+n, said circuit being connected to the input circuit of a detector in the output circuit of which is a receiving instrument.

When a static disturbance occurs the antenna branches resonate at frequencies N and N_1 respectively so that a frequency N is impressed on the modulator from the oscillation circuit 24 and a frequency n is also impressed thereon by the generator and consequently frequencies N+n and N—n appear in the output circuit of the modulator. At the same time a frequency N, is impressed on the modulator from oscillation circuit 27 while a frequency n is impressed thereon from the generator 29, so that frequencies N_1+n and N_1—n appear in the output circuit of the modulator. These several frequencies are impressed upon oscillation circuit 36 through transformers and if, as in figure 1, N—n is equal to N_1+n and oscillation circuit 36 is tuned to this frequency, frequencies resonant to frequency N and N_1 respectively, branch 40 being coupled through a transformer to an oscillation circuit tuned to frequency N, and branch 44 being coupled through a transformer to an oscillation circuit 45 having a natural frequency N. Circuit 43 is connected to the input side of an amplifier whose output circuit is coupled through a transformer to the input circuit of a modulator while circuit 45 is connected to the input side of an amplifier whose output circuit is coupled through a transformer to circuit 48. A generator comprising a vacuum tube having an oscillation circuit has its circuit arranged in a manner so as to generate oscillations of frequency n in the oscillating circuit 53, which is coupled through a transformer to circuit 48. Frequencies N, N_1 and n being impressed upon this circuit, it may be shown that frequencies N+n, N—n, N_1+n and N_1—n will appear in the output cricuit of the modulator, said circuit being coupled through a transformer to oscillation circuit 56 resonant to a frequency N—n=N_1+n. The input side of a detector is connected to an oscillation circuit and a receiving instrument is included in the output circuit of the detector.

If, now, a static disturbance occurs, branches 40 and 44 resonate at frequencies N and N_1 respectively, these frequencies being amplified by amplifiers and impressed on circuit 48 together with frequency n from the generator so that frequencies N+n and N_1+n will be of the same amplitude and in opposite phase relation. Oscillation circuit 56 suppresses frequencies $N+n$ and N_1+n and as the oscillations of frequency $N-n$ and N_1+n are of the same frequency and amplitude but opposite in sign, these frequencies neutralize each other in the oscillation circuit so that no effect is produced on the detector or receiving instrument. If, however, a signal of frequency N is impressed on the antenna systems, branch 40 resonates while substantially no effect is produced on branch 44. Frequency N is therefore amplified by amplifier 16 and impressed on circuit 48 together with frequency n from the generator so that frequencies $N+n$ and $N-n$ appear in the output circuit of the modulator, the former being suppressed by the oscillation circuit and the latter being impressed on the detector to produce a signal in the receiving instrument.

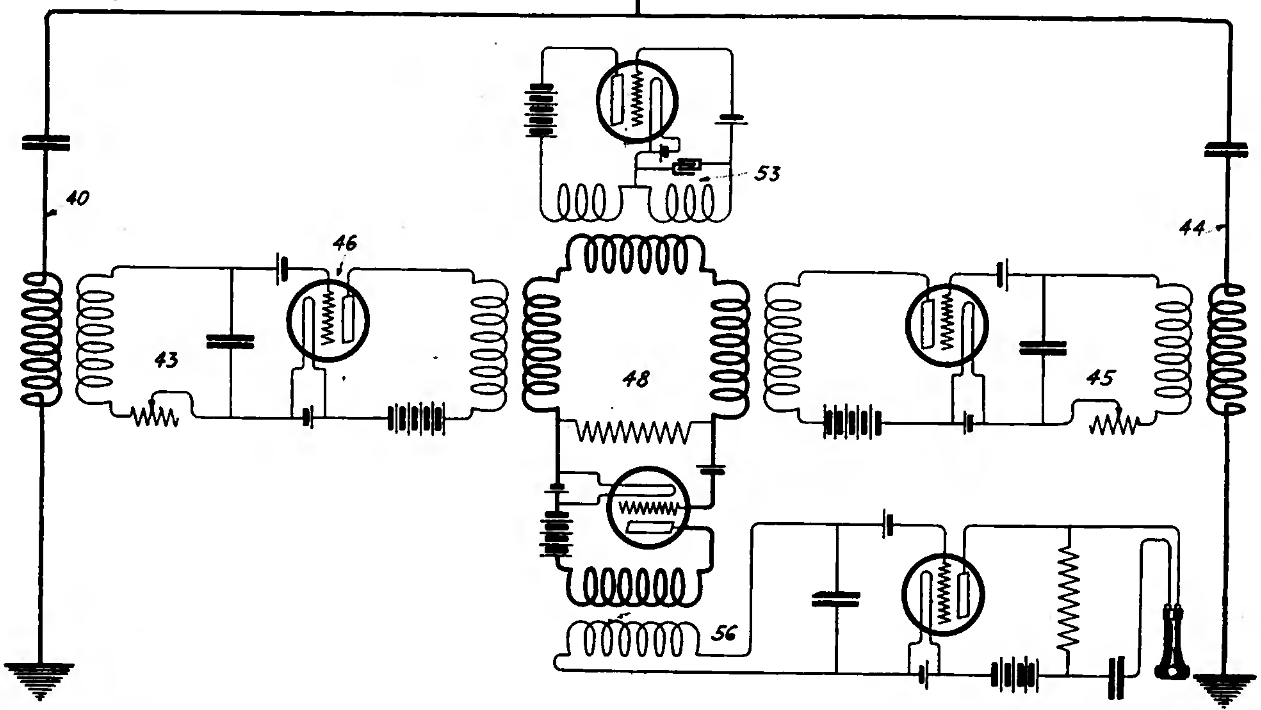


Figure 3—Another circuit used to secure radio frequency interference balance

Radiophone Modulator

LEE DE FOREST has devised a means of modulating radio frequency currents in accordance with the sound vibrations produced by the voice, these currents being of a greater order of magnitude than it would be possible to modulate with the ordinary telephone microphone. He has discovered that if a portion of the inductance which is in the antenna circuit is shunted by a microphone and the microphone actuated by the sound vibration produced by the voice, that the wave-length of the transmitted energy will be varied in accordance with the variations of the voice vibrations and that the energy received at a receiving station will therefore vary in accordance with the variation of the voice vibrations. Figure 1 shows several microphones actuated in phase, each microphone being in shunt to a portion of the inductance in the antenna circuit. It is apparent with reference to the figure that a considerable effect upon the wave-length of the transmitted energy may be produced in this manner.

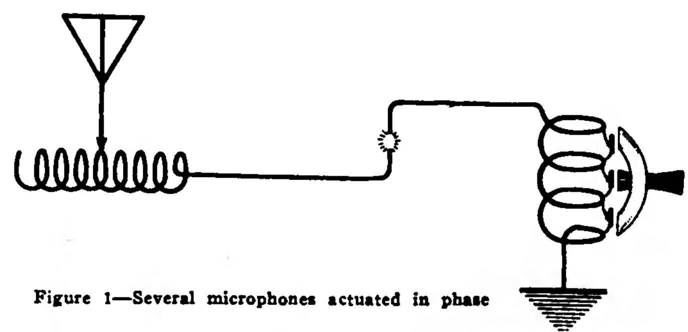


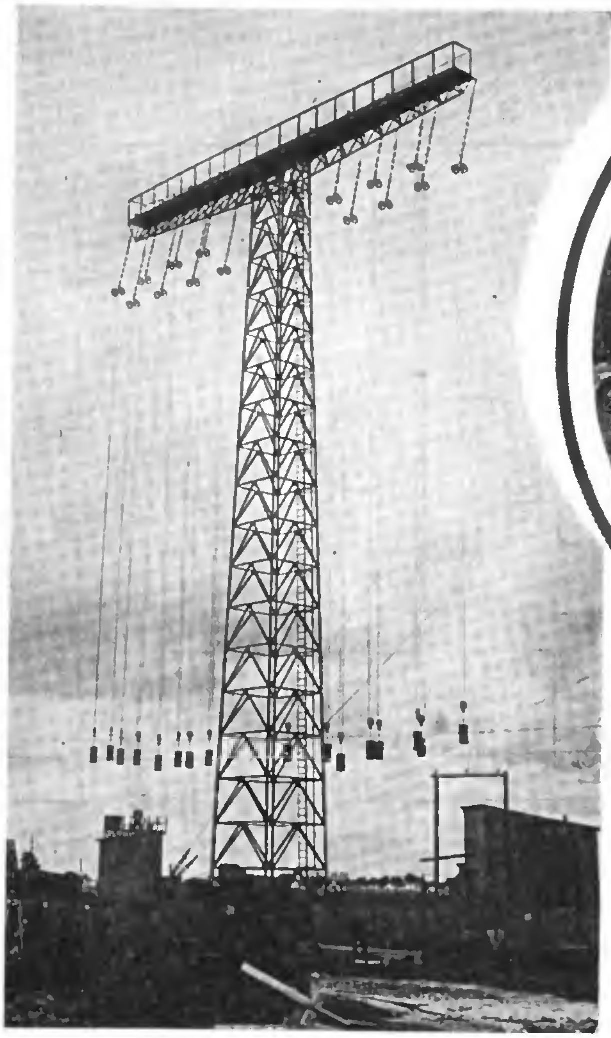
Figure 1—Several microphones actuated in phase

He has also devised means whereby several microphones may be actuated in phase electromagnetically.

The Radio Review

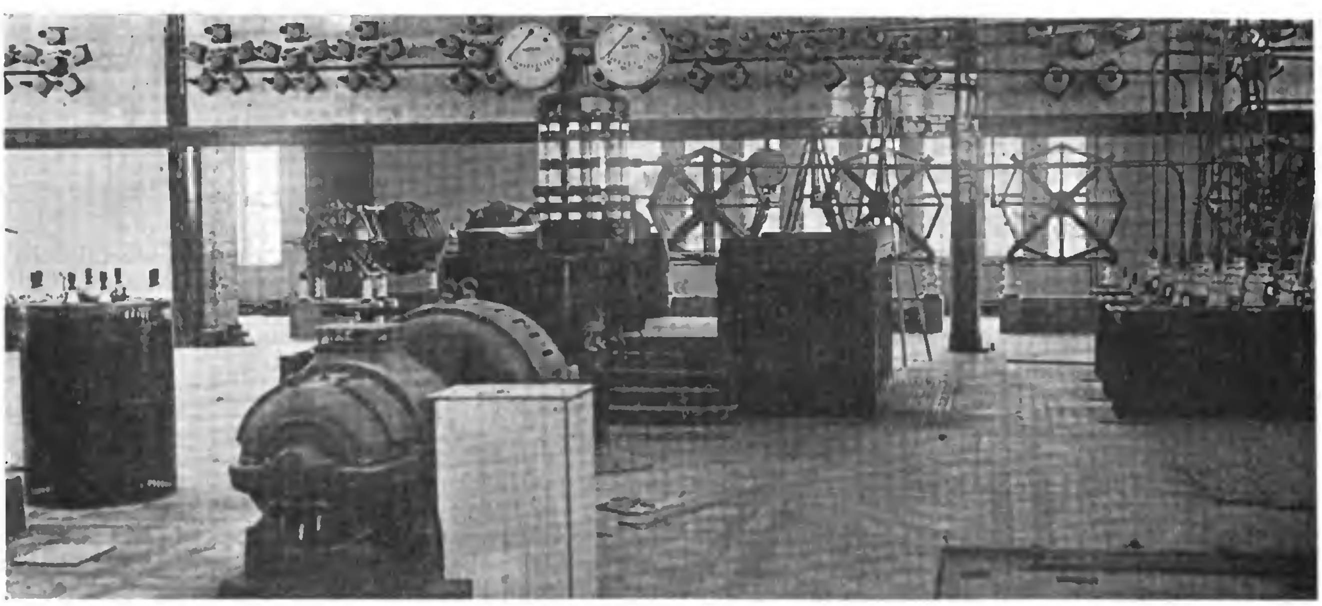
A HIGHLY technical publication, which appears under the title "The Radio Review," has recently been launched in London. Examination of the first issue makes it apparent that this carefully edited magazine will be of great assistance to radio engineers, for its mission is to report scientific progress in the art in a broad international way, and to shed special illumination on the radio conceptions and inventions of British scientists. This publication promises to occupy a niche corresponding to the enviable one attained in America by the "Proceedings of the Institute of Radio Engineers."

The keynote of the editorial policy, as sounded in the first issue, calls for a wide open forum wherein all science workers in the field of radiotelegraphy may communicate the results of their work and their opinions to their fellow workers. The scope of the articles will cover a broad range, comprising the treatment of subjects theoretical and practical, physical and mathematical, electrical and mechanical.



"Poz"—Nauen

Three views of the German station which acquired fame through the many historical messages sent from it during the war. At the left is seen one of the high towers whicb support the antenna; above, the receiving room, and below, the generating room, showing a motor generator, transformers and helices as part of the equipment that transmits signals overseas from a power source rated at 600 kilowatts



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

A Medium Wave Regenerative Receiver

By Ernest G. Underwood

THE following is a description of a medium wave receiver — shown in the accompanying photographs—designed and constructed by myself for use on an antenna of about two hundred meters natural period. Using an antenna of this capacity, the range of the receiver is from two hundred meters up to and including thirty-five hundred meters without an external primary loading inductance. By insertion of additional inductance at the binding posts directly above the primary inductance switch, the effective range of the receiver may be increased to fifty-four hundred meters, which is the capacity of the secondary circuit.

This receiver is of the regenerative type, using the standard Navy regenerative hook-up, which has been found to be very efficient. Strong amplification of spark signals is obtained when the receiver is used for six hundred meter work. The receiver is also an excellent undamped wave receiver.

The cabinet containing the receiver is made of birch with a dark mahogany piano finish. The size of the cabinet is 11x19x10 in. The bakelite panel is 11x19x3/8 in., the front of which is finished in a dull gloss. All parts of the receiver are fastened directly to the back of the bakelite panel.

The antenna circuit consists of a movable primary coupling coil, primary loading coil, and a variable series condenser. The primary coupling coil is used for varying the coupling between the primary and secondary circuits and is wound with 37 turns of No. 22 D.S.C. wire on a tube 2 in. wide by 4¼ in. in diameter. The coupling is varied by rotating the knob marked "coupling." The loading coil is wound in two sections on a composition tube 6 in. long by 4¼ in. in diameter. The first section contains 168 turns of No. 22 D.S.C. wire and the second section contains 162 turns of the same size wire. Each section is bank wound in two layers. The loading coils are disconnected from the coupling coil when not in use by two dead-end switches operated by a small cam attached to the shaft of the primary inductance switch. The primary condenser is of the balanced plate type. The fixed and movable plate systems are in two sections arranged 180 degrees apart and are thus balanced. The maximum capacity of the condenser is .0013 mf. The condenser has a maximum capacity of .0013 mf. and a dial on the front of the panel made from a piece of aluminum and having a scale engraved on it is fastened to the shaft. A fixed pointer indicates the capacity being used. A knob mounted on the receiver panel at the left below the condenser knob permits the condenser to be adjusted very closely by means of gears connected to the movable plates. The taps for varying the primary inductance are mounted on the back of the panel and a scale engraved on the front of the panel indicates the tap being used.

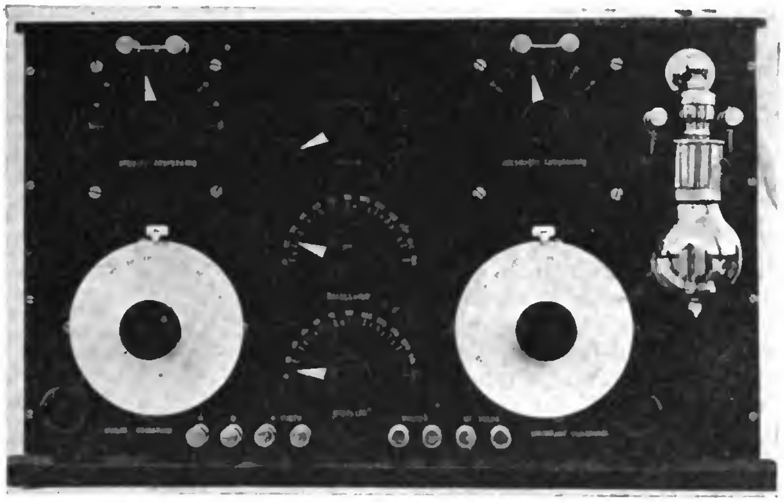


Figure 1—Front view of the medium wave regenerative receiver

The secondary circuit consists of the secondary coupling coil, loading coils, oscillator coil (tickler), secondary condenser, grid and bridging condensers and the audion control rheostat. The secondary coupling coil contains 56 turns of No. 22 D.S.C. wire bank wound in two layers on a tube 4¼ in. in diameter by 5 in. in length. Two sections of the secondary loading coil are also wound in the same tube and contain 74 and 87 turns of No. 22 D.S.C. wire respectively, bank wound in two layers. The loading coils are disconnected from the coupling coil by means of two dead-end switches. Taps for varying the secondary inductance are mounted on the back of the panel, the scale indicating the tap being used. The oscillator coil (tickler) is placed inside the secondary tube and consists of 90 turns of No. 22 D.S.C. wire wound on a composition ring 3½ in. in diameter. It is moved from a vertical to horizontal position by means of

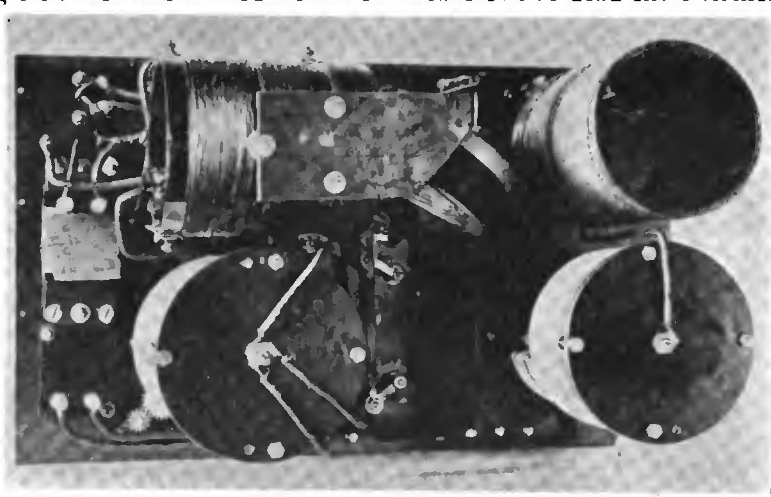


Figure 2—Back view showing secondary fine adjustment gears, and link motion for operating coupling coil

a lever motion which is worked by rotating the knob marked "Oscillator." The secondary condenser is the same size as the primary condenser with a maximum capacity of .0013 mf. and has a fine adjustment knob placed to the right and below the condenser knob. The grid condenser has a fixed capacity of approximately .00074 mf. The bridging condenser is variable by steps and has a maximum capacity of approximately .0025 mf. A standard 10-ohm battery rheostat, used for controlling the filament current, is mounted on the rear of the panel and is operated by the knob marked Audion. The socket for mounting the audion is at the extreme right of the panel.

Binding posts are provided for the connection of the antenna ground, filament battery, plate battery and phones.

This receiver has been in operation since July, 1919, and has given excellent results. The binding posts, audion socket and a small mica condenser, were the only complete parts purchased, all other parts, including the condensers, being home-made.

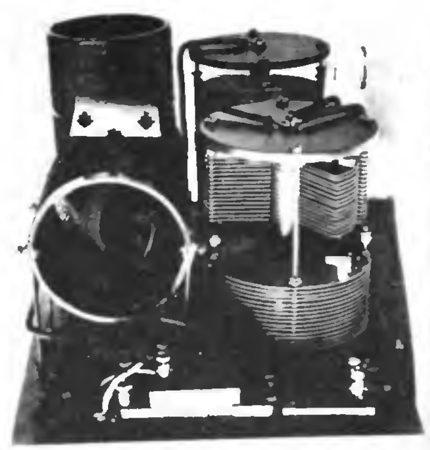


Figure 3—End view, showing method of mounting tickler coil

A Simple and Efficient Rotary Gap

By Wm. D. Reynolds, D.D.S.

THE gap here described has a marked quenching effect and is undoubtedly the easiest to construct of all rotaries I have ever made or seen.

A bakelite ring with ⅝-inch face, ¾ inch deep and 8 inches inside diameter and about 2 feet of ⅝-inch brass ribbon are the essential requirements.

Eight 2-inch pieces of the brass ribbon are first cut and bent in the manner shown in the accompanying diagram. After properly annealing, one inch of the brass ribbon is placed in a small vise. The protruding inch is grasped firmly with flat headed pliers and rotated a quarter turn, so that the ends are in planes at right angles to each other. A quarter inch slot is then cut in each piece of brass to permit adjustment and fastening to the bakelite ring. Eight holes are drilled and tapped equi-distantly around the face of the ring to hold the eight stationary electrodes.

The rotary electrodes are made of a single piece of the same kind of brass ribbon. One inch from each end the strip is twisted in opposite directions, making a fan-shaped rotating electrode. This is centered and bolted to a piece of bakelite and thus insulated from the motor shaft.

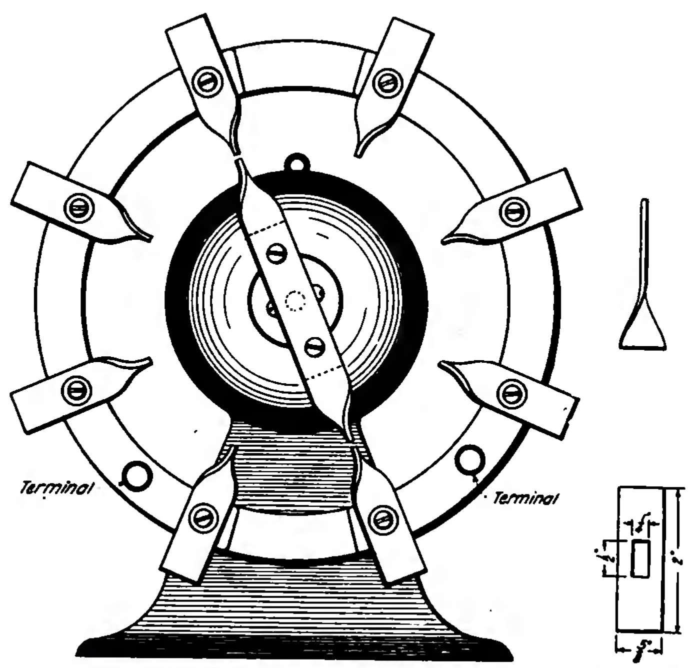


Figure 1—Assembled design of rotary gap and detail of stationary electrodes

The stationary electrodes should be so adjusted as to just clear the revolving member. The spark in this gap has practically no lead and does not jump until opposite the stationary electrodes. The peculiar shape of the revolving electrodes produces a blast of air which quickly quenches the spark and cools the gap.

This gap is easily constructed and correctly designed. The spark occurs between "knife edges" and is therefore almost instantaneous. The superiority of this gap over the slow starting heavy electrode gap is unquestionable.

An Economical "B" Battery

By E. L. Long

TO make an economical "B" battery secure one new dry cell which has a carbon element the cross section of which is a circle. Take off the outer covering of zinc in one piece. This may be easily done by making a cut lengthwise of the cell with a hacksaw. Remove the center carbon and with a hacksaw cut into pieces about ¼ inch thick. Now from the zinc cut out discs having a diameter equal to the carbon discs. These form the elements for the "B" battery cells which may be put together in the following manner. Bore a hole in a ½ inch piece of wood a trifle larger in diameter than the elements of the cells. Place this form on a smooth surface and put a carbon element flat in the bottom of the hole. Next place a thin layer of the black mixture from the cell in the hole, cover with a couple of discs of the blotting paper which should be remoistened. After having formed a small projection on the zinc disc with a center punch to serve to make the connection between cells more perfectly, place the zinc disc with the projection upward over the blotting paper and press the whole together tightly. Remove from the form and seal by using melted paraffin applied by means of a small brush or rag on the end of a stick. Twenty or more cells may be made in this way for the cost of a single dry cell, and they will serve very well as a "B" battery. They may be used by placing them in groups between springs fastened to a board or other support.

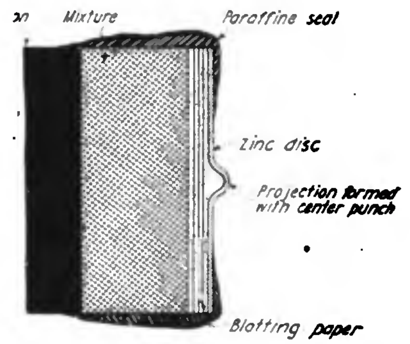
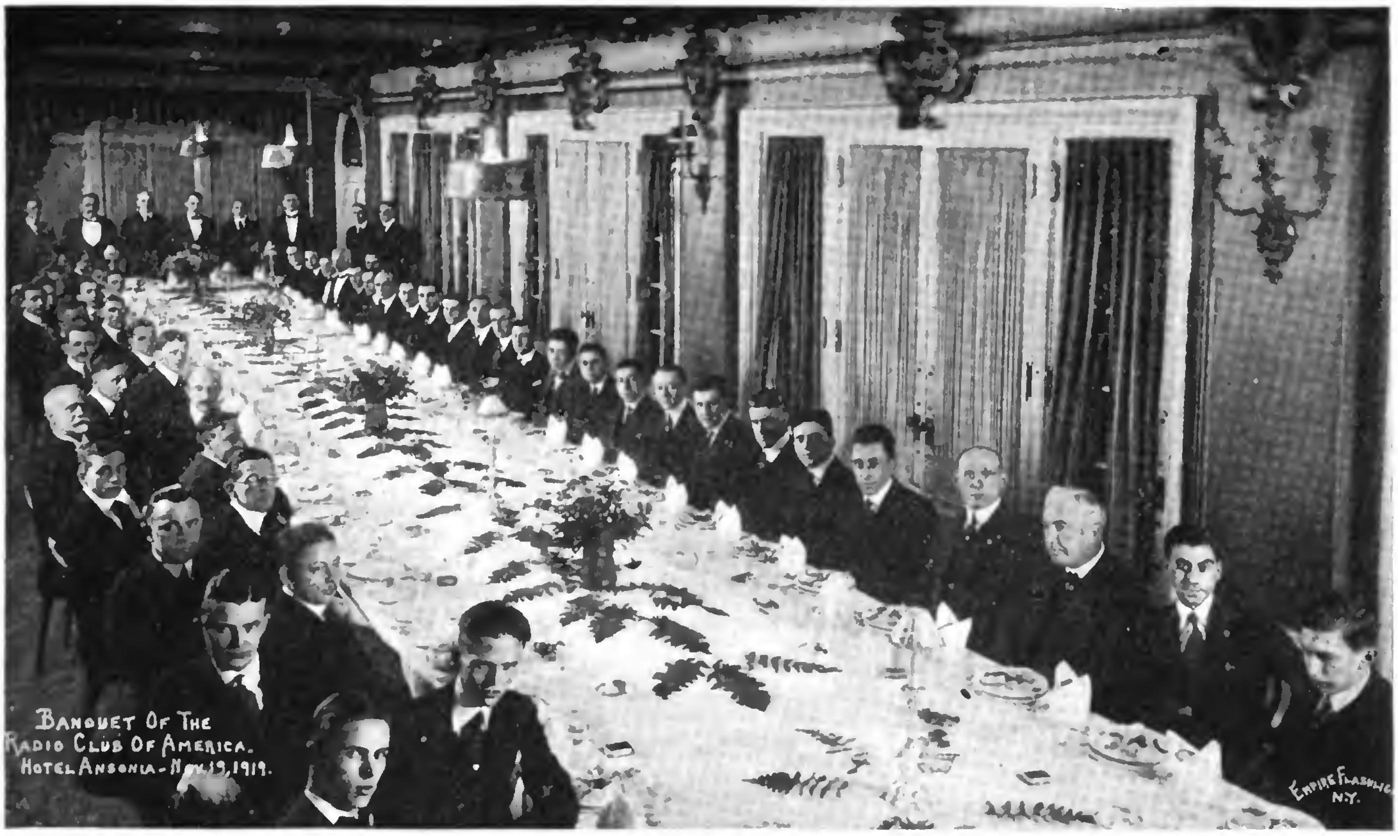


Figure 1—Showing constructional detail of the "B" battery



The three-score enthusiasts gathered to pay tribute to Major Armstrong. Those at the speakers' table in the rear, standing (from left to right), are: W. H. Davis, Prof. M. I. Pupin, Major Armstrong, T. Johnson, Jr., John V. L. Hogan, Dr. Alfred N. Goldsmith, George H. Clark and J. Andrew White

A Dinner to Armstrong

THE firm foundation in which amateur wireless rests in this country was clearly reflected in the testimonial banquet given in honor of Major Edwin H. Armstrong by the Radio Club of American on November 19, 1919. Sixty-four persons were present at the Hotel Ansonia, New York, to pay their respects to the returned president of the club, among whom were those who for ten years have held the leadership in directing the experiments in the New York district, and many men of distinguished scientific achievement who have inspired and encouraged the youthful workers in the art.

During the evening the guest of honor was acknowledged as the amateur who had set up new standards for the unpaid enthusiasts of wireless, established the work on a high plane and secured recognition for amateur radio. The debt to Armstrong, it was conceded, lay principally in the great merit of his invention of the regenerative circuit through which the sensitiveness of the vacuum tube receiver had been increased five thousand times. His work had been acknowledged by the conferring upon him of the medal of honor of the Institute of Radio Engineers, but it is a safe assumption that no tribute could have been more pleasing than the banquet given him by his original associates of amateur days. In the midst of this company it was recalled how he has remained an amateur at heart ever since the day seven years ago when, as a twenty-two year old college student, he perfected the invention which silenced the arguments of those that held amateurs to be meddlesome young men who accomplished no beneficial results in science.

T. Johnson, Jr., a director of the club and toastmaster for the evening, looked upon the club's activity in retrospect, fondly recalling its organization as a neighborhood proposition ten years ago and carrying its work through to the present day when it still retained its original usefulness and had the added prestige of accomplishment by many members. Prof. Michael I. Pupin responded with a sterling tribute to Armstrong's earnestness when a student at Columbia and gave many personal reminiscences of how the young inventor had challenged the admiration of men of great achievement, notably in the recent war; when French and British communication officers had been astonished at his feats in radio engineering.

Dr. Alfred N. Goldsmith responded with an appreciation of amateur workers as a whole, emphasizing the peculiar character of the hobby in that its converts always remained loyal — that they never recovered from the disease. He noted the significant fact that Armstrong had started with the most rudimentary apparatus, out of which he had erected a great structure of achievement and he looked hopefully to an immediate future holding great possibilities for other epochal inventions. The inspirational factor, he maintained, lay in the simple character of the apparatus itself, instancing the vacuum tube as virtually a three-element electric light; yet light at best could be thrown but a few miles, whereas radio signals spanned thousands and gave promise of circling the globe.

George H. Clark, former naval expert, told how at first the navy did not understand that the regenerative circuit was credited to Armstrong, stating that the principal reason for this was the modesty of the inventor. He gave an insider's view of the confidential inventions and developments made during the war and added a strong appreciation of the hard, conscientious and successful work of Major Armstrong as an officer abroad. Mr. Clark then, in lighter vein, effectively scored those of lesser accomplishment but greater pretensions, and with many witticisms drew a word picture of the results if all inventors were to adopt a like attitude.

Other speakers were John V. L. Hogan, Emil J. Simon, Capt. Willis H. Taylor, Jr., W. A. Davis and Prof.

(*Continued on page* 36)

First Prize—An Efficient Amateur Transmitting Condenser

By Norman A. Nyquist

THERE are so many different types of condensers being used for amateur radio work and so very little information available in regard to the types that are giving most satisfaction, that it is quite a problem for the average amateur to decide upon the proper type to build for his station.

A review of the various forms of transmitting condensers may be in order. Their advantages and disadvantages, in so far as amateurs are concerned, will be itemized accordingly:

No.	Type Dielectric	Advantages	Disadvantages
1	Compressed Air	Low losses Self healing Not fragile	Bulky Expensive Unreliable
2	Oil	Low losses Self healing	Bulky Sloppy
3	Glass & Oil	Fairly low losses	Bulky Fragile
4	Glass in wax	Fairly low losses	Bulky Fragile
5	Leyden Jar	Fairly low losses	Bulky Fragile
6	Mica	Low losses Very compact Not fragile	Initial expense

An analysis of the above data shows that for the ideal condenser, mica should be chosen for the dielectric. Mica is standard now in the Army and Navy.

In the average amateur transmitter arrangement of apparatus, the inductance of the leads are of such lengths that a capacity over .001 microfarads cannot be used on a wavelength of 200 meters.

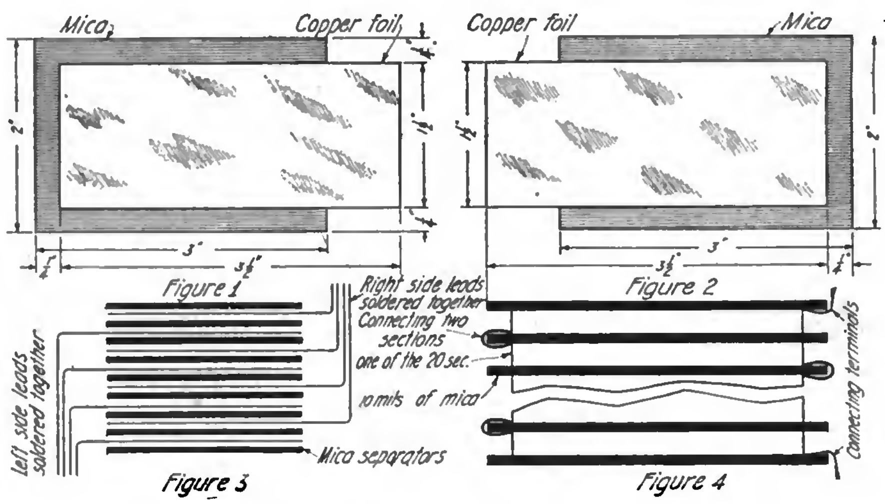
Condensers have electrical losses which summed up are referred to as the "power losses" of a condenser. A large portion of this power loss is in the dielectric between the metallic coatings. This loss is present in practically all insulators. This particular loss is due to "hysteresis" in the dielectric.

Experiments have been made to overcome the defects along this line, the results of which show that the energy absorbed per cycle in the condenser is proportional to the total energy in the condenser during the period, regardless of the frequency of the oscillations.

Therefore, that portion of the total decrement due to dielectric hysteresis is independent of the frequency of the oscillations or the physical size and capacity of the condenser and is wholly determined by the chemical composition of the dielectric and its temperature. There is also a small loss due to "eddy currents" in the metallic coatings.

During recent years much time and money has been spent by different radio investigators on research work with mica dielectric condensers and much valuable information has been obtained.

There is only one grade of mica which gives complete satisfaction, namely, Clear Ruby Mica, which is obtainable from the Mica Products Co., New York City. The cost of mica is rather high, but will not total the manufacturer's price on glass or moulded condensers.



Diagrams showing detailed plan of constructing the transmitting condenser

When purchasing the mica, sheets two inches by three inches should be specified, as this is a standard and convenient size. The thicknesses should be from two to three and one-half thousandths of an inch. The number of sheets required will depend upon the desired capacity of the condenser designed and the secondary potential which it will have to work on.

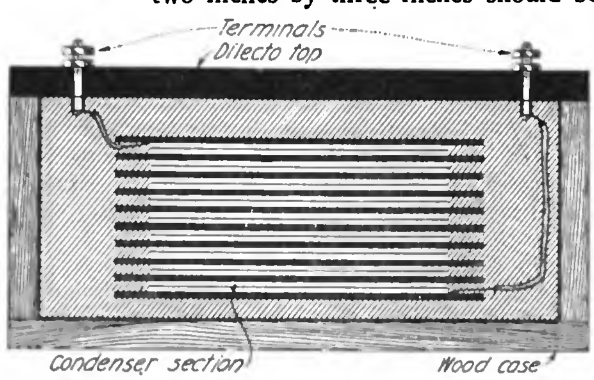


Figure 5—The finished condenser mounted in a case

Let us assume that a capacity of .001 microfarads is desired and that the secondary transformer voltage will be twelve thousand volts.

The particular grade of mica mentioned above will stand about 1,500 volts per one thousandth of an inch without puncturing, but the mica sheets should be tested before assembling. A convenient way of testing the mica is to use the transmitting transformer. A needle spark gap is set across the secondary terminals, separated one-tenth of an inch. Reactance is then inserted in the transformer primary circuit until the secondary voltage has been reduced to the point where it will only jump one-tenth of an inch, and no more, even if the gap is lengthened. Each piece of mica is now placed between two metal sheets slightly smaller than the mica sheets and connected across the secondary terminals of the transformer. All pieces of mica that puncture should be discarded.

Knowing that this mica will stand 1500 volts per mil, a safety factor of five is generally used, which means that each mil of mica is worked at one-fifth its tested voltage or 300 volts. As each mil is worked at 300 volts per mil and the mica is two to three and one-half mils thick, and a secondary voltage of twelve thousand is to be used, it figures out that we must have twenty sections in series.

If there are to be twenty sections in series and we want a resulting capacity of .001, the capacity of each section must be twenty times the desired capacity, or .020 microfarads.

The capacity may be calculated nearly enough by use of the following formula, and the proper number of plates per section can be determined roughly. The capacity need not be exact, as the capacity of the twenty sections in series is finally adjusted by taking off or adding a few plates to one of the end sections.

$$\text{Capacity} = \frac{2248 \times A \times K}{d \times 10^{10}}$$

A = Total area of coatings
d = Dielectric thickness
K = Dielectric constant, 4 for the above grade.

The metallic coating for the mica should be dead soft annealed copper foil one-thousandth of an inch thick and one and one-half inches wide. It may be purchased in rolls of this size. About one-half pound will be required.

The copper foil is cut into pieces three and one-half inches long and assembled on the mica as shown in figures 1 and 2. About eight of these plates placed together will give a capacity of .020 microfarads. After the proper number of plates are assembled to give this capacity, the rest of the sections are made and the twenty sections assembled as shown in figure 3.

All the sections are now held in between two blocks of wood and clamped tightly in a steel clamp, such as is used by machinists, or in a hand vise. This whole arrangement is then placed in an oven and baked at a temperature of 250 degress F. for at least twelve hours, if possible the clamps should be tightened about every three hours.

During the last hour of baking, a compound consisting of one part beeswax and three parts rosin should be prepared, melted, and brought to a temperature of 250 degrees. After twelve hours of baking all moisture has been removed from the condenser. It is then placed in the boiling compound and left there one hour, the temperature being kept at 250 degrees F. during this time.

The unit is next taken out and left to cool. When cold the surplus compound is scraped off and the clamps removed.

The finished condenser is mounted in a case as shown in figure 5, and the case is filled with the remaining liquid compound before it cools.

When soldering the copper lugs together as shown in the drawings, use the only soldering flux that will give complete satisfaction, which is equal parts of alcohol and rosin. The section should be tilted up-side-down when soldering so that the flux will not run into the mica.

The construction of this condenser entails considerable work and the various materials are quite expensive. It is, however, a real condenser,—worth all the time and effort required, and a unit of which any amateur may be proud. The substitution of a mica condenser for a glass and oil condenser will result in a 50 per cent. to 100 per cent. increase in radiation for a given input.

Second Prize—An Efficient Amateur Transmitting Condenser

By H. L. Stanley

THE amateur high tension condenser is usually the weak link in the chain of transmitting apparatus and the condenser described below was developed in an attempt to provide one that would be efficient, rugged, permanent, not too expensive, and capable of being built by an amateur himself with the assurance of success.

Glass plates were selected as being the simplest form of dielectric, having a suitable efficiency and for the ease of attaching the conducting medium. These plates were of plate glass 8x10 in. and varied from ¼ in. to 5/16 in. in thickness, and were obtained at a nominal price from a jobber in glass from pieces which would otherwise become scrap. Plates of this description have an average dielectric constant of 7.5 to 8 and are not affected by voltages up to 30,000.

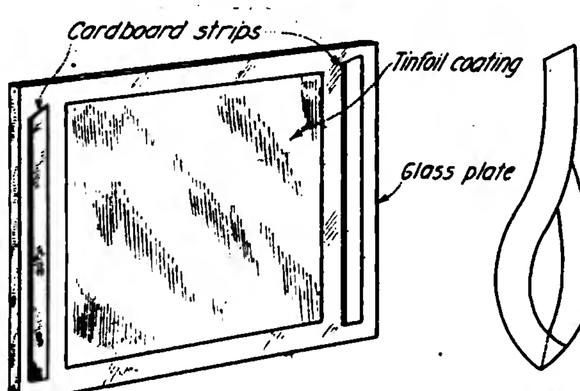


Figure 1 Figure 2

Design of plates with separating strips attached and the connectors made of brass

Commercial tin foil 6x8 in. was selected for the conducting coating, as it was easy to obtain, cheap, and filled all the requirements better than any other coating obtainable. This foil was purchased in the form of a roll of the proper width to require cutting for one dimension only, and of a thickness which would be sufficient to carry the full capacity of the usual transformer without heating.

After trial of several mediums for attaching the foil to the plates, it was decided to use pure beeswax, as this material lends itself readily to the operation, has a very high dielectric value, does not form bubbles of gas under the foil and solidifies at once after being applied.

The glass plates were first washed in warm soapsuds and wiped with a cloth wet with alcohol to remove all grease, etc. The foil was then cut and the corners rounded off.

To apply the foil to the glass the plates were first heated to a temperature somewhat higher than necessary to melt the wax, and while they were hot the wax was applied in a thin coating all over the part of the plate to be covered with foil, the foil laid on in position, rubbed down with a soft rag on both sides of the plate and the whole thing run through the family clothes wringer.

If this operation is properly carried out while the plate is still hot the foil on both sides will be squeezed absolutely flat and into intimate contact with the glass, and the film of beeswax between the foil and the plates will be so thin as not to be noticeable.

The plates and the foil were then washed with a soft rag wet with gasoline and all traces of surplus was removed. After the plates were dry the foil was examined for possible pin holes and these were covered with shellac wherever found and a heavy coat of shellac was flowed around the edges of the foil. The shellac was used to prevent the oil in which the plates were to be immersed from coming into contact with the wax under the foil, thus dissolving it and allowing the foil to fall from the plates.

A rack was then built of dry wood to hold the plates in an upright position and an oil tight metal container built which would hold the assembly. This container was sufficiently deep to allow the plates to be covered when the case was filled to within one inch of the top with transil oil.

When the plates were assembled in the rack they were separated 1/16 in. by means of cardboard strips which were pasted across the ends of the plates with shellac. (See figure 1.) This separation is necessary for the connecting strips to be placed between the plates. The connecting strips were made of 1x.005 in. half hard brass of the shape shown in figure 2, and are long enough to meet over the center of the condenser when placed in position between the various plates. When the connecting strip in this form was pressed between the plates it made a good and sufficient contact with the foil on the opposed sides of two plates. The connectors were placed on opposite sides of each plate connected in one multiple unit.

A condenser constructed according to the foregoing manner has a capacity of approximately .01 mf. when thirty-five plates are included. This is the proper capacity required for use with the ordinary amateur transformer on a wavelength of 200 meters.

Condensers of this type have been in use for some time in several of the best amateur stations and they have given very satisfactory service, being characterized by the absence of the usual losses present in the amateur transmitting condenser.

Third Prize—Transmitting Oil Condenser Suitable for 200 Meter Amateur Sets

By George T. Droste

A TRANSMITTING oil condenser suitable for 200-meter sets and for powers up to 1 kw. is described.

The material is easily obtainable and the condenser is easily constructed and highly efficient. I have been using one for over two and one-half years and there has never been a sign of a breakdown while under severe strain and using 1 kw. output. There is not the slightest sign of corona or brush discharge.

Following is given a list of material and sketches of the construction with all the essential parts being shown.

From a photographic supply house, obtain a composition Hypo fixing tank for 8x10 in. plates. This is a vertical black tank which looks like rubber. It is about 5¾ in. wide, 10¾ in. long and about 10 in. deep. The inside is scored or grooved at the sides for holding the plates vertically and raised baffle walls at the bottom are provided to keep the plates from touching the bottom of tank. The spacing of these grooves keep the plates about ⅝ in. from center to center and the tank holds eight 8x10 in. plates. (See figure 1).

Obtain eight 8x10 in. used photo plates. These may be had at the same photo supply house. Clean off the gelatin by soaking the plate in hot water and scrape off with a knife.

At a hardware supply house obtain sufficient copper foil to coat both sides of these eight plates with sheets 6x8 in. in size. Sixteen are required. This material comes about 12 in. wide, therefore, a piece 64 in. long is required, allowing enough extra for waste in cutting. This copper foil is recommended in preference to tin foil no matter how heavy the tin foil be, as it has tensile strength and does not tear in handling. No tabs for terminals are used. (See figures 1 and 5.)

Obtain from some hardware supply house enough stock for two pieces of brass 1/16 in. thick, ⅝ in. wide and long enough to fit the width of the tank. (See figure 2.) These pieces are bent down at the ends about ¾ in. and drilled and tapped for 12/24 screws for fastening to the tank and forming the terminals. On the long flat portion clear holes are drilled to take 12/24 machine screws. These holes may be slotted if the experimenter desires to allow easy removal of the clips. One piece is drilled with four holes and the other with five.

A dozen 12/24x1¾ in. brass round head machine screws and 24 hex nuts are obtained. Nine screws and eighteen nuts are used for the plate terminals, two screws and two nuts for condenser terminals. (See figures 3 and 5.) Next obtain enough spring brass ribbon 1/32 in. thick and ½ in. wide to form nine pieces as shown—see figure 3. This brass is bent as shown and soldered into the slots of the screw heads. The spring brass clips make rubbing contact with the foil plates at the upper edge and are all alike. Contact adjustment is easily accomplished by bending the lower part of the clip so that it will apply spring pressure between the foil plates or, by raising or lowering, which is accomplished by adjusting the lock nuts. (See figure 5.) 14/24 machine screws placed through holes drilled in the sides of the composition tank will support the horizontal bars. These holes in the tank must be near the top edge so as to be above the oil line, which has to cover the plates. The support bars are drilled and tapped in the turned down ends to take the screws. At one side these screws are long enough to take nuts for locking in position, and also form the binding posts of the condenser.

Two pieces of hardwood ½x⅝ in. and long enough to fit snugly between the walls of the tank are slotted with a hacksaw and the slot spaced the same as the plates. (See figure 4.) This separator is placed at both ends of the tank and holds the upper edges of the plates rigidly. (See figure 5.) The vertical grooves in the tank are tapered, being wider at the top.

The oil used is a standard transformer oil. Two gallons are needed. This will cost about 50 cents a gallon and may be purchased at any oil supply house. It is a vegetable oil and not a mineral oil and is poured into

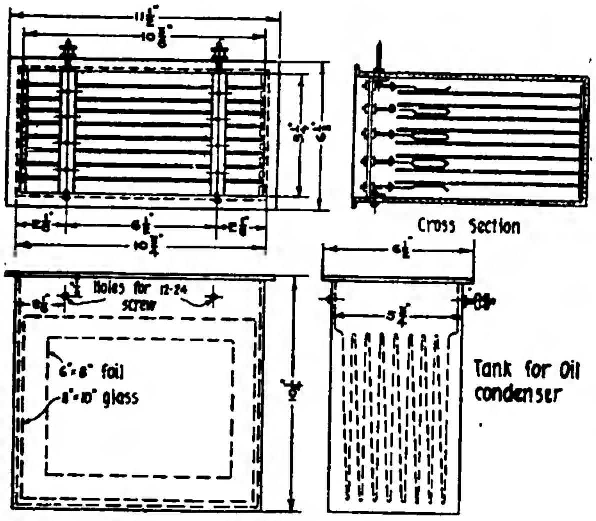
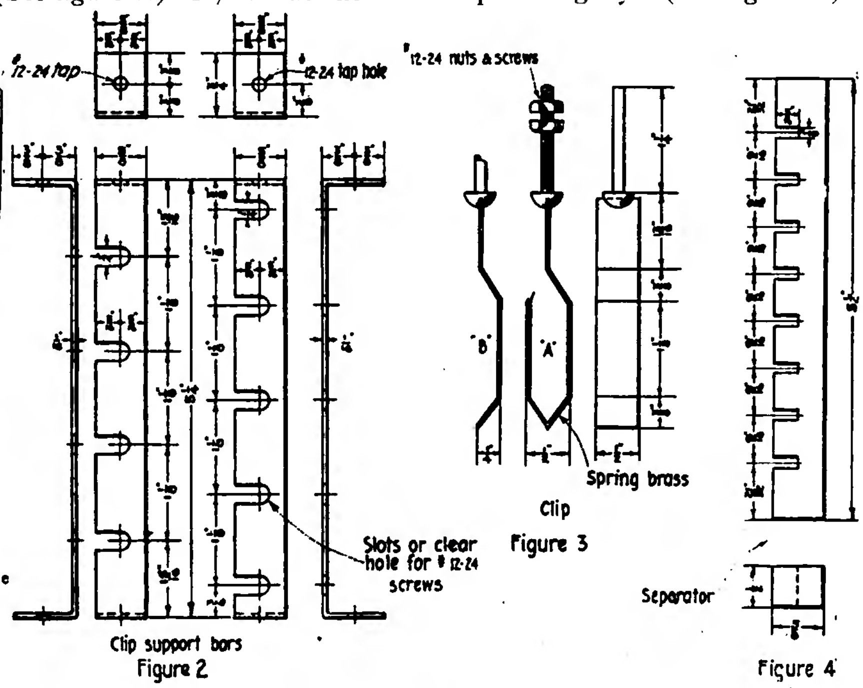


Figure 1

Detailed constructional plan and arrangement of plates of the oil condenser



Constructional plans of the clip support bars, clips and separator

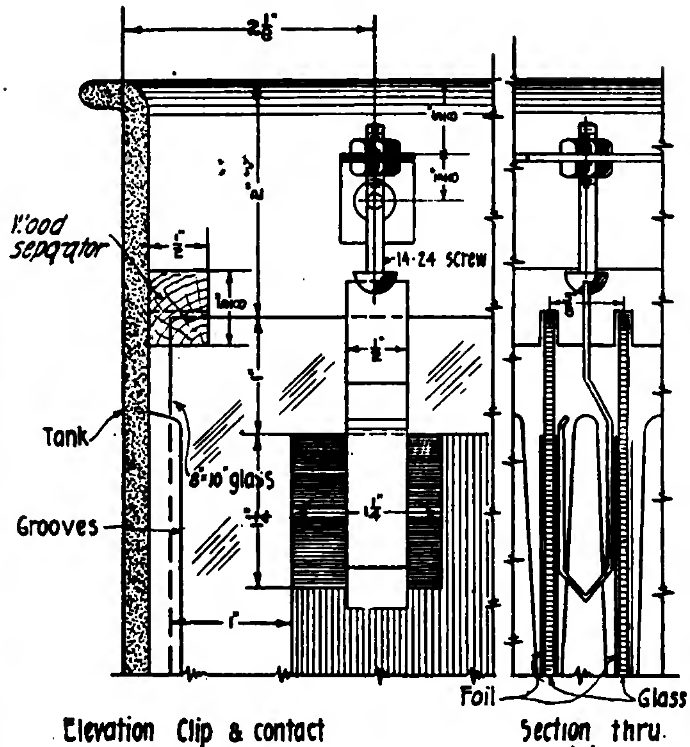


Figure. 5

Showing assembly of parts by means of a sectional and an elevation view

the container after plates have been installed and connections made. The entire unit may be placed near the transformer and oscillation transformer. A sheet of glass placed on top of the container will act as a cover. The foil is applied to the glass with orange shellac. Smooth it out with a squeege roller, or by hard pressure with a cloth pad. Do not use metal, as this will produce a curl to the foil, which makes it difficult to keep the edges down. After the foil is attached and the shellac dry, coat the entire surface of the foil and glass with shellac. Later clean the upper corner of the foil plate for the connections to the plates.

The Monthly Service Bulletin of the

National Amateur Wireless Association

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

AMATEUR wireless suffered a distinct loss with the death of Horace A. J. Upham, prominent lawyer of Milwaukee and an active member of the N. A. W. A. Mr. Upham, who was 66 years of age, died of apoplexy while motoring near his summer home. He took a great interest in amateur affairs and was the leading spirit in the organization of the Milwaukee Club.

A. T. Hovey of Boston has announced the inauguration of a new method of doing business in the wireless field. He is arranging to receive orders for all standard makes of apparatus by radio and will have the station in operation so amateurs may communicate with him either direct or relay on Monday, Wednesday, Friday and Saturday evening from 7 to 9 P. M.

A Radio Club has been formed at New Mexico College which will have for its object the advancement of its members in technical, general and practical information concerning radio telegraphy. The club will have the use of the college radio house and a tower 140 feet high will be built, with an umbrella aerial.

Following is a list of the officers elected: Louis Eddleman, president; Mortimer Beaty, vice-president; Clarance Fite, secretary-treasurer; Professor Goddard, faculty adviser.

The newly formed Philadelphia Radio Amateur Association announces that its initial meeting proved very successful and the regular program will call for meetings to take place the second and fourth Monday nights each month at 1611 Columbia Avenue, Philadelphia.

A course in the elementary principles of wireless will be conducted and there will be an address on technical topics and also on general topics.

The employment of the V. T. in amateur radio was taken up at the initial meeting and will continue to be a lively subject for debate.

The officers of the club are making arrangements to have demonstrations of apparatus and displays of meritorious equipment a regular feature of the meetings.

A prepared program is followed. Lectures and papers which have been thus far presented include: "Elements of Direct Current," by S. S. Harris; "Decrement," by Malcom Ferris; "Elements of Alternating Currents," by S. S. Harris; "Hook-ups for Honeycomb Coils," by P. J. Gallagher; "Poles and Aerials for the Amateur," by Elwood Casey.

At the initial meeting the following officers were elected: Gordon M. Christine, President; W. F. Wunder, Vice President; H. Paul Holz, Secretary and Treasurer.

The president is authorized to call an international communication conference to consider rates, cable and other questions, under a public bill passed by the Senate and sent to President Wilson. No date is fixed for the conference, which was conceived by representatives of the allies and the United States at the Paris Conference and is expected to deal with disposition of the German cables.

Bronze Victory buttons will be issued by the Navy Department to all persons who served in the reserve or regular Navy in the war. Recruiting stations have been authorized to issue them to all eligible persons now discharged or on inactive duty, and a supplementary distribution will be made from the Bureau of Navigation in Washington. Silver buttons of the same design, it was said, will be issued to those who received wounds during the war.

The Victory button, it was explained, is awarded in addition to the Victory medal, distribution of which is expected to begin shortly.

wild man who talked of making one was promptly dubbed as crazy. His aerial switch, if he used one, was once the switch of an auto coil, with slight changes. Since the "set," as it was always reverently termed, was usually in the shed (the family wouldn't let the thing in the house) a lightning switch was unknown and unnecessary.

For receiving purposes he always began with an 80 ohm phone and a single slide tuning coil wound with bare wire on a rolling pin, with string to space the wire. For detector, silicon was the favorite, though occasionally one would find perikon, perikon-electra, pyron, electrolytic, or galena. Soon he would graduate and build himself a loose-coupler, and buy a single 1000-ohm phone, in which case he was of the elite, and had the "best set in town."

But it was by the aerial that the true ham was really known. It invariably had one pole (of bent eucalyptus) in the backyard for one spreader, with the other attached in some weird manner to the house. It was insulated with everything, from old pop bottles to porcelain cleats salvaged from somewhere, and its wires were anything from the 18 telephone already mentioned to 14 galvanized iron. The spreaders were always at least 16 feet long—sometimes longer, for the ham had been told he could receive farther that way—and held from two to four wires. On such an aerial a true ham could copy NAA during the daytime half way across the continent, and with his Ford coil transmitter would work fifty miles through the worst 99 imaginable. I don't know why a true ham could always work farther than a mere commercial operator, but I suppose it is because he is a ham—for no one else could do it.

The ham's code was never to buy anything under any circumstances. This may have been why his publicly expressed opinion was always against such "trappings" as an Audion. "Such things ain't for us. Look at all the junk you gotta have. A bunch o' batteries, rheostats, and the darn things don't work half the time anyhow. No siree—no such junk in *my* station," he would remark when it was mentioned. Probably if an Audion could be made by him in his own workshop he would have had a seven-step amplifier, if he knew that such a thing existed, but he would absolutely refuse to allow any instrument with the taint of commercialism upon it to enter his station.

I have endeavored to set down the chief characteristics of the famous ham as he was in days gone by, and I have tried to do this in a friendly spirit, for I was a ham myself, and used to jam the ether at four words per by the hour, using about 2 k. w. talking to a fellow in the next block, perfectly oblivious to the BK's from nearby commercial stations. About 90 per cent of the 2 K.W. was used up in heating the interrupter. It was a wonderful life, but the day of the ham is past, and specimens now are few and far between. The place of the ham has been taken by a young, smart Alec who prates wisely of heterodynes, logarithmic decrement, vacuum tube transmitters, the relative efficiency of tuning by capacity and tuning by inductance, and other such things unknown to the simple ham of yesterday. We do not mean to unduly rebuke the present generation of radioists, but the ham was dear to our hearts, and we hated to see him go.

The King is dead—long live the King!

Suggestion for Prize Contest—February Wireless Age

An Original Design for an Antenna Switch

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 above subject by January 31.

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.

G. L. L., St. Anthony, Iowa:

In connection with your query concerning the four-stage amplifier described on page 33 of the April WIRELESS AGE, we suggest that before you spend any money in making up an amplifier incorporating this circuit, you set up one of the circuits to familiarize yourself with its action. Having done this, it will also be possible for you to make comparisons and draw your own conclusions. We regret that we are not in a position to do this for you.

* * *

R. C. A., Long Beach, Calif.:

With reference to the four-stage amplifier described on page 33 of the April issue, your inability to get oscillations on the three stages is due to the fact that the phase displacement or the "timing" of the third valve with reference to the first valve is not as it should be. It will be necessary for you to add a fourth tube, and if it should be desired to add more, it will be necessary to add them in pairs. Any tubes which have approximately the same characteristics are suitable for the hook-up above mentioned, that is, the tubes you select for this work should all operate on the same plate potential and approximately the same filament current. The amount of energy passed in the plate circuit of these tubes is very small and the resistances are sufficiently low to supply the required energy to the plate. It will be possible for you to use a three-stage radio frequency amplifier, but if you do so, it will be necessary for you to supply the oscillations to heterodyne incoming signals in some other way than that described. It might be done, for example, by the use of a fourth tube as an external oscillator.

No matter how many tubes are used, providing they have all been selected with regard to similarity of characteristics, the plate battery required will be the same. In connecting up three-element tubes, it is the custom to join the negative side of the high potential battery to the positive side of the filament battery as has been indicated in the diagram on page 33, April WIRELESS AGE.

The idea in supplying a local grid battery is to enable one to charge the grid negatively, in which case the negative terminal of the battery, of course, would be connected to the grid and the positive terminal to the filament.

We regret that we are unable to give you any comparisons which would be of more value to you than the comparisons between the various circuits which you are able to make for yourself. Using four tubes instead of three with the circuit, however, should increase your range considerably.

The Rogers underground antenna has no merits which would appeal to the amateur in particular. As we understand it, it has been originated in the belief that it aids materially at times in securing a better signal to static ratio. The energy picked up by such an arrangement, however, is very small in comparison to the energy picked up by an overhead antenna, and generally speaking, is not apt to become popular with the experimenter.

* * *

W. R. R., Pelham, N. Y.:

With reference to the fourth prize article in the July, 1917, issue, we regret that we are unable to tell you where to get gem salts or Peeble's powder. It may be that Mr. McIlvaine will see this query and supply you with the information. We are unable to find his present address. We presume that white wood or bass wood would take the finish described fully as well as, if not better than, cypress.

* * *

A. R., Scottville, Mich.:

Approximate fundamental wavelength of an antenna may be obtained by multiplying the length of the antenna plus lead-in, plus ground connection, in feet, by 4, which will give the wavelength in feet. For reduction to meters, the result should be divided by 3.3.

The fundamental wavelength of a four-wire aerial spaced 32 inches, which is 80 ft. in length and having a 30 ft. lead-in and a 15 ft. ground, is approximately 150 meters.

* * *

A. T. S., Betheny, Nebr.:

The condensers C-4 shown in the circuit on page 33 of the April Wireless Age have a value of .005 mf. each. The ordinary stopping condenser, as sold for use in crystal detector circuits, will serve the purpose admirably, or you may make one by cutting two strips of tin foil 2 inches in width and about 14 inches in length, the two to be separated by paraffin paper 2½ mils in thickness, and wound up until the whole forms a unit about 2½ inches in length by 1¼ inches in width.

With reference to the multi-layered receiving transformer described on page 34 of the September issue, this type of transformer will probably prove more efficient on the longer wavelengths than the usual single-layered solenoid.

* * *

A. C. C., Oneida, N. Y.:

The Armstrong receiving set described on page 39 of the February Wireless Age, was designed for 200 to 600-meter work. The 50 turns of wire need not necessarily have a tap taken off every turn, but if it is desired to do this, it may be accomplished by making a loop of wire long enough to reach the switch for every turn and tying the loop together tightly at the point where it leaves the coil with thread. After the coil has been wound, under these circumstances, it should be carefuly varnished.

It would not make a great deal of differ-

ence whether you used a 100 ft. aerial or an 80 ft. aerial in connection with a short wave receiver. It would only be necessary in the case of the longer one to compensate for its additional length by the use of a smaller value of series tuning condenser.

With reference to the article on page 41 of the April issue, it will be all right for you to substitute single silk covered wire for the donble silk covered wire called for.

This also applies to your question concerning the article in the May issne. You would probably get best resnlts by using either of the receivers described in the February and May issues.

* * *

H. W. S., Binghamton, N. Y.:

We see no reason why you are unable to get results with the cabinet set when working with your antenna. It would be better if you used solid copper wire instead of copper clad, but this should not entirely prevent your getting some results. Look for loose connections, or it may be that the dimensions of the aerial on which the set was tested are entirely different from the dimensions of your own aerial which might, depending upon the set itself, make considerable difference. The wavelength of your aerial is approximately 170 meters. The manufacturers of the receiver should be willing to help you out.

* * *

A. B., Hartford, Conn.:

We have noted your diagram and find nothing wrong with it providing you leave out your 15,000 meter loading coil. It will not be possible for you to tune to 15,000 meters by the use of a loading coil in conjunction with the loose coupler which you describe. In order to reach this wavelength and to receive undamped waves, you should provide yourself with coils similar to those described in recent issues of the WIRELESS AGE, and a Marconi vacuum tube.

"Practical Wireless Telegraphy" by E. E. Bucher, will thoroughly explain damped and undamped waves, and tuning. This will be supplied to you upon application to the Wireless Press, Inc., 64 Broad Street, New York City.

With the outfit which you now have, you should be able to receive upwards of 100 miles. We cannot tell you exactly because you have told us nothing concerning the dimensions of your aerial.

* * *

R. D. W., Plainfield, N. J.:

With reference to your query on page 44 of the July WIRELESS AGE, Mr. Allen C. Rockwood, of the Iowa State University, advises that radiosite consists of specially selected crystals of iron pyrites. We are also informed that lenzite is generally known as iron faced galena.

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C. H. McS., Pittsburgh, Pa.:
The honeycomb coils seem to be very popular with amateurs generally. They can be purchased separately, we believe, and refer you to the advertisements.

The only vacuum tube on the market is the Marconi vacuum tube. Vacuum tubes of the types used by the Navy and Army cannot be purchased.

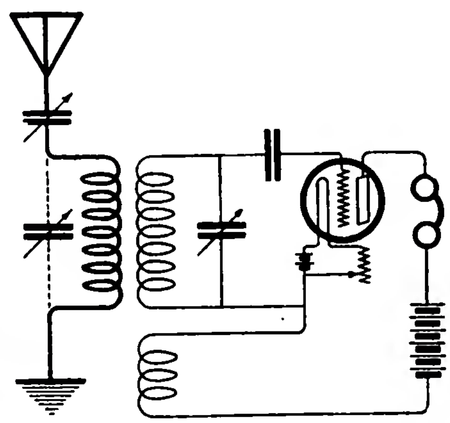
No special hook-up is required for the reception of wireless telephone speech, and vernier condensers are not necessary in order to tune in radio telephone signals.

In reply to your fourth question, we again refer you to the advertisements.

* * *

R. R., Wapinitia, Ore.:
In addition to the vacuum tube and the honeycomb coils you will need two variable condensers, having a capacity each of approximately .001 mfd. A storage battery for lighting the vacuum tube, a battery of dry cells giving you about 30 volts for feeding the plate circuit, a ten ohm rheostat for adjusting the filament temperature, and a pair of telephones.

A diagram of connections is shown below:



H. H., Atlantic City, N. J.:
Most spark coils give a scratchy note because of the fact that the vibrator either is not or cannot be properly adjusted. Best results are obtained from a spark coil when the note emitted is smooth and musical. The pitch of it does not matter so much, but usually best results are had with medium low pitch. This can only be obtained by experiment.

The single wire aerial, 300 ft. long and 40 ft. in height, may be used for transmitting with a 1½ in. spark coil. It is, however, too large for best results, and in addition to this, the wavelength would be in the neighborhood of 500 meters. The natural wavelength of the aerial is about 450 meters.

* * *

E. H. K., Detroit, Mich.:
Arlington sends out time signals at 9 P. M. Detroit time.

The natural wavelength of a four-wire antenna, 55 ft. long, and 35 ft. in height, with a 7 ft. lead-in, would be approximately 135 meters.

* * *

R. Y., Toronto, Ont.:
The hook-up which you have forwarded us is not a particularly good one for your purpose. In case you wish to use it, the bridging condenser around the telephones is not absolutely essential, although the range over which oscillations are available with your hook-up should be materially increased by its use.

The tickler coil design which you ask about is not suitable for long wave work. For data on the construction of long wave receivers we suggest that you read carefully the prize articles printed in the September Wireless Age.

The grid leak may be connected in shunt to the grid condenser, provided the lower terminal of the secondary of the coupler is connected to the negative terminal of the lighting battery, or it may be connected direct from the grid to the negative terminal of the lighting battery.

If your vacuum tube functions properly, the fact that the plate is a little out of line will not in any way affect your results.

* * *

W. G., Burlington, Iowa:

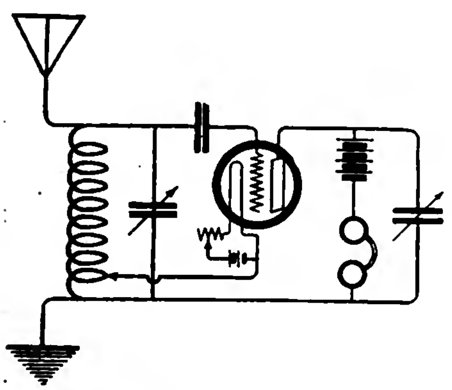
We regret that we are unable to give you the address of anyone who makes the double filament auto headlight bulbs. Such a bulb could, no doubt, be used for the rectification of alternating current at voltages depending upon the insulation between the two filaments, but we are inclined to believe that electrodes so small as these would necessarily be, would not work at all efficiently. An electrolytic rectifier would in all probability give trouble at 400 volts, particularly if an effort were made to draw any considerable amount of current through it. We regret that we have had no experience with electrolytic rectifiers at voltages higher than 100.

* * *

C. R. U., Rutherford, N. J.:

The diagram which you show would not be an efficient receiver for undamped long wave stations. If you desire to use a single coil, connect your apparatus as per diagram herewith.

The vacuum tube which you mention as being 3" in diameter and having plates 3/4" by about 1 5-16" could be used as a rectifier on 60 cycles, 110 volts, connected as per hook-up shown below.



A. R., Scottville, Mich.:

Question 1—The charges on all radiograms are collected at the office of origin, in U. S. currency. The charges will depend upon who controls the radio station on the ship that relays the message. As an illustration: On a ship equipped with Marconi apparatus and controlled by the Marconi Company, the ship tax will be four cents a word; relayed through a ship not equipped and controlled by the Marconi Company, there is a relay charge equal to the ship tax of the relaying ship, generally four cents a word. There is then the coast tax at the New York station controlled by the U. S. Navy, six cents a word. To this must be added a Western Union forwarding charge from the Naval station in New York to the point of destination. Should the relaying ship be controlled by the same company as the office of origin, there would be no charge for relaying the message.

Question 2—A message is seldom relayed through a number of ships as the operator at the office of origin must route his message to shore before sending, in order to be able to compute the charges. If a message must be relayed and it cannot be done in one relay, the message is usually not accepted from the public until the ship can establish better communication. In this case, question one answers number two.

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