May, 1920 20 Cents

The WIRELESS AGE

Volume 7 Number 8

Members of Congress Sitting as a Committee on Army Appropriations Get Their Data by Radio 'Phone

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The Design of Multi-Stage Vacuum Tube Receiving Circuits

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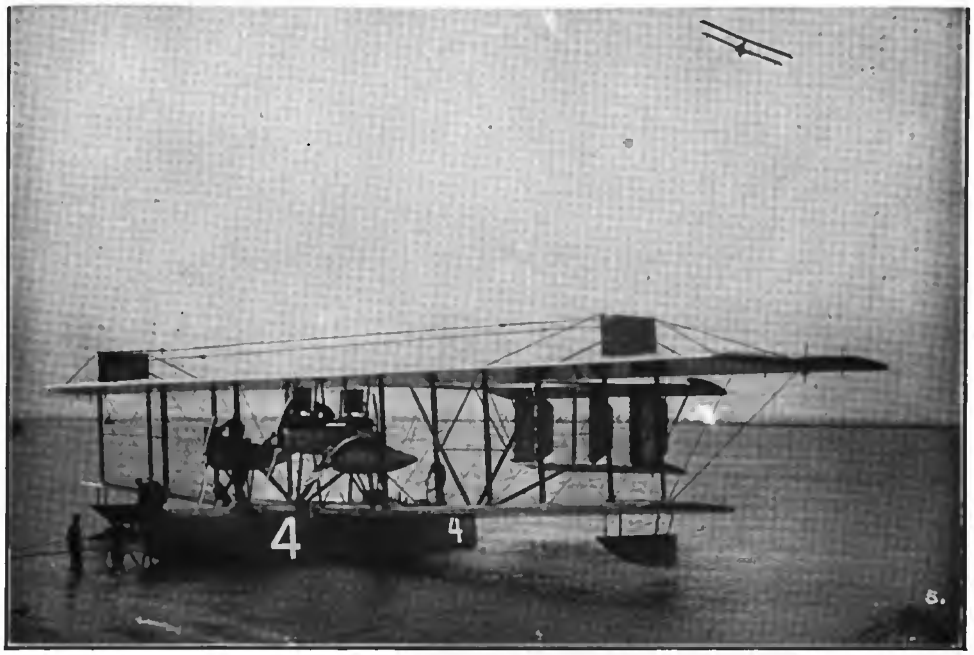
Extract from New York World, June 3, 1919.



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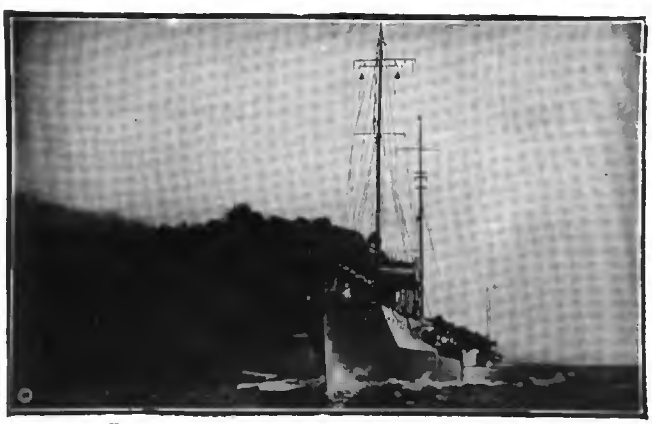

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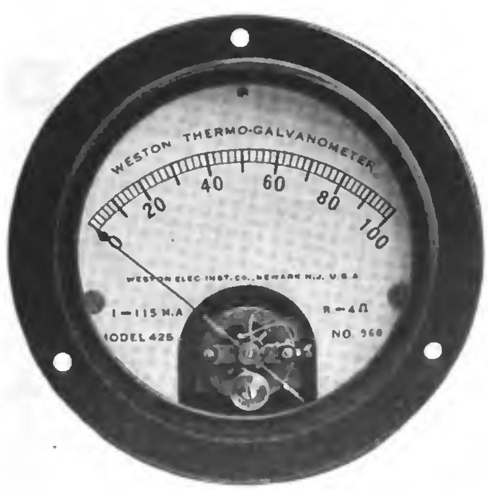

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Vol. 7 Contents of **The Wireless Age** for May, 1920 No. 8

Edited by J. ANDREW WHITE

Advertisements

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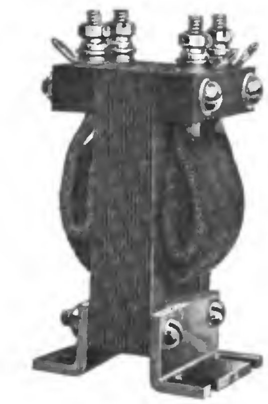

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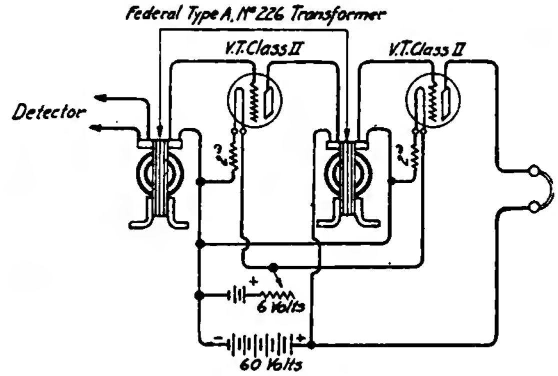

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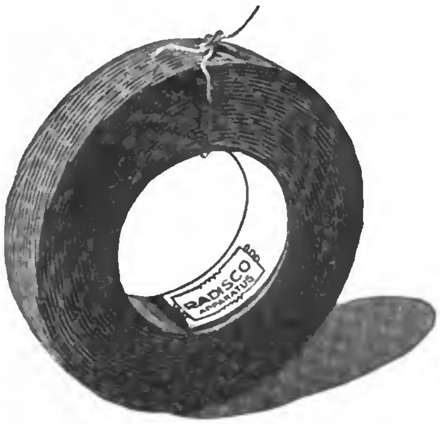

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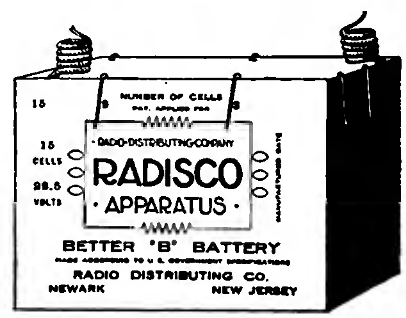

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May 1st, 1920.

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Our contention that there exists a large and growing demand on the part of the high grade amateur, experimenter, college and laboratory for radio apparatus of the same grade of design, workmanship and material as is demanded and secured by the United States Navy has been amply proven by the ever increasing volume of orders which we are receiving direct from the user. While everybody cannot pay the price for this type of equipment, the fact remains that practically all who see our apparatus find ways and means of buying it because they realize that it is far more economical and satisfactory in the long run to possess the best that can be had as regards design and workmanship and they are generally willing to follow the Navy's lead in this respect.

Heretofore no effort on our part has been made to put this equipment before the amateurs and experimenters through dealers because our commercial, Government and foreign orders have occupied our constant attention.

We feel, however, that the amateur and experimenter of today is the commercial or Government employee of tomorrow and that it is to his and our benefit that he now become acquainted with the type of apparatus he must eventually use, even though it costs a little more than the typically amateurish apparatus with which the country is flooded.

If you believe as we do and if you are the best, or on a par with the best,dealer in your territory, we have an interesting proposal whereby you may secure the exclusive agency for our equipment.

We recently tried out this idea by giving our exclusive agency for a large Eastern city to a live-wire dealer. The results were immediate and phenomenal. Orders are pouring in and, if we had a few more dealers like him in the principal cities of the country, we feel sure that our amateur and experimental trade would soon rival our commercial and Government business, the same apparatus being sold to both trades.

Are you such a dealer? If so, write us.

Yours very truly,

WIRELESS IMPROVEMENT COMPANY
Radio Engineers, Manufacturers and Distributors
47 West Street, New York, U. S. A.

If this page is cut out and appended to the same page cut from the editions to follow, a complete file of very interesting information will soon be available. (No. 5)

Vol. 7. No. 8. MAY, 1920

THE WIRELESS AGE

WORLD WIDE WIRELESS

Marconi Leaves On Testing Trip in Mediterranean

GUGLIELMO MARCONI is working out the details of an invention which will enable wireless stations to tell the exact location of any ship that reports herself in distress. Mr. Marconi has begun a cruise in the Mediterranean to make tests.

Mr. Marconi was asked if he would attempt to communicate with Mars, as was recently reported. He replied:

"No effort will be made to send wireless communications to Mars or receive them. Our vessel will be equipped with sending apparatus having a radius of 3,000 miles only. We are taking two sets for experimental purposes. One is of ½ a kilowatt strength, with a radius of 300 miles for telephone and 500 miles for telegraph. The second is of 3 kilowatts strength, with a radius of 1,000 miles for telephone and 3,000 miles for telegraph.

"I am more interested at this time in practical development of the wireless telephone than vague electrical impulses which may come from wireless apparatus on some other planet. However, the experimental laboratory is keeping in close touch with such phenomena, and when it occurs notes are being taken, in an effort to determine the source and meaning of the wireless waves.

"We hope that soon lighthouses and ships can be equipped with instruments that will enable them to tell precisely the location of any ship at sea that reports herself helpless."

Radiophone an Aid to Legislation at Washington

A RADIO telephone was used to gather information for members of Congress at Washington when the hearings were held on the Army Appropriation bill before the House Military Affairs Committee. It was the first time on record that the new invention was used for such a purpose.

Whenever a question arose on which the committee desired information Major General Lord, Chief Finance Officer of the Army, was called on the radiophone. Headgear was provided for all members of the committee so they could hear the questions and answers.

Music by Radiophone From San Francisco to Victoria, B. C.

E. A. HAUGHTON, radio superintendent of the Canadian Government, reports that he was recently working on a long wave length in his wireless station in Victoria, British Columbia, when he heard the following conversation:

"Hello, Point Arguello. This is San Francisco. Wait a moment and I'll play you a record."

Haughton then heard a record of "The Star-Spangled Banner" played.

Radiophone Service Between England and Holland

WIRELESS telephone communication between England and Holland is about to be opened. Results with test calls have been excellent, it is announced, conversations having been carried on up to a distance of 1,200 miles.

Radio Service for Wanamaker Stores

AFTER being out of operation since April, 1917, the wireless station on the roof of the John Wanamaker store in Philadelphia has been restored and is ready for regular communication with the New York store.

All the hurry-up messages necessary between the two stores will be sent regularly by wireless instead of by telegraph. The antennae for the receiving of messages are 350 feet from the the ground, the poles being 130 feet high from the roof of the building. The wireless equipment installed is largely that which was dismantled at the beginning of the war. Testing or "tuning up" was done under the direction of E. M. Hartley, district manager for the Radio Corporation of America.

Rogers Honored by Maryland Assembly

DR. J. HARRIS ROGERS, of Hyattsville, Md., developer of underground and underwater radio, has been extended a vote of thanks in a joint resolution unanimously adopted by the Maryland State Assembly. The resolution was introduced in the Senate by Oliver Metzerott and in the House by Clarence Roberts.

General Electric Company's Radio Report

THE pamphlet report of the General Electric Company for 1919, which has just been issued, contains the following statement by C. A. Coffin, Chairman of the Board:

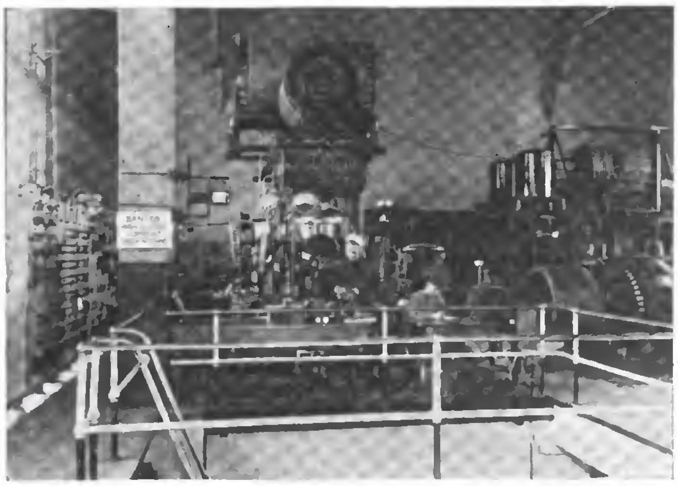
"Your company has for several years been engaged in its research laboratories and factories in the development and manufacture of apparatus and devices essential to the transmission and reception of wireless communications. Its inventions have had a far-reaching effect on the entire radio art. The Marconi Wireless Telegraph Company of America is also the owner of valuable patents, rights and licenses, and it has seemed wise to the Boards of Directors of both companies that their research and engineering resources should hereafter be used in closest co-operation. To this end, and in order to secure the benefits of the long and varied electrical manufacturing experience of the General Company on the one hand and the operating experience of the Marconi Company on the other, a new company has been formed, known as the Radio Corporation of America, in which both your company and the Marconi Company have accepted a considerable participation."

Wireless Operators Needed for Alaska

LIEUT. COL. F. B. SHAW, chief of Army recruiting in Boston, has been urged by the War Department to recruit radio and telegraph operators for the Signal Corps, for service in Alaska. Men accepted in New England will be instructed at Camp Alfred Vail, Little Silver, N. J., and sent to Alaska promptly.

Oriental Radio Rates Reduced

THE Radio Corporation of America announces that the rate for wireless dispatches between San Francisco and Japan were reduced from 80 to 72 cents a word, beginning April 1.



General view of the power room of the Arlington station showing switchboards at left and the 30 kw. arc transmitter at top

Japan Erects Tall Concrete Wireless Masts

THE highest concrete poles in the world (650 feet) are being erected at Tomioka-cho, in Fukushima Prefecture, Japan, for the new wireless stations which will be opened soon, especially for communication between Japan and the United States. One station will receive and the other will send. The capacity each way is about 8,000 words a day.

Vancouver-Victoria, B. C., Radiophone Service Opens

THE Marconi Company of Canada has installed a wireless telephone apparatus at Vancouver, B. C. and at Victoria and will open a service within a few days. The plant has a radius of over 500 miles. It is planned to place stations throughout Canada. The success of the Montreal Rimouski experiment has led to the present development in this branch of utility.

Resumption of Radio Service Pleases San Francisco Business Men

SHIPPING men, operators, exporters and importers announce that the resumption of the wireless service by the Radio Corporation of America will prove an advantage to all concerned and that it will be possible to get messages through between this country and the Far East with the same degree of regularity that obtained before the war. Instead of waiting three weeks for replies, it will be possible to get returns in two and three days at most. This will have a beneficial effect upon all overseas shipping and will stimulate the movement of commerce and the sale of merchandise.

Wireless on Chinese Wall Unite Ancient and Modern Wonders

A REINFORCED concrete wireless mast of large dimensions has been erected upon the Chinese wall for the use of the American navy. It is 164 feet in height. The original program called for the making of the mast by the precast method in two parts, and then erecting them by means of derricks, but an accident occurred while the erection was taking place and an American engineer and four coolies were killed. The method of forming in molds was then tried, and although it was much more expensive than the other, it was successfully carried out.

English Use Wireless for Police in Ireland

IN consequence of the frequency with which telephone and telegraph wires in Ireland are being cut out, the government has decided on an extensive use of wireless telephony there, says the Daily Mail, London.

Naval signal men are being employed to start the system, and the newspaper intimates that portable telephones with a radius of about thirty miles are being employed in transmitting messages from one police station to another or between adjacent towns. It is asserted that the system has proved satisfactory.

Oregon Pilot Commissioners Want Wireless Service

THE Oregon State Board of Pilot Commissioners voted at a meeting to ask the Port of Portland Commission to restore the radio apparatus and service of the bar tug Oneonta. The bar tug's radio set, which was of considerable assistance in receiving reports of vessels in distress off the Oregon coast or reaching the mouth of the Columbia in need of a pilot, was dismantled with the outbreak of the war and has not been replaced.

As the radio station at North Head is operated by the United States navy, all messages received by it are relayed to the Bremerton navy yard before they are placed on a commercial wire, and some complaint has been made that the service thus is not so rapid as it might be. The board of pilot commissioners, acting on this matter, joined the Astoria port commission in asking the navy department that some change be made to facilitate the radio service.

Wireless Withstands Effects of Aurora Borealis in New York

THE Aurora Borealis, or Northern lights, made a brilliant display in the heavens in New York recently and up to 2 o'clock in the morning the wonderful streamers danced, shivered and waved over nearly the whole visible sky. The display appeared more vivid and strong in the north and northwest, but the banners of mystic light repeatedly shot up to the zenith, or uppermost part of the celestial sphere, where they met in an apex or hub.

As usual, the effects of the aurora was promptly felt in the offices of cable, telephone and telegraph companies, communication being seriously interfered with. Wireless service was also affected, but in a less degree.

The aurora, which is seldom visible in New York skies, is a common spectacle in Arctic regions.

Scientists have little to say in explanation of its occurrence, except that it is the result of magnetic activity in the upper region of the earth's atmosphere, these disturbances, in turn, being mysteriously associated with the frequency of sun spots.

Wireless Concert Aboard the Mauretania

W. S. TODD, of Hartford, Conn., who has just returned from a trip to England and Scotland, says that the Steamship Mauretania had a unique experience before leaving Southampton on her last voyage. A wireless message was received by her captain from the Marconi works at Chelmsford, Essex, as follows: "Hear demonstration of wireless telephone from the Marconi works, Chelmsford."

The Cunard Bulletin, issued while the Mauretania was en route for New York, contained the following description of that concert.

"There followed immediately a summary of the day's news and the listeners on board the ship were asked to 'wait a minute.' Suddenly, the voice of a soprano singing 'Land of Hope and Glory' was heard distinctly, followed by a rich baritone who rendered 'The Trumpeter.' A violin solo was clear and resonant, as was the voice of the lady who sang 'There's an Old-Fashioned House in an Old-Fashioned Town.' The little concert closed with the national anthem played on the cornet. Then the call: 'How did you enjoy the concert? The Marconi works are closing for the night but another demonstration will be concluded to-morrow morning at 11:15, Greenwich time. Good night!'

"Although only six ear pieces were used in the cabin on board the ship, it was possible for six other persons to overhear the demonstration distinctly. The voices were almost too loud, but that may have been due to the extreme sensitiveness of the ship's installation.

"At the time the concert was held, the Mauretania was 100 miles away from the works."

Charlestown Navy Yard to Use Radiophone

IN order to expedite conversations between naval ships coming in and going out a wireless telephone has been established at the Charlestown navy yard. It frequently happens that commanding officers of ships desire to talk with the commandant of the yard and they have to resort to the wireless. The telephone will have a speaking radius of 10 miles during the day time.

Destitute Austrian Operators Appeal for Aid

AN appeal to brother wireless operators has been received from the Austrians at the Deutschenburg Station and the following radiogram sent via Lyons, France, to the Ottercliff Station:

> "In sorrowful condition of nourishment in Austria we beg the American wireless operators as commands to help us with Dollapackets. None of us have relations in the United States, but each of us has been very often with the ex-Austrian steamers as wireless operators. The number of members of this wireless station is sixteen. With foremost thanks,
>
> THE WIRELESS OPERATORS OF THE AUSTRIAN STATION DEUTSCHENBURG."

This is a humane appeal which many of the wireless operators are going to answer. A substantial fund has already been collected. All readers of THE WIRELESS AGE are invited to help out.

The "Dollapackets" contain a dollar's worth of food—and the Austrian operators need food badly. Further comments are unnecessary.

Let us show them by quick action that the American radio men are really and truly the foremost members of the great fraternity of men who never fail—especially where an S.O.S. call of distress commands their action. This is obviously a call of distress.

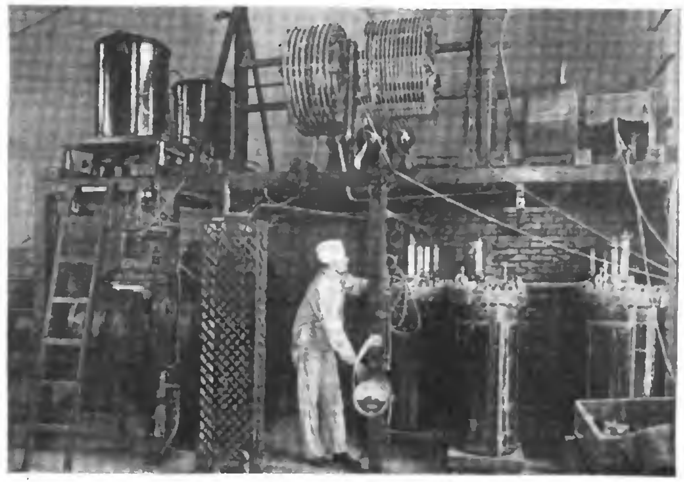
Those who would like to be of some service to the suffering radioists abroad are invited to send their contributions to the "Dollapacket Fund," c/o THE WIRELESS AGE.

Senate Passes Radio Bill

SENATOR POINDEXTER'S bill authorizing the Navy Department to operate certain radio stations for transmission of press and commercial messages was passed by the Senate March 10 without a record vote after it had been amended to provide that private business should not be handled at less than cost.

Senator Phelan, Democrat, California, put into the record a letter from Secretary Daniels urging some such legislation, and one from V. S. McClatchy, of the Sacramento Bee, declaring that provision for transmission of news to the Orient at a low rate would be a powerful factor in promoting good relations with Japan.

The bill expressly provides, Senator Poindexter pointed out, that special low rates be established for press dispatches.



Section of the power room showing 100 kw. spark transmitter of the U. S. naval high power station at Arlington

American Marconi Company Dissolved

STOCKHOLDERS of the Marconi Wireless Telegraph Co. of America at a special meeting held April 6, voted to dissolve the company. This action finally concludes a plan whereby the assets of the Marconi Wireless Telegraph Co. with certain exceptions, are to be taken over by the Radio Corporation of America. Henceforth the business of the company will be conducted under the latter name.

President Wilson's Wireless to Open Air Meet

PRESIDENT WILSON will officially open the third Pan-American Aeronautical Congress on the Steel Pier, Atlantic City, N. J., and at the Airport beginning May 20.

A wireless plant is being installed on the end of the pier, where the flash from the White House will be received at 3 P. M. on the opening day. Wireless greetings also will come from government heads of several South American republics, where aviation now is popular.

Legion's Radio Intelligence Post Making Progress

THE third meeting of the Radio Intelligence Post of the American Legion was held in New York City. Men were present who had traveled many miles to attend, but all agreed that it was worth it.

All former members of the Radio Intelligence Department, either in service abroad or at home, and who wish to get in touch with their former pals are cordially urged to communicate with the acting secretary of the post, Arthur L. Bernhard, 1679 42d Street, Brooklyn, New York.

Visualizing the Unseen

By Jerome Lachenbruch

A FEW hundred feet of film, a motion picture camera and an artist with imagination and ingenuity are solving the intricate problems of electricity for the beginner. The various phases of electricity have been visualized on the motion picture screen so that any one may understand them. The principle of induction, the working of the wireless telegraph and telephone, and many other phases of the subject are now being shown to the general public; also they form part of the curriculum of instruction in many elementary and secondary schools.

E. Lyle Goldman, of the Bray studios drawing the background for one of the electrical animated drawings

Strange as it may seem, the visualization of electrical topics is a direct development of the process by which the animated cartoon is made. A few years ago John R. Bray, a Brooklyn newspaper cartoonist, discovered that by making a series of cartoon drawings and photographing them on a motion picture film, he could produce the appearance of cartoons in motion. In his first attempt he drew about 10,000 individual pictures, worked for about ten months and then saw his arduous work reeled off in about ten minutes. He realized that the work was impractical if done in this way and began to study ways to simplify the method. After several weeks of analytical study, Mr. Bray discovered that many different motions may be represented by the same bodily action. For instance, the delivery of a blow, represented by the arm drawn back, is very similar to the motion executed in throwing a baseball. Consequently, when these two motions are to be shown in the same picture, the drawings are not duplicated. They are simply photographed on the motion picture film in their proper order. Furthermore, it was learned that many motions require only a change in part of the figure, say the arms or the legs. And so a cartoon figure may go through several movements without changing the position of the body. In utilizing this fact, Mr. Bray drew a man's body, then on another sheet of paper his legs, and when the legs changed position he drew them in the new position. By superimposing the second drawing over the first picture of the body, a new complete figure appeared. This eliminated the drawing of thousands of lines and avoided immeasurable duplication in the making of the original drawings. Now, only about 1,500 drawings are necessary to make an animated cartoon.

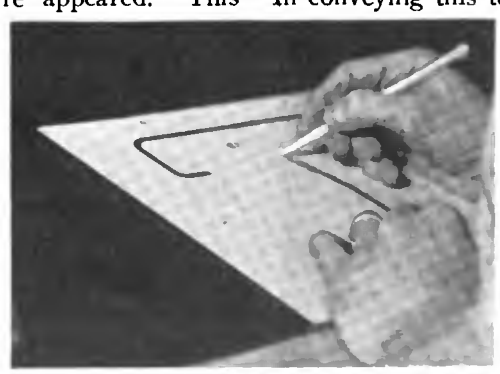
The original drawings are made on transparent paper and are traced on transparent composition plates which are then photographed by an inverted motion picture camera set up on a rigid frame above a table. An ingenious arrangement of gears and small linked chains carries the control of the motion picture camera to a pedal beneath the photographing table which the photographer operates with his foot. At every pressure of the pedal the shutter opens for a measured length of time. Of course, on the table is a frame to which Cooper Hewitt lights are fastened.

Every drawing is numbered and when each is photographed a little indicator, similar to a speedometer in its action, records the number of drawings that have been thus far photographed. The developing and printing of the negative follows the same process undergone by films taken from living figures.

The accompanying photographic diagrams give an idea of the method by which the animated technical drawings are made. Figure 1 shows a battery, upon which is mounted an iron core wound with two coils of wire of different thicknesses. It will be observed that the heavier wire has fewer turns than the finer coil.

The action indicated is an excerpt from the way in which the principle of induction is taught by the "movies." When the connection is made at A, the current flows through the heavy wire, or, technically, the primary winding. In showing this on the screen, figure 1, which is a drawing made on a dark grey cardboard and used as a background for the succeeding pictures, is photographed first.

The phenomenon resulting from the closing of the circuit is twofold. First, a current is set up in the primary winding; secondly, a magnetic field is built up about the core. This fact is conveyed in a title, and is followed on the screen by figure 2, showing the current passing through the primary, then figure 3, showing a magnetic field and the apparent "flow" of the magnetic lines of force. Here the relationship between magnetism and electricity is explained. In the diagram, the lines of force are shown to "flow" all about the core; and the direction of the course of the magnetic lines from north to south through the air is indicated by moving arrows. In conveying this to the screen, the artist who made the drawings made several similar drawings showing the arrows in slightly different positions. When these were photographed on the motion picture film the effect was similar to the flickering which we are all familiar with, securing an effect on the screen of the constant activity of the electro-magnetic field. The diagram of the electro-magnetic field is a photograph of the original background with two transparent plates superimposed upon it.



Close-up showing the background of an animated technical drawing

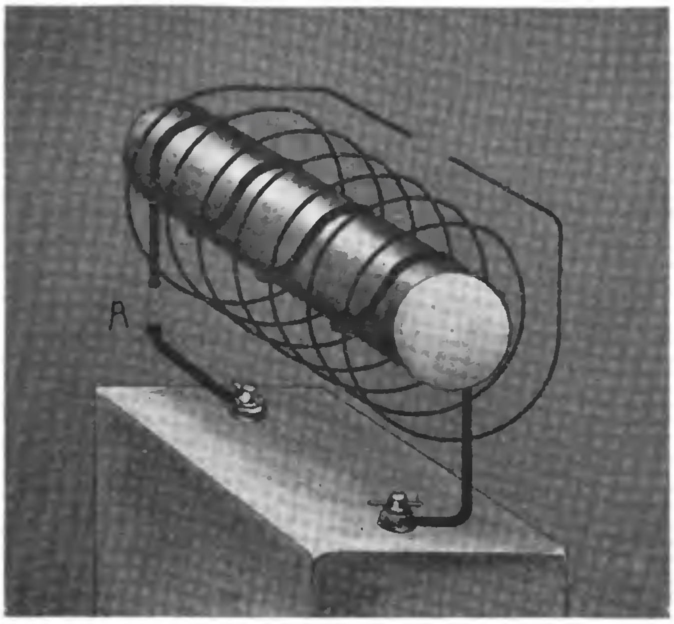


Figure 1—Iron core wound with two sizes of wire mounted upon a battery

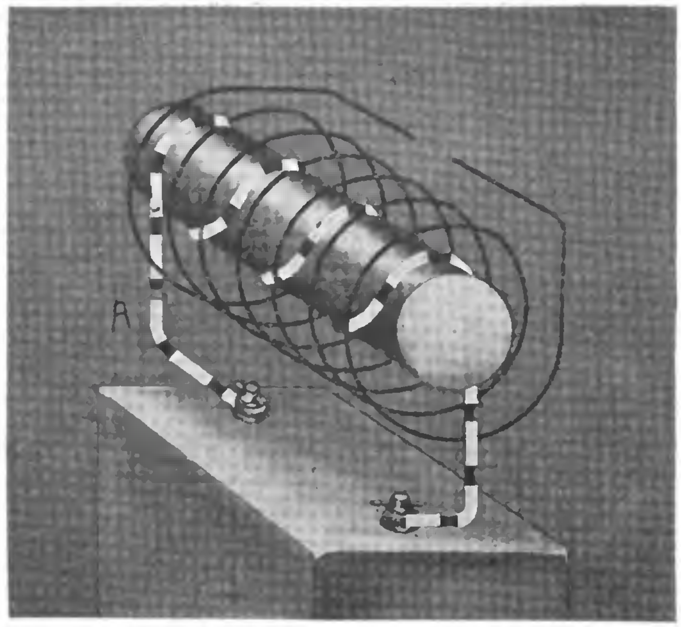


Figure 2—The battery or primary current passing through the primary coil

In following the electrical action further, the contact at A is broken and the electro-magnetic field immediately collapses. What happens now is told in another title that explains, in a few words, the principle of induced currents. The building up and breaking down of magnetic fields constantly results in currents being induced from the primary winding to the secondary. In the motion picture portraying this phenomenon, the current is seen now in the coil of fine wire, the secondary winding. Figure 4 shows this clearly.

It is an electrical fact that a current induced as shown in the figure has its voltage increased and its amperage reduced. This is a principle that has made wireless telegraphy possible, because it permits of the creation of high frequency currents.

But to return to our diagram. The voltage in the secondary is now much greater than it was in the primary winding. This is proved by the fact that it has a potential, or electrical, pressure sufficiently great to enable it to jump the gap and make a completed circuit. The gap, of course, is a familiar contrivance in wireless hook-ups. And here, in the animated technical drawing, its fundamental uses are explained.

Another most important elementary principle of electricity elucidated by the animated technical drawing is the action of the condenser as used in connection with a circuit breaker. This is of particular interest to the student of wireless telegraphy, for the condenser is a storehouse of electrical energy, and in the wireless set is indispensable. The circuit breaker acts as a danger signal by flying open and breaking the flow of the current in case anything goes wrong in the circuit.

To apply the action of the condenser to the screen, the flow of the current in an electrical circuit is shown by means of a series of individual drawings, each differing very slightly from the other. This produces the effect of movement. As a background, a fundamental diagram of a condenser is shown connected with a circuit breaker. The circuit breaker is not drawn on the background, but is a cardboard cutout attached to the background by pins. The various positions of the circuit breaker in opening the line are obtained by moving the dummy by hand and

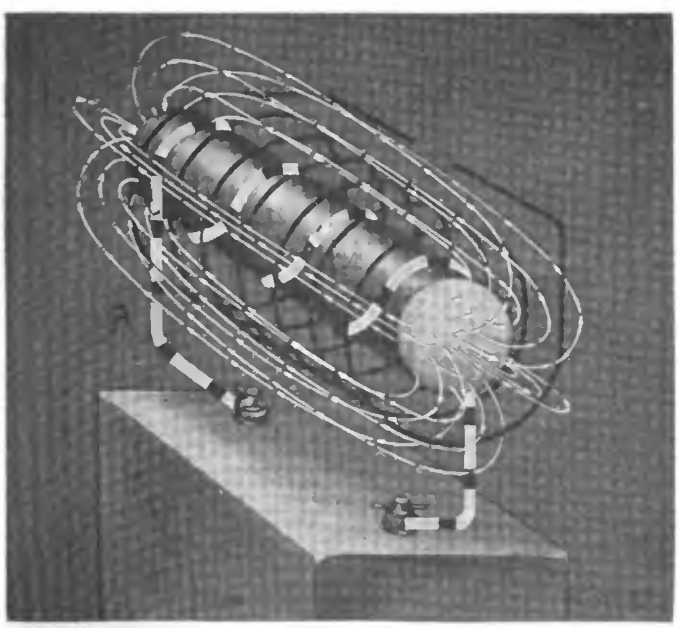


Figure 3—The magnetic field produced by the flow of primary current

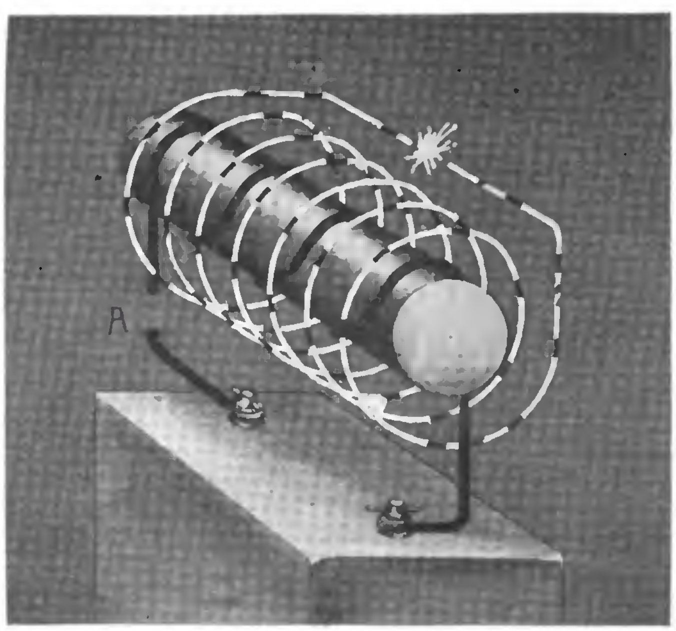


Figure 4—Primary broken at A and induced current in secondary jumping the spark gap

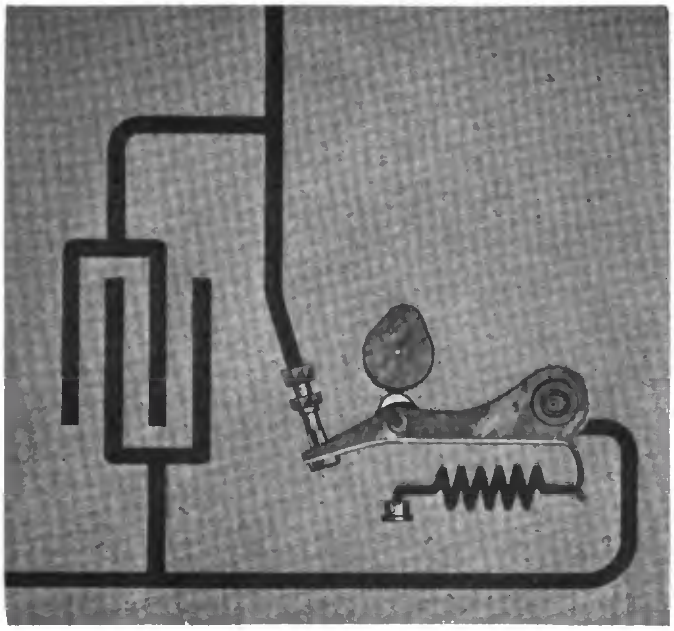


Figure 5—Electrical circuit with circuit breaker and condenser connected

photographing it during the different stages of its action.

The circuit breaker is shown to operate by means of a spring; but to represent the spring in the act of springing many individual drawings of the spring had to be made, otherwise the action as shown on the screen would appear as a jerk. In order to obtain smoothness, the various parts of the diagram that are supposed to move must be drawn in their different positions while the circuit is breaking, and each drawing then photographed on the motion picture film.

Let us assume that the current is running smoothly through the line. In this arrangement the circuit breaker is closed. The dashes in the photographic diagram suggest the course of the current flow. It will be seen that the condenser is not in use, and the point of the cam, which operates the circuit breaker, is turned upward. To obtain this effect on the screen, three drawings were necessary. The first was a background showing the dummy circuit breaker and the general outline of the electrical circuit, together with the condenser. Then a drawing of the spring was made, traced on a transparent composition plate and laid on top of the background, with the result shown in figure 5. Finally, the dashes representing the current were drawn, and the three photographed together, the completed picture being shown in the diagram, figure 6. Now, to make the lesson move on the screen, the plate showing the spring when the circuit breaker is closed is removed as well as the plate indicating the course of the electric current.

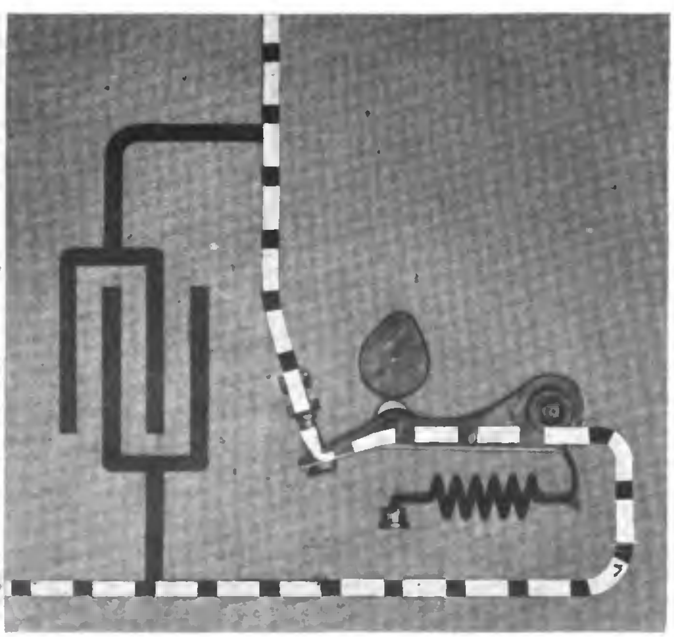


Figure 6—Circuit breaker closed, permitting flow of current

For the next series of drawings, the same background is used. But instead of the first drawing of a spring, another, in a slightly different state of tension, is drawn and placed over the background. Then the cam of the dummy circuit breaker is moved by hand, so that the breaker opens the line and the current flow is seen to be interrupted. See figure 7. Here a title is inserted to state that when the line is open the current flows into the condenser. In order to show this, another drawing of dashes is made to fit over the condenser drawing of the background. What would happen if the line opened and there was no condenser to catch the surplus current is shown by a spark jumping across the opened circuit. This involves several other drawings.

This elementary electrical instruction is invaluable in the teaching of wireless telegraphy. From such fundamentals, the Bray Studios have progressed to the point of teaching how the wireless telegraph operates. For example, most students who are interested in this phase of electricity know that electro-magnetic waves radiate in all directions, yet follow the general course of the earth's surface. Now, the best way to teach an unknown thing is to compare it to a known one and then to show in what particulars the new fact to be taught differs from the thing known. So, in animating the principle of wireless telegraphy, the movie artists have gone back to two known facts: one, the electric bell and the action of sound waves; and two, the ripples on the surface of a lake made by a stone being thrown into the water. This natural phenomenon is understood by everybody; so the comparison between the ever-widening circles on the surface of the water and the electric-magnetic waves of the wireless brings the general principle to the understanding of the masses. Coming closer to the subject, the electric bell comparison tells a similar story, but adds to it by showing that sound waves act like water ripples and also like electro-magnetic waves. In visualizing this, an electric bell in the act of striking is seen to send off waves in ever-widening concentric circles.

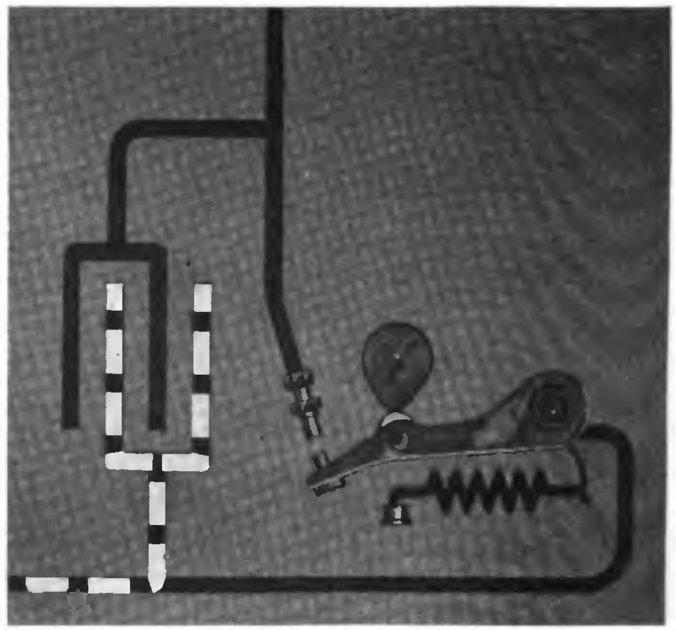


Figure 7—Circuit breaker open and interrupted current flowing into the condenser

But to amplify on the examples, the difference between sound and electro-magnetic waves must be emphasized. This is done by showing a boy shouting, and flashing the fact, in a title, that his voice carries only about a quarter of a mile under the best conditions. The sound waves emanating from his mouth are represented in the form of very short waves. Now the far greater length of the electro-magnetic wave is shown in animated form, and the fact stated that these waves are carried by the ether for thousands of miles. When the possibility of transporting electro-magnetic waves has been established, the construction of various pieces of apparatus is taken up in detail.

The generation of high frequency currents, and their oscillation in the closed circuit until they jump the gap (see figure 4) and pass into the ether; the apprehending of the electro-magnetic waves by the antennae of some receiving station many miles away, and the passing of the current through the receiving set; and finally the "ironing out" or reduction of the current to audible frequency are all shown in a graphic manner.

In all subjects relating to electricity, the screen offers teaching opportunities scarcely realized at present. In the naval wireless school, the schools for general electricians, and for instruction aboard ship, not to mention the many private institutions for the teaching of electrical subjects, the animated technical drawing offers a new way to impart the intricacies of the subjects in an intensely entertaining and practical way.

The Design of Multi-Stage Vacuum Tube Receiving Circuits

By John Scott-Taggart

(*Continued from the December,* 1919, *issue*)

WE NOW come to the usual aperiodic air-core oscillation transformers as a means of coupling the output circuit of a vacuum tube to the input circuit of the succeeding tube.

A two-tube receiving circuit employing this method of coupling is shown in figure 3. An aperiodic inductance coil L_3 is included in the plate circuit of the first tube, a second aperiodic inductance L_4 being placed across grid and filament of the second tube. A leaky grid condenser is included in the grid circuit of the second tube for the purpose of rectifying the high frequency current and producing audible signals in the telephones T. The two inductances L_3 and L_4 may very conveniently be wound together at the same time, or if desired, one of the inductances may be wound directly over the other. This type of amplifier will respond over a wide range of wave lengths, which range may be greatly increased by using resistance wire in place of ordinary copper wire for the inductances L_3 and L_4. The value of the resistance may be made as high as about 20,000 ohms. Obviously, a certain loss in efficiency is unavoidable, but this disadvantage is outweighed by the greater usefulness of the amplifier.

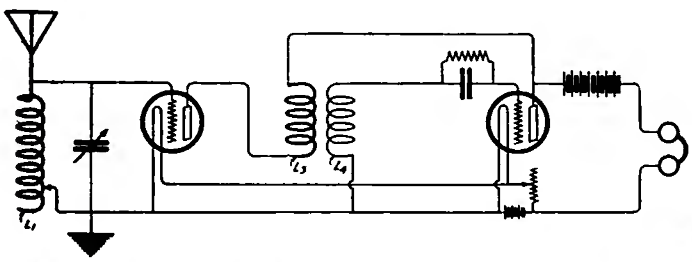


Figure 3—Two-tube receiving circuit coupling the output circuit of one to the input circuit of the other

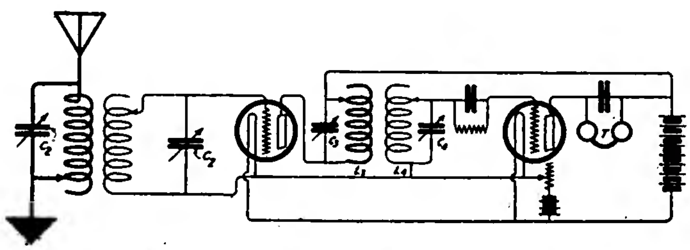
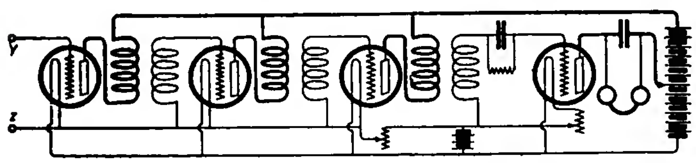


Figure 5—Two-tube receiving circuit which permits very fine tuning



Figue 4—Four-tuhe amplifier-detector for oscillatory circuit

Figure 4 shows a 4-tube amplifier-detector which may be applied to any oscillatory circuit for the purpose of receiving wireless signals. As will be seen, the arrangement is merely an elaboration of the circuit of figure 3, the coupling between the tubes taking the form of aperiodic air-core transformers. The terminals YZ are connected across the oscillatory circuit, in which the received oscillations are taking place.

An improved arrangement would consist in tuning the grid circuits of the various vacuum tubes in the series. This arrangement somewhat increases the efficiency of the amplifier and also improves its selectivity. The number of adjustments required, however, make the circuits somewhat unwieldy. It will be realized that a certain step-up effect is obtainable by arranging that the inductances of the plate circuits will have fewer turns than the inductances of the grid circuits. If the grid circuits be tuned, it may be an advantage to have the coupling between the plate and grid oscillatory circuits variable in order to increase the selectivity. If, however, we are aiming to produce a highly efficient circuit which is exceedingly selective, it will be preferable to tune both the plate and grid circuits by means of variable condensers. Figure 5 shows a useful 2-tube receiving circuit which is capable of giving excellent signals and at the same time

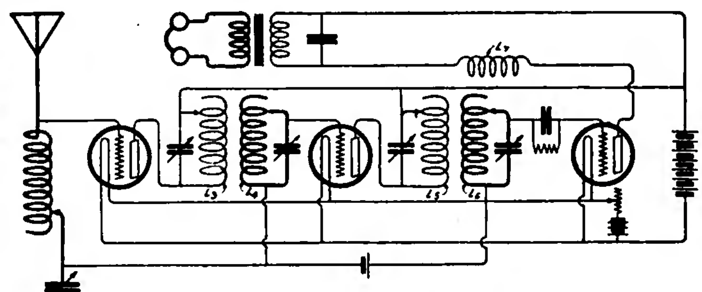


Figure 6—Three-tube circuit which provides for reception of continuous waves

very fine tuning. All circuits are now accurately tuned to the incoming frequency and the degree of selectivity may be varied by altering the coupling between L_3 and L_4. The second tube of this circuit acts as detector, the signals being obtained in the telephones T. Figure 6 shows a 3-tube receiving circuit which is a development of the 2-tube circuit, and which also provides for the reception of continuous waves. In the plate circuit of the last tube is included an aperiodic coil L_7 which may be coupled to any of the foregoing inductances in order to amplify spark signals on the regenerative principle or to produce self-oscillation, and so enable us to receive continuous waves. This class of circuit is especially useful when it is desired to receive within a fairly narrow range of wave length, or on a definite fixed wave length. As a general statement, in amplifiers utilizing air-core transformers an aperiodic coil for producing regeneration may always be placed in the plate circuit of one or other of the tubes and coupled to one of the circuits of a previous tube. If grid current rectification in the last tube is being used, self-oscillation may be produced by the use of an oscillator coil. If, however, the last tube is made to operate as a detector by utilizing one of the bends on the plate current curve, it is not possible to produce self-oscillation. If this form of detection is employed and we desire to produce self-oscillation, an oscillator coil may conveniently be included in the plate circuit of the vacuum tube next to the last. It is to be noted that a condenser of about 0.001 mfd. is invariably connected across the telephones. This condenser, among other things, allows self-oscillation to take place more readily. Incidentally, when a suitable number of tubes are used for amplifying high frequency oscillations, the radio-frequency component in the plate circuit of the detecting tube may be very considerably increased and is liable to cause arcing in the telephone windings, unless a shunt condenser is provided.

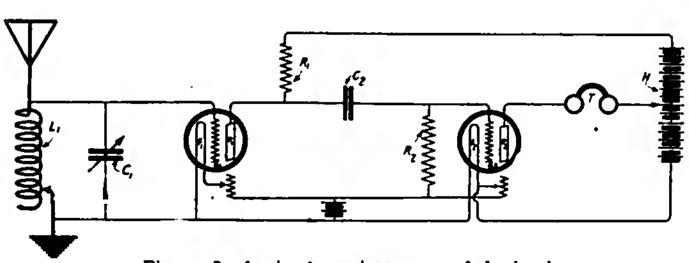


Figure 7—A simple resistance-coupled circuit

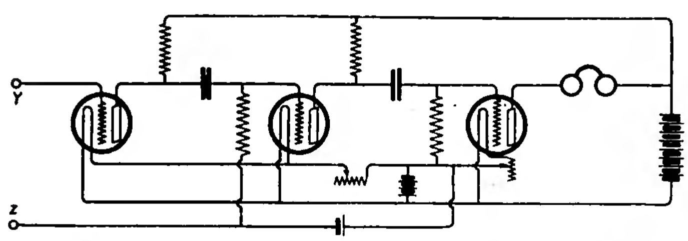


Figure 8—Three-tube resistance-coupled amplifier suitable for general reception

Except for special purposes, it will not usually be desirable to employ more than 3 tubes with tuned inter-tube transformers. The circuits become expensive and difficult to adjust, although this latter disadvantage may be largely overcome by employing a switch which changes the values of the inductances L_3, L_4, L_5, L_6, simultaneously.

We now come to the use of coupling resistances in vacuum tube amplifiers. This class of coupling is aperiodic, and after a certain wave length, is usually efficient for all wave lengths. A simple resistance coupled circuit is shown in figure 7, where two vacuum tubes are shown in use. The first one acts as a high frequency amplifier and the second one as a detector. The resistance R_1 has a value of about 80,000 ohms, and should have neither capacity nor inductance. It may be constructed by cutting two or three parallel grooves 2" long on a sheet of ebonite and rubbing the point of a lead pencil across them. Suitable terminal connections are made at the ends of the conducting grooves. A more suitable type of resistance may be constructed by using strips of paper on which heavy India ink lines have been ruled. Various commercial types of resistances have been placed on the market. Care should be taken to see that the terminal connections do not form a small condenser in parallel with the resistances.

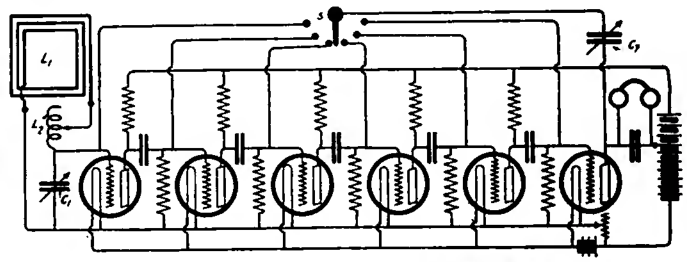


Figure 9—Six-tube amplifier for use with a frame aerial

A condenser C_2 of about 0.0003 mfd. which is connected between the foot of R_1 and the grid G_2 of the second vacuum tube insulates G_2 from the battery H, which would otherwise give the grid a very high potential. When the grid G_1 of the first tube becomes positive, the electron current through R_1 increases; consequently, a momentary negative pulse is communicated through C_2 to the grid G_2 of the second tube. Similarly, when G_1 is made negative, the electron current through R_1 is decreased and a positive pulse is impressed on G_2. In this manner the high frequency potentials across R_1 are passed on the second tube, which rectifies the radio frequency EMFs. Owing to the drop in potential across R_1 the plate battery H will have to be of considerably greater voltage than is the case in an ordinary amplifier. The value of H may conveniently be from 70 to 100 volts. Each tube is shown as having a separate rheostat of about 10 ohms resistance. These rheostats may frequently be dispensed with. Such minor variations in the circuits given here are left to the experimenter. To prevent excessive negative charges building up on the grid G_2 of the second vacuum tube a leak R_2 of about 3 megohms resistance may be connected directly across grid and filament. In place of the telephones T a step-down transformer may be used. A high resistance winding may be included in the plate circuit and a low resistance winding connected across a pair of low resistance telephones. This applies to all tube circuits and the use of such a transformer possesses considerable advantage.

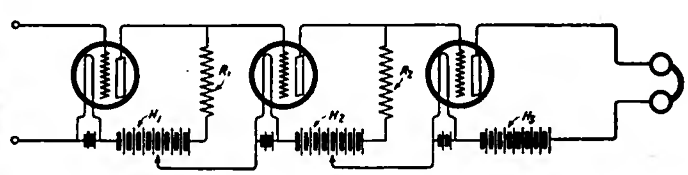


Figure 10—Marconi resistance amplifier circuit containing three tubes

Figure 8 shows a three-tube resistance coupled amplifier suitable for general reception. This circuit is simply an elaboration of the previous circuit and no comment is necessary. The values of the resistances are the same as before. The terminals YZ are connected across the oscillatory circuit in which the incoming oscillations are flowing. The important point to notice in connection with resistance coupled amplifiers is that they are not suitable for reception of short wave lengths. This is due largely to the capacity effect, which is invariably in parallel with the plate circuit resistances. This capacity effect may be chiefly due to the capacity of the electrodes in the tube and is also due to the capacity of leads and connections. This capacity acts as a resistance, or rather, reactance, in parallel with the resistances R. Since the condenser acts

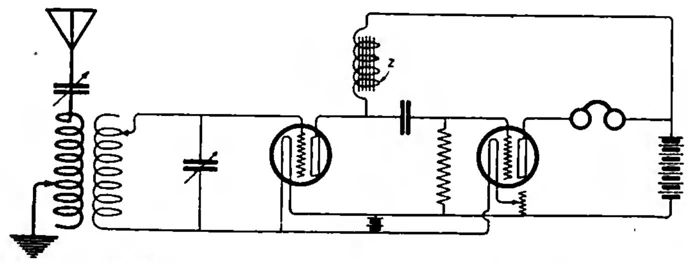


Figure 11—Two-tube impedance circuit for short waves

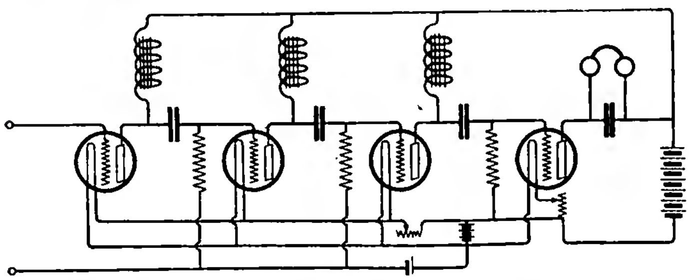


Figure 12—Four-stage amplifier for short waves

as a detector towards oscillatory current, the higher the wave length received, the greater will be its frequency and the more readily will the unintended shunt capacity act as a by-path to the oscillations, and so reduce the impedance of the resistances R. The resistance amplifier is consequently most useful for wave lengths exceeding 1,000 meters. In any case, every precaution should be taken to avoid capacity effects in resistance amplifiers.

Figure 9 shows a 6-tube amplifier being used to receive signals picked up on a frame aerial L_1, which consists of a number of turns of insulated wire on a large frame several feet square. The loading inductance L_2 and the condenser C_1 is for tuning purposes. The amplifier calls for no special comment except that a small condenser C_7 is used for obtaining regenerative amplification. By means of a switch S this condenser may be connected

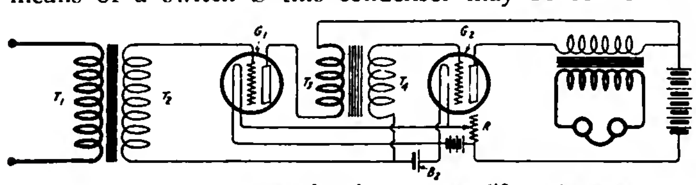


Figure 13—A simple two-stage low frequency amplifier using a step-up transformer

across the plate of the last tube and the grid of another of the preceding tubes. This condenser should have a very small capacity. By gradually increasing this capacity the circuits may be made to pass through the various stages prior to self-oscillation, thus enabling us to obtain regenerative amplification of spark signals, or to receive continuous waves.

In a resistance amplifier, the grids are alternately positive and negative at any given moment. For example, if the first grid is positive, the first plate will be negative, the second grid negative, the second plate positive, the third grid positive, the third plate negative, and so on. To obtain regeneration, the condenser C_7 should be connected across two electrodes of similar sign. Regenerative amplification may be obtained not only by coupling the plate of the last tube to the grid of the first, but by making suitable connections between any of the intermediate tubes. The condition for regenerative amplification is that when the potential of the plate increases, the grid of the preceding tube chosen should also increase, and vice versa. If the condenser is now connected across the plate and grid, regeneration is obtained and if the condenser is of sufficient capacity self-oscillation is set up.

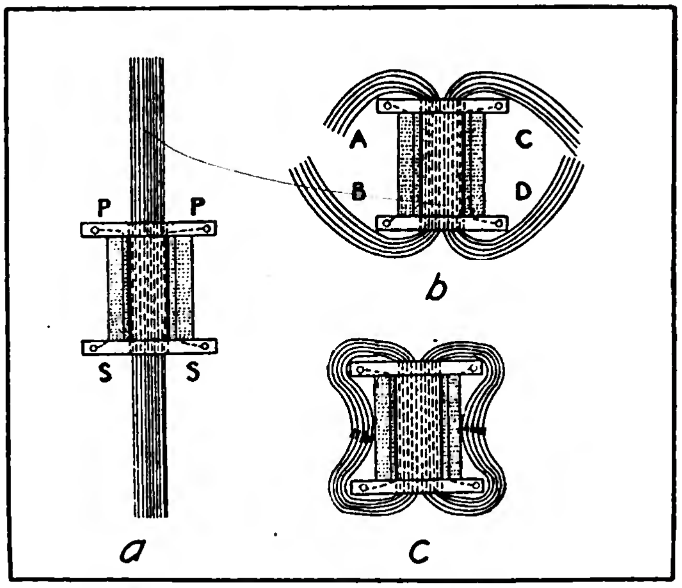


Figure 14—Detailed construction of a transformer

For example, regeneration may be obtained by connecting the last plate to the first grid of an amplifier possessing 2, 4, 6 or, in short, an even number of tubes. If an odd number of tubes were used, absorption—the opposite to amplification—would take place, and the greater the capacity, the less would be the amplification and the less the tendency to oscillate. We can see that regenerative oscillation is obtained when the coupling condenser connects the plate and grid of tubes adjacent to each other, or separated by an even number of tubes. Obviously, the greater the number of tubes in between, the more critical is the adjustment of the coupling condenser, which thus requires to be of very small dimensions. Owing to the difficulty of insuring regular working, it is desirable to arrange the coupling between the plate of one tube and the plate of a previous tube in the series. Rectification is

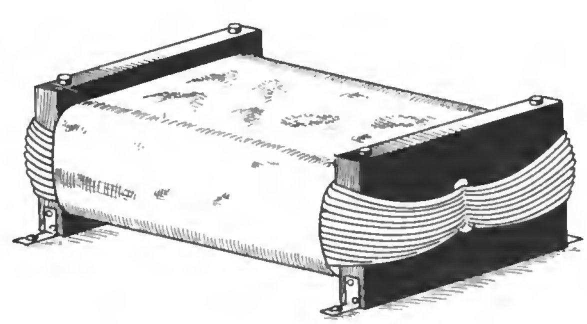


Figure 15—The completed amplifier transformer

now weak and allows of a more gradual adjustment. The coupling condenser should now be connected across any two plates which are undergoing potential changes of the same sign as, for example, 1st and 3rd, 3rd and 5th, 1st and 7th, and so on. Instead of using a condenser, a high resistance of the order of about 10 megohms may be connected across the plate of one tube and the grid of a previous tube, or the plate of one tube and the plate of another. These general remarks will explain the conditions under which regeneration is obtainable in a resistance amplifier. The present regeneration is obtainable in a resistance amplifier.

However, the writer is not inclined to recommend the use of methods for obtaining self-oscillation in an amplifier, although regeneration is frequently desirable. It will almost invariably be preferable to use an external heterodyning oscillator when it is desired to receive continuous waves.

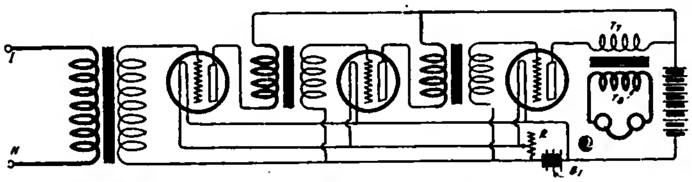


Figure 16—Three-tube low frequency amplifier circuit

An interesting resistance amplifier has been patented by the Marconi Company, which is illustrated in figure 10. In the plate circuit of the first tube is included a high resistance R_1 and a plate battery H_1. If connections were taken from the ends of R_1 across the grid and filament of the second Marconi tube there would normally be a negative potential on the grid of the second tube. This potential would be equal to half the emf. of H_1, if the resistance R_1 equalled the internal resistance of the tube between filament and plate.

It is to be noted that it is usually desirable to make the plate circuit resistance equal to the internal resistance of the tube. To overcome the potential drop across the high resistance in the plate circuit, we have seen that usually a stopping condenser has been used. The Marconi circuit, however, achieves the same object by taking the connections from the top of R_1 and the mid-way point along H_1. It will be seen that the emf. across R_1 is balanced by half the emf. of H_1 acting in the opposite direction. If R_1 does not equal the internal resistance of the tube a suitable point is readily found on H_1 so that the potential difference between that point and the top end of R_1 is zero. When a varying potential is placed on the grid of the first tube, the potential across R_1 also varies whereas the potential across the half of H_1 involved does not vary, at least, not to any appreciable extent. The magnified potential variations are consequently applied to the grid of the second amplifying tube, and the same process is repeated in the case of the second tube, the magnified variations in R_2 being applied across the grid and filament of the third vacuum tube. This last tube may, if desired, be arranged to act as a detector.

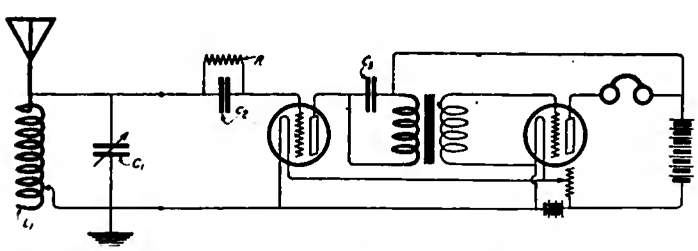


Figure 17—Two-tube detector amplifier circuit in which the first tube acts as a detector

This circuit requires separate plate batteries and filament accumulators. Moreover, it will be seen that any low frequency variations of plate current in the first tube will be passed on throughout the series; consequently, any undesired current variations such as those due to variations in filament temperature or leakage in the circuits are liable to be magnified by the amplifier and produce undesirable noises. In the case of those amplifiers in which stopping condensers are used, these condensers, if of small enough capacity, will only pass on high frequency current variations, and will filter out any audio-frequency effects. The Marconi circuit, however, is capable of being used as an amplifier of steady, maintained, direct current potentials, whereas the other type of amplifier is unsuitable. The principle of taking a tapping from the plate battery to avoid the potential drop across the plate circuit resistance is one of considerable value and may be applied in many vacuum tube circuits with advantage.

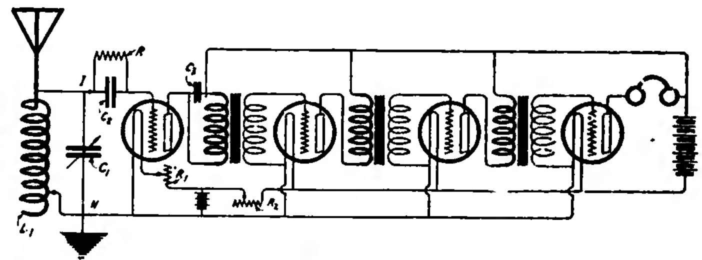


Figure 18—Four-tube detector-amplifier circuit witb tbree tubes for amplification

We have seen that owing to the capacity of the vacuum tube and various strong capacity effects in a *resistance* coupled amplifier, the arrangement is not suitable for the efficient reception of waves less than about 1,000 meters. For the higher wave lengths we can use an impedance coil in place of a high resistance. The impedance offered by such a coil increases with the frequency of the oscillations. It will thus be seen that an amplifier employing impedances will be very efficient for the reception of short waves. Wave lengths as small as 100 meters may be very effectively received on an amplifier of the type shown in figure 11. Two vacuum tubes are here shown in use, the first one acting as a high frequency amplifier and the second one as a detector. The impedance coil Z may conveniently consist of about 10,000 turns of No. 40 silk covered wire, wound on an iron wire core 2½" x ½". An elaboration of this simple circuit is shown in figure 12. which illustrates a 4-stage amplifier which may be applied to any oscillatory circuit receiving short waves. As in the case of resistance amplifiers, regenerative amplification may be obtained by connecting a high resistance of about 12 megohms, or a very small condenser across the plate of the last tube and the grid of say the first tube.

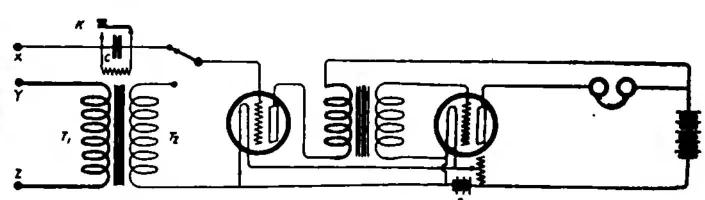


Figure 19—Circuit for use as low frequency amplifier or receiver

Obviously, in a tube of this nature, we can obtain regenerative amplification or self-oscillations by connecting an aperiodic oscillatory circuit consisting of an inductance in the plate circuit of the last tube and coupling this coil to the input oscillatory circuit. In this class of amplifier and also in any other type in which an impedance, such as a telephone transformer winding, is included in the plate circuit of the last tube, the oscillatory regenerative circuit may be connected in *parallel* with the impedance. In this case, one end of the coil is connected to one end of the impedance, while the other end of the coil is connected through a fixed or, if desired, variable condenser to the other end of the impedance.

We now come to the design of amplifiers employing several vacuum tubes coupled by means of iron-core transformers. Of these the most important are probably those employing transformers having primary and secondary, the primary being included in the output circuit of one tube and the secondary in the input circuit of the following tube. A simple two-stage low frequency amplifier is illustrated in figure 13, in which an initial step-up transformer T_1 T_2 is provided. This step-up ratio may conveniently be 1 to 5. The winding T_1 should have a resistance approximating to the resistance of the circuit to which the amplifier is to be applied. In nearly all cases, the winding T_1 will be included in the plate circuit of a tube being used as a detector, consequently the resistance of T_1 should be fairly high. In most British commercial amplifiers the winding T_1 has a resistance of from 300 to 2,000 ohms, or even more. Suitable windings for an initial transformer for general work are: primary—44 gauge single silk covered copper wire, 300 ft.; secondary—44 gauge single silk covered copper wire, 3,000 ft.

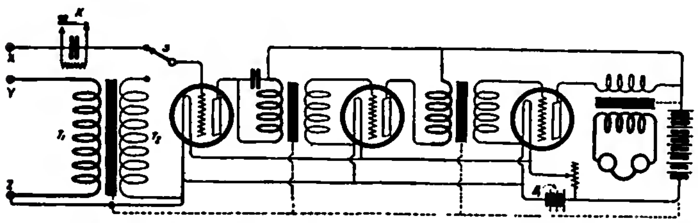


Figure 20—A three-stage amplifier used during the war

Although a little outside the scope of the present article, the design of a transformer shown in figures 14 and 15 may appeal to experimenters. These diagrams are taken from an article by the author which appeared in the November, 1919, issue of The Wireless World. Figure 14 shows stages in the manufacture of a simple transformer. A hard rubber tube about ½" external diameter and 2" long is fitted at each end of a square rubber cheek, 2" x 2", through which a ½" hole has been drilled. Wooden cheeks and a paper tube soaked in paraffin wax could be substituted for this. On this tube is wound the primary winding. This can best be accomplished by rotating the tube on the shaft of a small electric motor. The two ends of the winding should then be brought to two small terminals fixed on one of the cheeks. The secondary

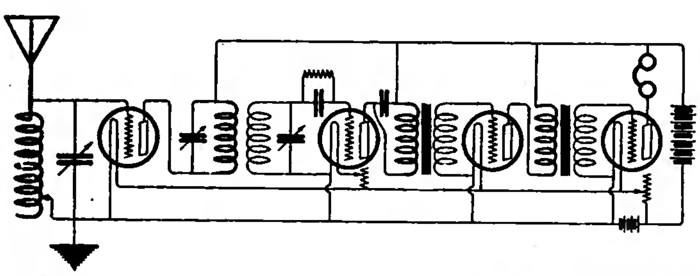


Figure 21—Circuit for high-frequency and low-frequency amplification

winding may be wound in the same direction in a similar manner, the two ends being brought out to terminals fixed on the other cheek. The greatest care should be taken to insulate the windings, which should be separated by one or two layers of varnished cloth. The iron-core consists of a bundle of iron wires 7" long which fit into the hard rubber tube and project about 2½" beyond the cheeks. The wires at each end should be parted, each half being bent round the side of the cheek. Figure 14b shows how the ends A and B and C and D have been bent round the sides of the cheeks. The ends A and B, and C and D are now worked into each other so that the core appears as two rectangular rings as shown in figure 14c. The finished appearance of the transformer is illustrated in figure 15.

A second transformer T_3 T_4 is shown in figure 13. This inter-tube transformer is of the step-up type, a suitable ratio being 1 to 5. The transformer may be constructed in the manner just described, the winding T_3 containing about 3,000 ft. of wire and the secondary about 15,000 ft. These values give excellent results, but there

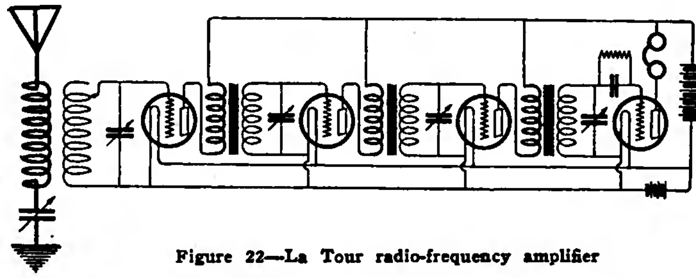


Figure 22—La Tour radio-frequency amplifier

is no reason why they should be too closely followed. Different commercial types of amplifiers vary very much indeed in the resistances of their transformer winding. Instead of connecting high resistance telephones in the plate circuit of the second tube, we conveniently use a step-down telephone transformer and low resistance receivers. It will be noted that a single cell B_2 is connected in such a position as to give the grids G_1 and G_2 a small negative potential with respect to the filament. This largely prevents any grid currents and the loss of efficiency which would otherwise result. A rheostat R of about 10 ohms resistance varies the filament currents of the two tubes simultaneously.

Our next figure (figure 16) shows a useful form of low frequency amplifier which can be applied to any circuit in which low frequency current variations are taking place. The terminals I N are simply connected where the telephone receivers would normally be placed in the circuit. A special point to notice is that the author has connected the grids of the tubes to the negative side of the filament heating accumulator B_1, and so placed the rheostat R that the grids will always be slightly negative with respect to the negative end of the filament, on account of the voltage drop across the used portion of R. This arrangement is technically preferable to the use of a small cell, although an accumulator of higher emf. may be required.

A telephone step-down transformer T_7 T_8 is now shown in use. The winding T_7 may conveniently have a

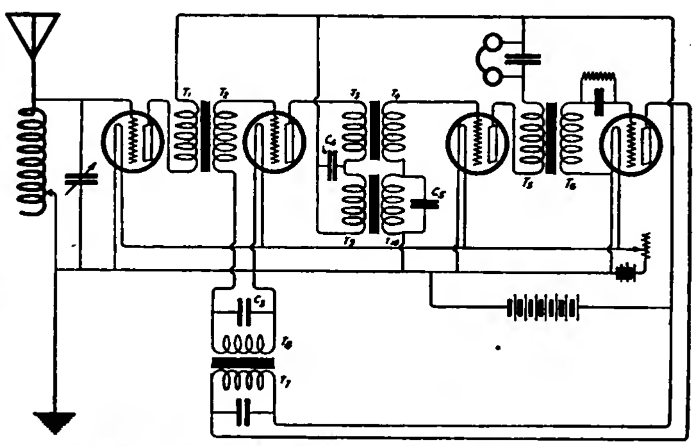


Figure 23—Four-stage amplifier designed by La Tour

resistance of about 5,000 ohms and should consist of about 5,000 ft. of wire. The low resistance winding may be wound with the same wire to a resistance equal to that of the phones to be used.

Figure 17 shows a very convenient form of detector amplifier in which the first tube acts as a detector; only two tubes are shown. The input terminals are connected across the receiving circuit L_1 C_1, but it is to be understood that the terminals could be connected across *any* oscillatory circuit in which incoming oscillations are taking place. It will be noticed that a leaky grid condenser C_2 of about 0.0003 mfd. shunted by a resistance R of 3 megohms is included in the plate circuit of the first vacuum tube. Across the winding T_1 of the inter-tube transformer is connected a condenser C_3 of about 0.01 mfd., which is intended to by-pass the high frequency component of the plate current of the first tube. An obvious but very useful development of this circuit is shown in figure 18. The condenser C_2 is shown having a value of 0.00005 mfd. and R as having a resistance of 4 megohms, but these figures depend very largely on the type of tube used. The author has shown the filament current of the first tube variable by means of a separate rheostat R_1. A similar rheostat R_2 may be made to regulate the filament current supplied to the second, third, and fourth tubes, although with suitable tubes this rheostat may frequently be dispensed with.

Figure 19 shows a design of amplifier which may be used either for low frequency amplification or for the reception of wireless signals. Three terminals X Y Z are now provided. The terminals Y Z are used when low frequency amplification is desired, the switch S being placed on the stud A. When, however, it is desired to receive wireless signals, connections are made to the terminals X and Z and the switch S is placed on the stud D; the input transformer T_1 T_2 is now entirely cut out and wireless signals are rectified by the aid of the leaky grid condenser C. This condenser may be shorted by the switch K. To avoid using four terminals and also to improve the effectiveness of the amplifier for low frequency amplification, the terminal Z is connected to the negative side of the filament accumulator B_1.

A three-stage amplifier which proved very successful during the war is shown in figure 20, which is a similar circuit to figure 19, but possesses three tubes. In all these low frequency amplifiers it is almost invariably desirable to connect the iron-core of the transformers to the positive side of the plate battery H, as shown in figure 20 by the dotted lines. This steadies the action of the amplifier and lessens undesirable noises which are otherwise usually heard. Most of the improvements in these types of amplifiers are due to Marius LaTour.

If it is desired to resonate low frequency transformers used in amplifiers, large variable condensers may be connected across the windings, but such resonated circuits have not found very much favor in Great Britain and France for low frequency amplification.

Figure 21 illustrates a typical example of a circuit in which high frequency and low frequency amplification is obtained in a single amplifier employing a single filament accumulator and plate battery. The first tube acts purely as a radio-frequency amplifier, the second acts as a detector, while the third and fourth act as audio-frequency amplifiers. There are obviously very many modifications of circuits of this type, but the one given will, no doubt, be sufficient to indicate the general principle of employing single batteries and the combining of the various functions of a vacuum tube in the single amplifier. The author, however, recommends that for general experimental work it is preferable to employ a separate three-stage low frequency amplifier independently arranged, but which could be applied to any experimental circuit.

Iron-core transformers have been very largely used by Marius LaTour in France for the purpose of coupling the various vacuum tubes in a multi-stage radio-frequency amplifier used for the reception of long waves. He has used both resonated and aperiodic windings and obtains a step-up effect which is not obtainable to the same extent in the case of an air-core transformer. Figure 22 shows an arrangement of vacuum tubes used by LaTour for radio-frequency amplification. The disadvantage of this class of amplifier is that it does not lend itself to reception over wide ranges of wave lengths and is, moreover, difficult to design. LaTour has also devised an amplifier which is shown in figure 23. Four stages of amplification are shown, the last tube acting as a detector. The transformers T_1 T_2 T_3 T_4 and T_5 T_6 are designed for radio-frequency amplification. The last tube acts as a detector and the rectified pulses in the plate circuit are passed into the primary step-up transformer T_7 T_8, the winding T_8 being included in the plate circuit of the second tube. A condenser C_3 is shunted across T_8 to allow the passage of radio frequency current. The second tube now amplifies the low frequency pulses at the same time as it is amplifying the high frequency energy supplied by T_1 T_2. The low frequency amplified pulses pass through the primary T_9 of a step-up transformer T_9 T_{10} which is included in the plate circuit of the second tube and in series with the winding T_3. The secondary T_{10} is included in the grid circuit of the third tube and is in series with the winding T_4. Condenser C_4 and C_5 are connected across T_9 and T_{10} to by-pass the radio-frequency current in these circuits. The telephones T are included in the plate circuit of the third tube. The type of amplifier shown does not seem to have achieved the success that might have been expected from a double magnification circuit of this kind.

From the foregoing remarks it will be seen that a very large number of amplifier circuits may be devised. As a rule, it is preferable to aim at high selectivity and the reception of very weak signals rather than merely to obtain a very loud response in the telephones; consequently, attention is to be called chiefly to those circuits employing radio-frequency amplification.

An Oriental Radio Set

By Howard S. Pyle

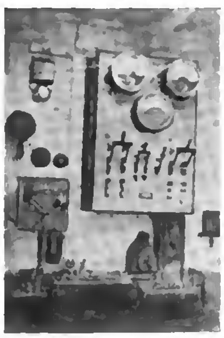
WE are hearing considerable discussion of various new radio apparatus brought out during the period of hostilities, but very little has appeared in print descriptive of the marine apparatus in use by the Japanese vessels.

This equipment has remained substantially the same for some years. It has, and is, proving very efficient and satisfactory in the long voyages in the trans-Pacific trade. A Japanese operator is often able to clear with a Japanese station and one in North America on the same night. This means spanning two thousand miles of water each way, and in spite of the many records made in both transmission and reception during the war, the almost nightly long distance work of the Japs is not to be scoffed at.

The writer, shortly after our entry into the war, had the good fortune to be assigned to a large steel freighter which the United States had purchased from the Japanese government, and which was equipped with the "Annaka" type of apparatus. We were to sail for South America and then the east coast, to enter into the transatlantic transport service. Having a civilian crew, although we were all naval operators, we saw a splendid opportunity for experimentation with the Japanese apparatus, and we were left entirely alone, having absolute control of the radio.

Reporting aboard our vessel, formerly the *Yoshida Maru 3d* but renamed the *Eastern Chief*, we were agreeably surprised at the excellent appearance of the apparatus. It was mounted entirely on marble, all the metal parts being nickel plated. Even the smaller instruments, such as starting boxes and field rheostats, had individual marble panel mountings. The receiver was very elaborate and enclosed in a mahogany cabinet with a heavy hard rubber top, all the controls and metal parts being silver plated. A solid oak operating table with drawers and files was installed, and a built-in settee of oak with green plush cushion added to the operator's comfort.

Our stateroom was connected by a door with the operating room, and a speaking tube connected us with the chart house. The location in the starboard wing of the bridge was also desirable.



Starting box and power panel for main 3 kw. set

Loading coil panel and antenna switch

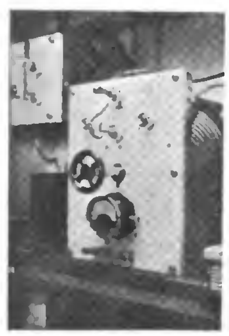
As to the apparatus itself: the transmitter was of three kilowatt capacity for the main set, with an auxiliary generator and transformer of half-kilowatt size, which, when cut in, used the same oscillating and open circuits as the main set, the change being effected by merely shifting transformers and starting the small generator. A separate power control panel was provided for both motor generator units, and contained all the controlling appliances with the exception of starting boxes and field rheostats which were mounted individually, convenient to the operator's hand. The auxiliary motor generator was powered by a fifty-volt storage battery, contained in a suitable housing on the bridge. Circuit breakers and the necessary controls for charging were contained on the power panel. The ship's mains, of course, furnished current for the operation of the main transmitter. The generator sets, while bearing Japanese nameplates, were evidently of General Electric type, and consisted of the usual DC motors, coupled to the generators with flexible couplings. The generators were of the solid rotor type, the main set being of 600-cycle frequency and the auxiliary of 500 cycles.

The transformers were of low secondary potential and of closed core design, immersed in oil. A removable plate on the top of the cases permitted of easy access, by means of a small forked wire, to single-pole-double-throw switches immersed in the oil, and which controlled the secondary potentials. Leads from the transformer were connected directly across the condenser, consisting of two large units of glass plates and copper foil, embedded in beeswax, and contained in a suitable case. A heavy single-pole-single-throw switch, permitted of change in capacity, which was necessary for operation at the 300-meter wave length. This switch was mounted on a marble panel which formed the cover of the condenser case.

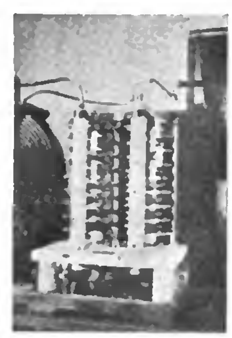
The quenched gap, which appears in one of the illustrations, is probably the most unique instrument in the transmitting equipment. This consisted of sixteen plates, mounted vertically in two rows, and having a geared edge on one plate of each gap. A series of fiber gear wheels moving on a shaft passing between the two sets of plates, engaged the teeth in the gap plates. A small tube led from the sparking surface of each gap to a larger feed pipe, and thence by a rubber tube to an alcohol chamber. A motor actuated bellows, forced the alcohol vapor onto the sparking surfaces, assisting in the quenching. The blower motor, by means of a system of chains and gears, also caused the plates to slowly revolve while the alcohol was forced onto the plates. By this means the whole surface of the gap was presented to the alcohol blast. The mica rings separating the sparking surfaces gave trouble for a while by leaking, but after a little experimenting we remedied this.

In series with the gap and condenser was the primary of an auto transformer, the almost perfect quenching of the gap permitting the use of this type of inductance in place of the customary oscillation transformer and still insuring a pure wave. The inductance was variable by means of a large wheel fronting on the marble panel which supported the auto transformer, and which may be plainly seen in one of the accompanying photographs. On this panel was also mounted the hot wire ammeter and the wave changing switch, which latter consisted of three plug sockets for the insertion of a plug connected by flexible cable to the circuits. A similar plug arrangement was in use on the loading coil panel. The loading coils themselves, were, as was the auto transformer, wound in the well known pancake style. As the Japs work their own stations on a wave length of 1,700 meters when interference is heavy on the 600 meter wave, several loading coils were installed, but ours had been connected in circuit to permit a range of waves from 300 to but 952 meters, hence several coils were removed. A heavy single-pole switch on the front of the loading coil panel provided for short-circuiting the loading coils at will.

From the loading inductance, the circuit went to the antenna switch, which was a single-bladed affair with a throw of 60 degrees. The primary power circuits and the blower motor for the gap were controlled by this



Auto transformer and control panel showing wave changer switch



Sparkgap of novel design and unique operation

switch as well as the high frequency circuits. A deck insulator of massive dimensions and heavy porcelain construction carried the lead to the antenna. Contrary to the usual United States custom of using 7/22 phosphor bronze for the antenna, the Japanese use a cable of seven strands of number 14 phosphor bronze, which makes a very heavy, but at the same time, efficient high frequency conductor. In place of our usual Electrose insulators, two heavy 10-inch ribbed porcelain insulators, heavily glazed were in tandem at both ends of each strand. The lead in was brought from the middle and was not bunched until reaching the deck insulator. Our antenna had a natural period of 310 meters, which made a series condenser necessary for transmission on 300 meters.

Two hand keys of massive dimensions were provided, and as these were of the old massive pump handle type, we pulled them out and installed a smaller navy key.

As has been stated, the receiving set was elaborate. Of the older cabinet type rather than the more recent panel design, it was a marvel of intricacy. A bird's-eye view of the top of the cabinet had the appearance of the letter E with the middle leg left out. In the narrow part, a small drawer was set, which served to hold spare crystals, etc. A loose coupler of about 3,000 meters held the right hand side and provided for the inductive transfer. The primary was varied by a slider moving on a rubber strip which

The receiving set showing a compact arrangement of instruments

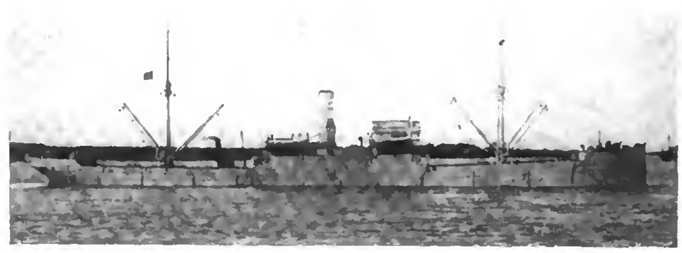
carried thirty switch points. A similar slider, but working on a worm gear from the inside of the coil, varied the secondary inductance. This was controlled by a small crank projecting from the secondary head. A loading inductance was mounted within the cabinet, controlled by the usual dial switch on the panel, and was used for considerable of the rough tuning. A fixed condenser, made up similar to a variable by using spaced aluminum plates, but stationary rather than movable, was controlled by a five point plug switch on the panel. A similar plug switch controlled a smaller paper and tinfoil condenser across each variable and the telephones. A variable was connected in shunt to the secondary and a primary variable was thrown in shunt, series or short circuit by another plug switch. A dial switch controlled a non-inductive potentiometer, which could be used with either of three crystal detectors, using foreign minerals which we couldn't analyze. Binding posts were provided for connection of the wing, grid and filament circuits of a vacuum tube detector, but none was provided, so we arranged our own tube. An extremely intricate switch contained within the cabinet and controlled by a handle on the outside, served to change the hookup for crystal or vacuum tube work. We found it to be poorly arranged for tube reception but very efficient on crystal.

In making the diagram of the connections of the receiver, two whole evenings and several choice bits of temper were used up in tracing the circuits. The wires connecting the various instruments in the cabinet made a bundle the size of a man's wrist, and we thought a considerable loss of energy in vacuum tube work was due to the presence of so much useless inductance. The telephones were probably the one real discredit to the outfit, and they were as good as worthless. Single pole construction, apparently of a low resistance and cheaply constructed, we had trouble with them continuously until we substituted a pair of navy 'phones.

We made several noteworthy transmissions, but I believe our record was hung up, when, by some freak or other, we communicated with San Diego, California, at 2,000 miles in daylight, and during July, when we were somewhere around the equator. This was purely freak work, but our night transmissions of ordinary occurrence gave clear signals easily readable at from 1,400 to 1,800 miles regularly.

The hot wire ammeter showed only about 14 amps. on our highest power, which only serves to show that the hot wire ammeter is really very much of a liar, for it has been proven time and again, that a high reading at the meter does not necessarily mean great energy from the antenna. I have done far less distance with ammeters showing as high as 20 and 22 amperes, and have come to take the meter reading as merely an indication of what you are really getting in the circuits, not what is hopping off into space.

On the whole, we were well satisfied with the performance of our Oriental outfit, but were relieved to exchange it for a navy set. Its complicated construction kept both myself and my two assistants constantly on the job to keep it going right, and often when high power work was attempted, two or three of us would have to stand by for emergency breakdowns. Nevertheless, we take off our hats to our little yellow brothers for their remarkably fine workmanship and attention to detail and to the results



U. S. S. Easternchief, formerly Yoshida Maru 3d, in Scheldt River near Antwerp, Belgium

they succeeded in getting as a regular occurrence—not as freak work. We were handicapped in having to trace all our circuits, as everything was lettered with name-plates in Japanese, and next time, we hope to have the pleasure of accepting a Japanese set lettered in English—or at least with a blueprint under the mattress.

Radio Frequency Inductance Coils

By M. K. Zinn

SUMMARY: The purpose of this paper is to discuss some of the practical considerations which enter into the design of inductance coils for radio frequencies, with particular reference to their application in circuits intended for the reception of long undamped waves. The theoretical behavior of coils at high frequencies is reviewed, and for illustration, impedance measurements on a typical antenna load coil are presented.

GENERAL THEORY: The problem of designing a coil to function within a particular band of frequencies usually presents itself in this form:

To design a coil which will have a given inductance with the smallest possible resistance consistent with cost.

At relatively low frequencies, the impedance of a coil approaches $R + jpL$ where R and L are respectively its direct current resistance and inductance and $p = 2\pi f$.

At radio frequencies, however, the impedance departs from this ideal value chiefly by reason of two influences:

1. Distributed capacity.
2. Skin effect.

DISTRIBUTED CAPACITY: For practical purposes, the distributed capacity of a coil may be represented by a fictitious lumped capacity, C, shunted across its terminals. The magnitude of C may be found experimentally by measuring the self-resonant frequency of the coil when excited by a wavemeter very loosely coupled to the same. A better method is to measure the impedance of the coil with an impedance bridge properly shielded and arranged to give accurate results at high frequencies. C may then be computed from the frequency at which the angle of the impedance reverses its sign, knowing the low frequency inductance of the coil

Tests indicate that this equivalent capacity is independent of the frequency for ordinary types of coils. We may represent an inductance coil, then, by the schematic circuit of figure 1, where R and L are the direct current resistance and inductance, respectively, and C is the equivalent capacity defined above.

At this point it becomes necessary to differentiate between two methods of connecting the coil in the circuit, viz.: (1) whether the acting voltage is applied externally, or (2) induced internally, with respect to the coil. The use of a coil as an antenna load inductance is representative of the first case. The secondary coil of a coupling transformer is representative of the second case. Figure 1a shows the circuit that must be considered in finding the impedance offered to an external e. m. f. Figure 1b shows the circuit that must be considered in finding the impedance offered to an internal e. m. f.

In the first instance, the impedance $Z = \frac{e}{j}$ is

$$\frac{R + jpL}{jp\,RC + (1 - p^2\,LC)}$$

Separating this expression into its real and imaginary components we find respectively the effective resistance and reactance:

$$R_{eff} = \frac{R}{(pRC)^2 + (1-p^2\,LC)^2}$$

$$X_{eff} = \frac{pL\,(1-p^2LC) - p\,R^2\,C}{(pRC)^2 + (1-p^2\,LC)^2}$$

For coils of the type used in radio work, the terms pRC and $pR^2\,C$ are very small and negligible in comparison with $(1-p^2\,LC)$ at all frequencies except those very near the self-resonant frequency, or "critical" frequency, of the coil (i.e. where $1-p^2\,LC = 0$); so that the effective resistance and reactance are approximated very closely by the following:

$$R_{eff} = \frac{R}{(1-p^2\,LC)^2}$$

$$X_{eff} = \frac{pL}{1-p^2\,LC}$$

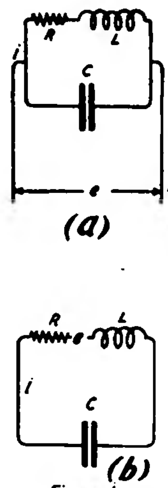


Figure 1

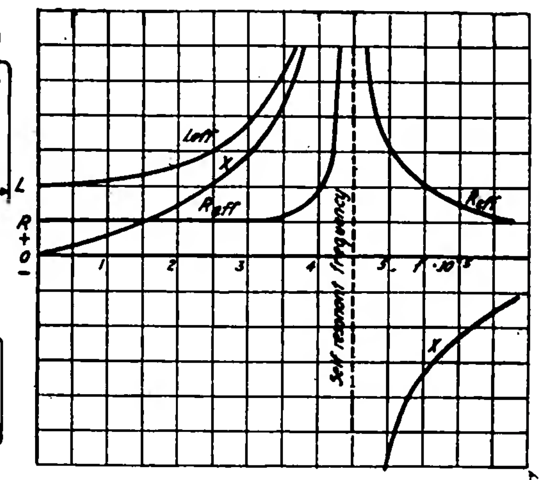


Figure 2

Figure 1—Schematic circuit of an Inductance coil. Figure 2—Theoretical curves showing the action of a coil when the acting e. m. f. is applied externally

The effective inductance is then,

$$L_{eff} = \frac{L}{1-p^2\,LC}$$

The effective resistance of a coil is a measure of its efficiency since it determines the current that will flow at resonance when the coil is used in a series resonant circuit. From the above relation we see that this effective resistance is increased over the d.c. resistance by the factor $\frac{1}{(1 - p^2\,LC)^2}$. This increase is attributable to the capacity of the coil alone, and is quite independent of the increase in resistance due to skin effect.

The effective inductance of the coil in like manner has been increased by the factor $\frac{1}{1 - p^2\,LC}$. For practical purposes, we are interested only in the frequency range below the critical frequency of the coil. At higher frequencies the coil has negative reactance, that is, it no longer functions as an inductance.

The behavior of a coil when the acting e.m.f. is applied externally is illustrated in the theoretical curves of figure 2.

It may be of interest to note in passing that the capacity of a load coil may indeed have quite a beneficial effect in eliminating short wave interference. For example, the writer has a long wave receiver employing several load coils immediately beneath the antenna. These coils quite accidentally have different self-resonant frequencies pretty well distributed over the short-wave spark range. The result is that neighboring spark station interference is very completely choked out, while otherwise these short wave signals would come in through the coupling capacities and cause trouble, even if the secondary circuit were tuned to 10,000 meters or more.

In the second instance (figure 1b), where the coil is so located that the acting e.m.f is internally applied, the distributed capacity effect does not increase the effective resistance of the coil. The effective inductance is changed by a small amount depending upon the dimensions of the remainder of the circuit. In fact, in this case, the effect of the coil capacity is unimportant and entirely negligible, at least if the tuning condenser associated with the coil is sufficiently large in comparison.

SKIN EFFECT: The second influence which causes the effective resistance of a coil to depart from its ideal d.c. value is the well-known "skin effect."

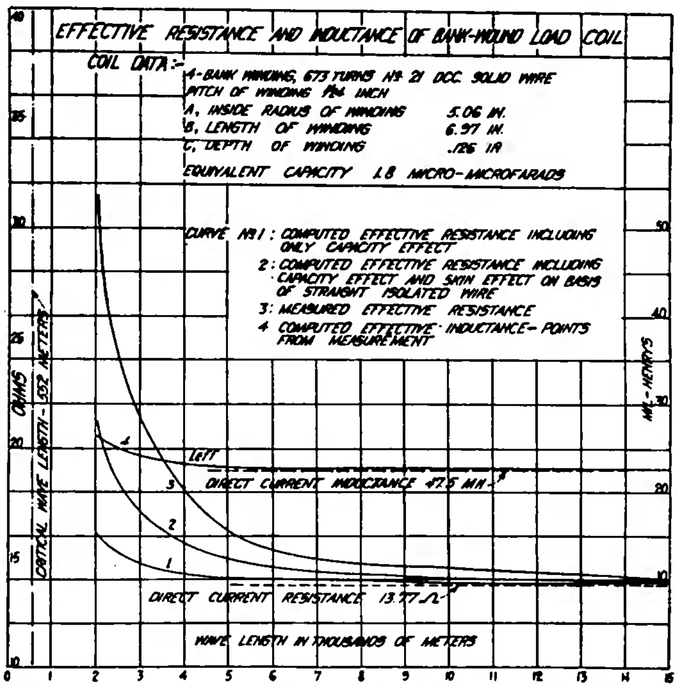


Figure 3—Graphic curves giving the results of calculation and measurement on a sample coil

Unfortunately, the magnitude of this effect cannot be accurately predicted when the conductor is wound into any form of multilayer coil. In general, however, the skin effect appears to be considerably greater in a multilayer or bank-wound coil than in a single layer coil, the skin effect in the latter being in turn greater than that in a straight wire remote from other portions of the circuit.

In default of an accurate formula for predetermining the skin effect in multilayer coils, the designer must resort to his accumulation of test data on coils of various dimensions. The results of impedance measurements on a four-bank load coil are presented below and may serve as a rough guide in estimating the increase in effective resistance due to skin effect for coils of similar construction.

EXAMPLE: Table I and the curves of figure 3 present the results of calculation and measurement on a sample coil. This coil consisted of a four-bank winding of No. 21 D.C.C. solid wire on a threaded bakelite tube 6 inches in diameter. Specific dimensions are given on figure 3.

As a basis for calculation, the self-resonant frequency of the coil was first determined by the simple wavemeter arrangement sketched in figure 4. This measurement gave the equivalent lumped capacity, C. The D.C. inductance of the coil was computed from Brooks and Turner's data offered in bulletin 53 of the University of Illinois.

From these data it was possible to compute the effective resistance including the increment due to the capacity effect but exclusive of that due to skin effect, from

$$\frac{R}{(1-p^2 LC)^2}. \quad \text{(Curve 1).}$$

For purposes of comparison, the effective resistance was again computed taking also the skin effect into account on the basis of a straight isolated wire—from $\frac{RK}{(1-p^2 LC)^2}$: (where K is the "resistance ratio," $\frac{R}{Ro}$, given in "Radio Instruments and Measurements." (Wireless Press, N. Y.) These results are plotted on curve 2.

Impedance measurements were then made to determine the magnitude of the actual skin effect in the banked winding. The measurements in question were made by means of the radio frequency bridge sketched in figure 5. Although elementary precautions were taken to maintain a balance between the capacities to ground of the various corners of the bridge, it was found that shifting the apparatus changed the balance point noticeably, so that an accuracy greater than 5 per cent. is not claimed for the results.

Table I summarizes the increments in effective resistance contributed by the capacity and skin effects. The effective inductance apparently did not suffer any appreciable deviation from the theoretical values computed from the capacity effect formula along: $\frac{L}{1-p^2 LC}$. The inductance curve has been plotted from these calculations. The points on the curve represent the results derived from the impedance determinations.

TYPES OF COILS: By far the most practical and convenient information available for the rapid computation of the inductance of coils of all shapes is contained in bulletin 53 of the University of Illinois by Brooks and Turner. The results obtained from these data are sufficiently accurate for engineering work.

This paper assigns to all coils three characteristic dimensions, viz.: a, the inside radius of the winding; b, the length of the winding; and c, the depth of the winding. It is shown that a given length of wire will have a maximum inductance when wound into a multilayer coil of the relative proportions, a:b:c = 1:1.2:1, approximately. Coils containing the same length of wire but of different proportions will have a lesser inductance equal to a "shape factor," Fo, times the optimum inductance. Curves for Fo in terms of the fundamental dimensions a, b, c are given in the bulletin.

If we accept these relations, we may draw certain instructive conclusions regarding the relative efficiencies of various types of coils for radio work, keeping in mind that our problem consists in designing a coil for a given inductance with the smallest possible resistance consistent with cost.

Coils employed in circuits intended to receive long wave signals, i.e., 5000 meters or more, fall into three classifications:

1. Single layer coils.
2. Multilayer coils.
3. Bank-wound coils.

As stated above, the effective resistance of a coil is an inverse measure of its efficiency. This effective resistance may be expressed as

$$R_{eff} = R + R_c + R_s$$

where R is the direct current resistance, R_c is the increment in resistance caused by the distributed capacity effect, and R_s is the increment in resistance caused by the skin effect.

The single layer coil possesses a decided advantage in that it suffers a smaller resistance increment due to capacity and skin effect. However, for a given inductance, such a coil requires a very much greater length of wire and therefore has a much greater D.C. resistance than a coil of the same inductance wound in either of the other two forms. A glance at the curves of figure 3 will show that for long wavelengths, the D.C. resistance R is decidedly the largest term in the total, $R + R_c + R_s$. For wavelengths in excess of 5000 meters, therefore, a bank-wound coil is many times more efficient than a single layer coil. Brook's shape factor data shows, in fact, that a single layer coil may have a D.C. resistance as much as ten times the D.C. resistance of a bank-wound coil of the same inductance. For long waves, some form of multilayer coil approaching the maximum inductance shape is nearly always even more efficient than a bank-wound coil. The reason is, in brief, that the increase in resistance due to the greater capacity and skin effect in the multilayer coil is more than made up for by its smaller direct current resistance, since the latter comprises the major part of the total effective resistance at these frequencies.

Of course, for short wavelength circuits the reverse is true; that is, when the frequency is high enough to cause $R_c + R_s$ to become comparable in magnitude with R, the single layer coil may be the most efficient.

A type of coil called the "honeycomb-wound" coil has recently appeared on the amateur market. It is a multilayer coil with the layers wound askew so as to enable the turns to be spaced while still retaining the desirable multilayer maximum inductance form. The spacing of the turns is no doubt quite effective in reducing the increments R_c and R_s. At the same time it is obvious that for a given inductance a greater length of wire is required due to the less compact nature of the coil, which increases R a certain amount. Whether the total R_{eff} is reduced by the scheme depends of course upon the relative magnitudes of these two opposite effects for a given frequency range.

NOTE: The resistance increase caused by dielectric loss in the insulation of the wire is entirely negligible at frequencies lower than 60 kilocycles, in comparison with the three terms just mentioned.

The term R_s can be most effectively reduced by the use of litzendraht wire in place of solid wire. At high frequencies, where R_s occupies a formidable proportion of the total, R_{eff}, litzendraht is highly desirable. For long wavelengths, however, its desirability becomes more questionable. The choice between solid and litz-conductor must be governed by the practical consideration of maintaining a balance between the increase in efficiency and the accompanying increase in cost.

For example, in the case of the load coil whose effective resistance is shown on figure 3, it would have been decidedly uneconomical to use litzendraht braid. At the minimum wavelength for which this coil was designed, 5000 meters, $R + R_c$ is 14.1 ohms and R_s is 2.1 ohms. Assuming for the moment that the use of an equivalent litz braid would have eliminated the skin effect entirely, the resulting gain in efficiency would have been about 15 per cent. at the same time, the cost of the coil would have been increased about 225 per cent. This increase in cost might possibly have been justified had the coil been intended for use in a standard measuring circuit, but never in the case of its application to a practical receiving circuit; since a 15 per cent increase in audibility can be gained far more cheaply by a few modifications in the amplifier.

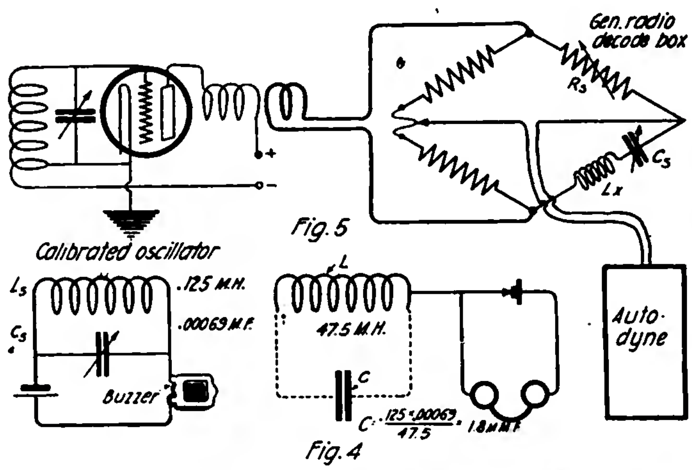


Figure 4—Simple wavemeter arrangement used in making calculations
Figure 5—Radio frequency bridge used in measuring impedance

TABLE I

Characteristics of 47.5 Milhenry Load Coil

Wave Length, Meters λ	$p.10^{-6} = \frac{600\pi}{\lambda}$	$p^2 LC$	$1-p^2LC$	KR computed on basis of isolated straight wire U. S. B. of S. Bulletin 74, table 19, p. 311. and formula 209	R_{eff} on straight wire basis $\frac{KR}{(1-p^2LC)^2}$	R_{eff} from test results	R_c increase in R_{eff} due to capacity effect $R\left[\frac{1}{(1-p^2LC)^2} - 1\right]$	R'_s increase in R_{eff} due to skin effect on straight wire basis $\frac{R(k-1)}{(1-p^2LC)^2}$	R_s increase in R_{eff} due to skin effect—from test results—by remainder	L_{eff} computed from $\frac{L}{1-p^2LC}$
300	6.28	3.37	-2.37	41.3	7.36					
500	3.77	1.215	-.215	33.9	734.					
600	3.14	.844	.156	30.42	1252.					302.5
700	2.69	.618	.382	28.36	194.4					124.9
1,000	1.884	.304	.696	24.23	50.00					68.1
2,000	.942	.0759	.9241	18.18	21.30	31.5	2.37	5.16	15.36	51.4
3,000	.628	.0337	.9663	15.97	17.10	21.3	.98	2.35	6.55	49.1
4,000	.471	.0190	.9810	15.15	15.73	18.0	.53	1.43	3.70	48.4
5,000	.377	.0122	.9878	14.60	14.95	16.2	.34	.84	2.09	48.1
10,000	.188	.0030	.9970	14.05	14.14	14.5	.08	.29	.65	47.6
15,000	.126	.0013	.9987	13.86	13.90	14.0	.04	.09	.19	47.6

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 Spark Coil Panel Transmitter

By Thos. W. Benson

IN the design of spark coil panel it is not sufficient that we merely group the apparatus as conveniently as possible; an effort should be made to centralize and simplify all variable factors so as to make them easily and quickly adjustable. In spark coil design it is difficult to calculate the values of capacity and inductance required, hence we make them adjustable, actual tests determining the proper values. Furthermore, the modern spark coil set must be inductively coupled with the antenna, or trouble is sure to result from interference with other stations.

The set described here possesses several novel features, including a quenched gap as well as an easily adjustable oscillation transformer. Figure 1 illustrates a front view of the panel with the apparatus assembled. For the sake of clearness the secondary of the oscillation transformer is omitted.

The panel may be made of bakelite or fibre. Any hard wood, however, will serve if insulating washers are used in mounting the live parts.

The panel, which should measure 12" x 15", is attached by braces to a base 12" x 10".

A hole is cut in the lower left corner of such a size that the interrupter on the spark coil mounted in the rear can be adjusted. A switch occupies the lower right corner.

Above the interrupter is mounted the quenched gap. This comprises two brass rods ½" square, and 1¼" long, mounted 1½" apart. The upper rod is drilled and tapped to take an adjusting screw 1" long which serves to hold the gap elements together. The elements of the gap are made from a strip of copper 1" wide and ⅛" thick. This strip is cut up into one inch lengths and all corners neatly rounded with a fine file. The faces of the elements are polished up on fine emery or sand paper. Eight elements suffice for a one-inch coil, the exact number to be determined by test.

Separators one inch square are cut from mica .005" thick, a hole ⅝" in diameter being cut in each with sharp pointed dividers. In assembling the gap, alternate pieces of copper and mica are piled up, the edges made even by tapping on a flat surface and then clamping them between the brass posts rather tightly.

The condenser for a one inch coil can be made by placing 7 plates of tinfoil or thin copper or brass 4" x 6" between sheets of glass 6" x 8". Four of the plates have lugs brought out to a common terminal, the other three plates being brought out separately for the purpose of varying the capacity. The usual practice of coating the plates with vaseline should be followed, clamping them between two pieces of wood 6" x 8".

The condenser unit is held upright behind the panel by 4 brass clips as

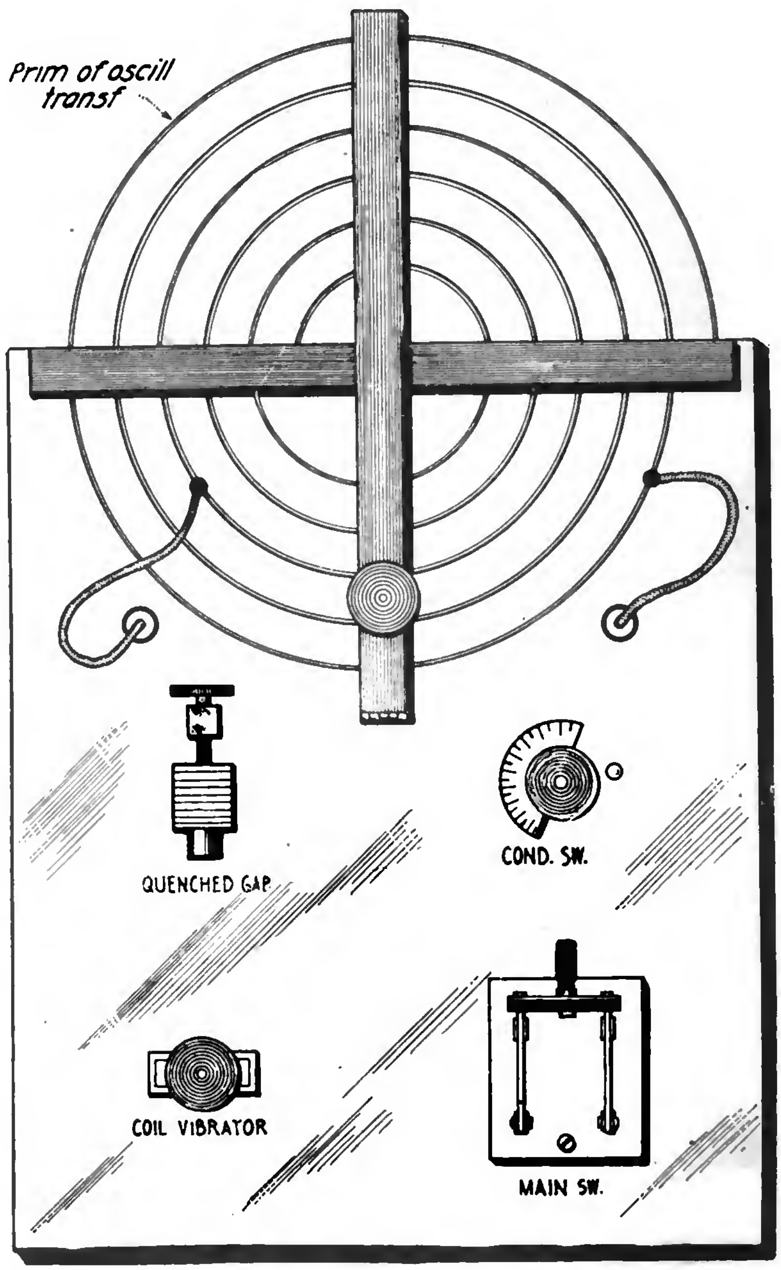


Figure 1—Front view of panel with apparatus assembled

shown in the side view, figure 2. A 3-point multiple switch on the front of the panel controls the capacity. This is made in the usual manner from a semi-circle of thin copper with a radius of 1", fitted to an insulating knob. The copper is split near the edge with a pair of snips, 3 contacts connecting to the condenser plates being mounted so that the copper contactor travels over them.

The oscillation transformer is simple in construction, the primary and secondary being identical. The cross is made from ⅜" x ¾" strips, notched and glued together. Before assembling, holes are laid out and drilled in the arms to pass No. 10 copper wire. It is preferable to use stranded wire or difficulty will be experienced in threading the wire through the holes. If preferred, slots can be cut for the wire in place of holes, thus simplifying the assembly. The turns are ¾" apart, starting 1½" from the center, making 5½ turns.

The secondary is mounted on the rear of the panel as shown in figure 2. The primary is mounted on the front. being pivoted at the bottom by a small brass hinge. The adjustment for coupling is obtained by means of a threaded rod shown in the side view. One end of this rod is fitted with two nuts jammed together and slipped through a slot in the panel. The primary is slotted directly opposite and the rod passing through has a knob threaded on it. The slots permit the up and down movement of the rod when the coupling is varied by turning the knob.

The flexible leads to the primary are passed through holes in the panel properly bushed to prevent leakage of the high voltage current.

The hookup presents no difficulties. Stranded wire is preferred. Binding the wire in smooth curves and keeping it away from all supports maintains the efficiency. No connections are made to the front of the set. Binding posts for the primary current should be mounted on the base at the rear. This leaves a clean panel with no wires at the front, making unnecessary the drilling of the operating table.

The wiring diagram shown in figure 3 shows the preferred method of wiring in the aerial switch. This reduces leakage across the switch, permitting the use of a smaller and more compact aerial switch. In addition, the lead can be brought directly to the secondary of the oscillation transformer, making a much neater installation.

It should not be necessary to dwell on the advantages of this set. By marking the inductances with different values of capacity the set may be tuned for three or more wave-lengths. In this connection it might be well to state that for local work it is best to cut down the wavelength to 150 meters or so. This will enable a spark set to get through when a number of sets are working around 200 meters. For maximum distance, however, the wave length should be run up to the limit, 200 meters.

Most Government stations do not tune lower than 300 meters, so even if you run over 200 and emit a sharp wave, little interference will result. By all means, keep the wave sharp. It is easily accomplished with an inductively coupled set as described. Watch your operating range increase.

For other than a one inch spark coil the size of condenser and number of gap elements will be different. For a ½" coil, use 5 plates in the condenser and about 4 elements in the gap; for a 2" coil, use 9 plates in the condenser and 12 or 14 elements in the gap. The panel described will permit of the change of power, the gap being designed to take more elements, and the condenser can be increased by adding plates. One of each pair of additional plates can be connected permanently to the condenser switch.

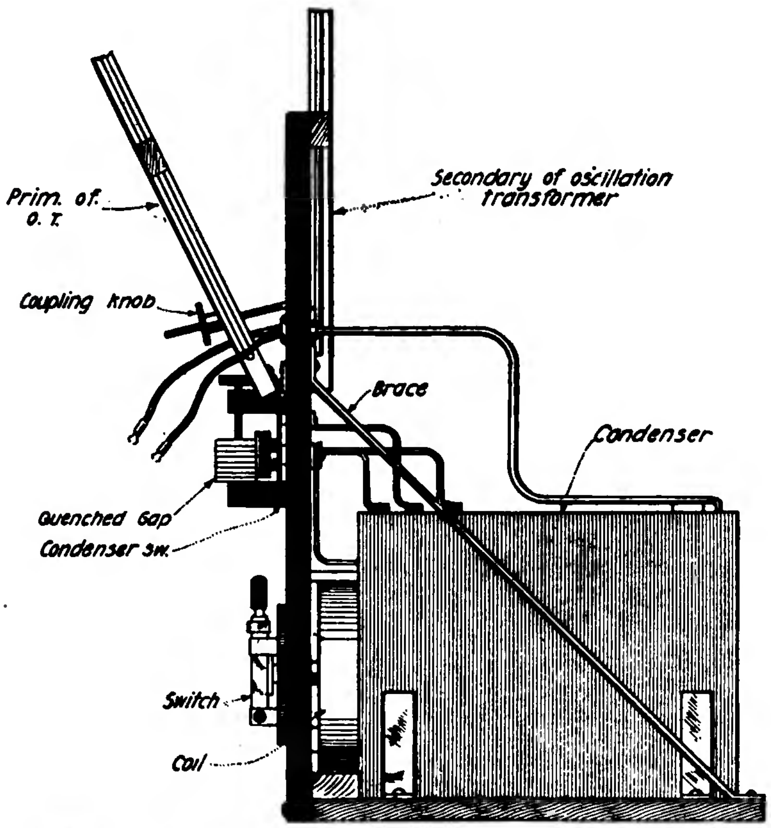


Figure 2—Side view of panel showing condenser unit, oscillation transformer and other apparatus in place

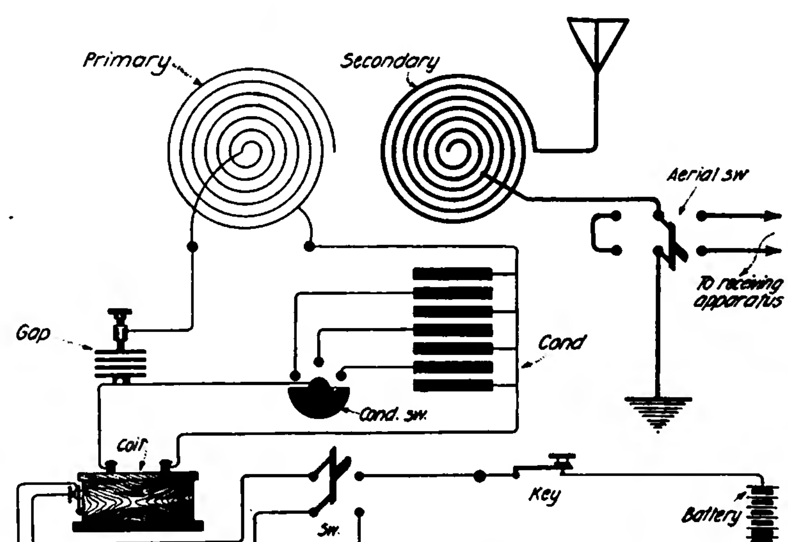


Figure 3—Wiring diagram used in the spark coil transmitter

Multi-layer Inductances for Long Wave Work

By Frank V. Bremer

FOR many obvious reasons coils of rectangular cross section are much more convenient than single layer solenoids when one wishes to effect reception at the longer wave-lengths.

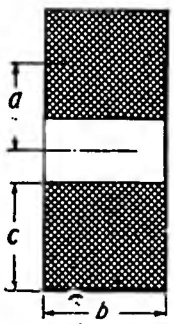


Figure 1

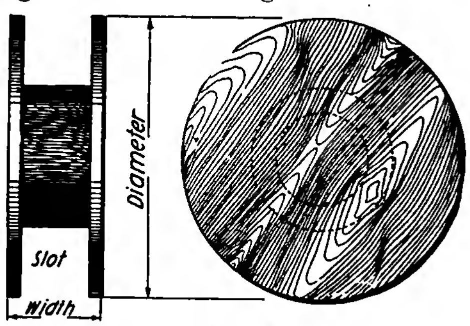


Figure 2

Figure 1—Dimensions used in the formula. Figure 2—Constructional details of block used for winding the coils

Not only are there physical advantages arising from decrease in amount of space taken up by the coil but there are no electrical disadvantages which will in any way materially affect the results to be obtained when coils of rectangular cross section are used. The usual large single layer loading inductances are very awkward to handle and there is always the disadvantage that, by reason of the comparatively low value of distributed capacity which the long solenoid has, any movement of the hand in the immediate neighborhood of the long coils changes the effective distributed capacity. As a result the wave-length of the circuit of which the coil is a part is also changed. In the case of the multi-layer coils, the distributed capacity is not only considerably higher, but the electrostatic field of the coil is so concentrated that the proximity of foreign bodies has no appreciable effect upon the wave-length of the circuit of which the coil is a part.

Although it is considered best practice to use single layer solenoids when dealing with shorter wave-lengths, it is possible to build and use multi-layer coils of rectangular cross section on the shorter wave-lengths.

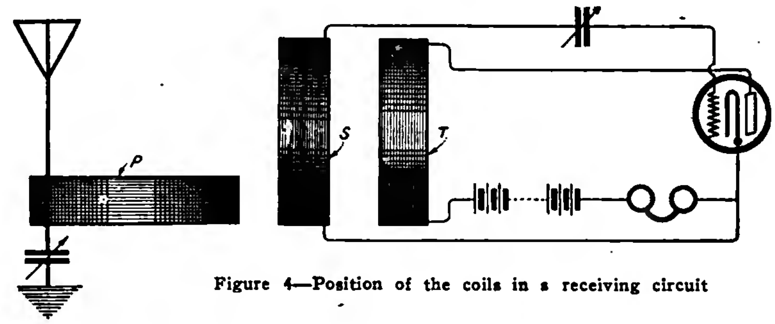


Figure 4—Position of the coils in a receiving circuit

Formulas for the calculation of multi-layer inductances of rectangular cross section are to be found in the circular of the Bureau of Standards No. 74, "Radio Instruments and Measurements." In the formula

$$L = \frac{4\pi n^2 a^2}{.2317a + .4466b + .39c}$$

a very fair approximation of the inductance value of a multi-layer coil of rectangular cross section may be obtained. Here n equals the number of turns, a the mean radius, b the width, and c the radial depth in centimeters. See figure 1. For example, assume that we wish to construct a coil to work up to 10,000 meters in conjunction with a variable capacity having a maximum value of .001 microfarad. Using the formula, $\lambda = 59.6\sqrt{LC}$, we determine that approximately 28,000,000 cms. inductance will be required. Ignoring the distributed capacity and assuming that the coil is to be 6" outside diameter and 1" wide and the winding to have a radial depth of 1", we find by solving the equation for n that it will be necessary for us to place within this space (1" x 1") approximately 910 turns of wire. It will then be necessary, of course, to choose a size of wire such that it will be possible to place this number of turns within the space allotted, but if only a certain size of wire is available for use, a certain number of turns in a certain area may be assumed and the formula solved for L which being too large or too small, a new assumption is made, etc.

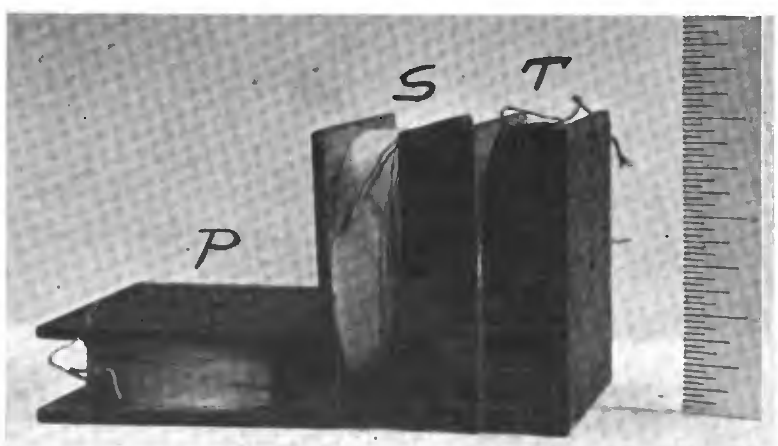


Figure 3— Rectangular cross section coils constructed by an amateur in New York

For undamped wave reception in conjunction with vacuum tube detector, three coils will be required, viz., a primary, a secondary and a tickler coil. The coils are all constructed in a similar manner, the only difference being in the dimensions, these varying with the wave-lengths. A solid block of close-grained wood, such as birch, of a size suited to the dimensions of the coils to be constructed, is selected and placed in a lathe. This block is turned round to the correct diameter and width. Without removing it from the lathe a slot of square cross section, figure 2, is turned in and the whole given a smooth finish.

A layer of bond paper, about .01", is then laid in the bottom of the slot and the winding is begun by placing a layer of wire upon the paper, being sure to have the turns all even and to fill the layer up full. Another layer of bond paper is then laid over the first layer of wire and the winding is continued, a layer of paper being placed over each layer of wire, etc., until the slot is completely filled up.

For use in conjunction with the average amateur antenna it will usually be found desirable to construct two coils of the same dimensions for each range of wave-lengths chosen, one of these for use as a primary and the other for use as a secondary. The tickler coil may be made smaller and usually a value of inductance about one-third that of the secondary is sufficient. Because of its lower resistance, it is desirable to use Litzendraht, but solid wire may be used with excellent results. No taps should be taken off from any of these coils.

For those who may have difficulty in having the forms for the winding of the coils turned out a substitute may be made by obtaining two pieces of close-grained board ¼" thick and cut to the desired size. Next obtain a round piece of wood of the proper diameter, divide each piece of board so as to get the exact center, and glue a piece of round stick between the boards, but do not fasten the pieces together. The winding is done about as outlined above. Some dimensions of coils constructed in this way are given below and are shown in figure 3. All the European stations have been copied in Jersey City, using these coils in connection with an antenna 150 ft. in length and a single vacuum tube.

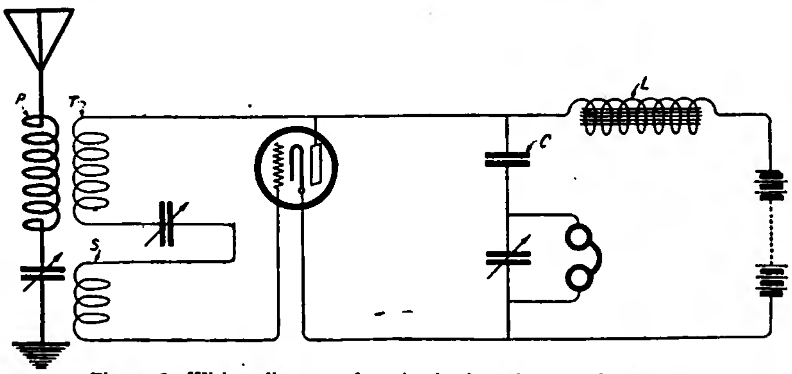


Figure 5—Wiring diagram of a circuit that gives considerable amplification

For wave-lengths from 2,200 to 6,000 meters the diameter of the core should be 2", width of slot ½", depth of slot ½", wound with about 300 turns of No. 10-38 Litzendraht or No. 28 single silk-covered wire.

For wave-lengths up to 15,000 meters, the diameter of the core should be 3", width of slot ¾", depth of slot ¾", wound with about 2,100 turns of No. 10-38 Litzendraht. In this and the above case, 6.5 mil paper was used between layers.

For receiving, the coils should be placed as shown in figure 4. In the event that the circuit does not oscillate, the position of the tickler coil T as related to the secondary S, should be changed and it may be that the coil should be reversed in the circuit. This same effect may be accomplished by reversing it in its plane. If everything is in proper order, a slight click will be heard when it is dropped from a plane parallel to the plane of the secondary coil to a plane at right angles to the secondary coil. Figure 5 shows another circuit which may be tried and which gives considerable amplification. Here C has a capacity of about .5 microfarad; L an iron core inductance such as the secondary of a telephone transformer. For damped wave reception the circuit shown in figure 6 is convenient.

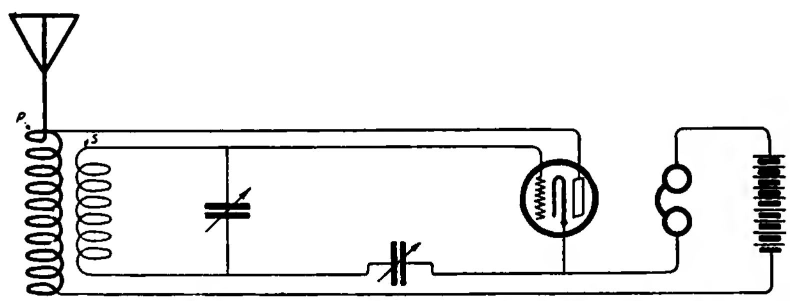


Figure 6—Diagram of a circuit suitable for damped wave reception

The coils shown in the photograph were constructed by an amateur, Emil Heydolph, of New York.

A Modern Receiving Set

By L. W. Van Slyck

HAVING designed and operated the receiving set shown in the photo, and since my results were so good in every respect, I am submitting the specifications, believing they might be of interest to readers of The Wireless Age.

The "loop" is constructed as shown in figure 2, and can be seen at the left in the photograph. The loading coil and the "X" circuit coil may be made in any required dimensions. For 2,500 meters, I find that a coil 4" in diameter and wound for a length of 10" with No. 24 wire is amply sufficient.

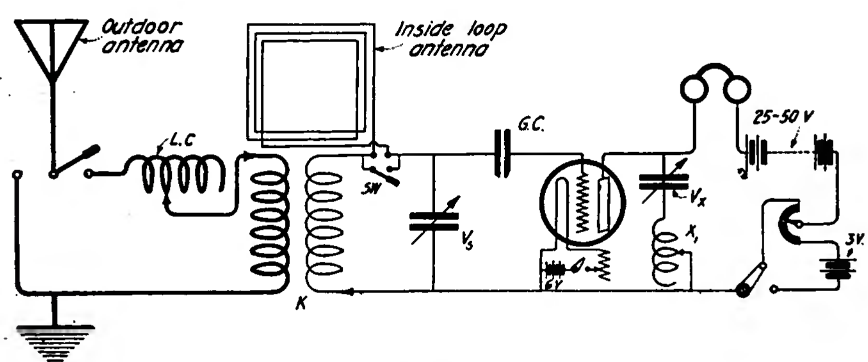


Figure 1—Wiring diagram of circuit used

The two variables, Vx and Vs are of .001 and .0005 mfd. capacity, respectively. The loading coil, LC, and the loose coupler K, may be of any design for the range of wave lengths desired. I am using a loading coil similar to the coil X, and about half as long, with a "Blitzen" receiving transformer. The rest of the outfit is, I believe, self-explanatory.

When it is desired to use the loop, open switch SW, turn the secondary

The complete receiving set using a loop antenna

of the receiving transformer to 0° coupling and disconnect the outdoor antenna (if desired). Then tune with Vs and Vx, orientating the loop until signals are a maximum.

With the set described, and using the loop, I find no trouble in copying along the coast from NAH to NAR, and NAT, and the large majority come in plenty loud enough to read.

Using the outdoor antenna with these instruments, the same stations come in about five times as loud, and, of course, many others which are in-

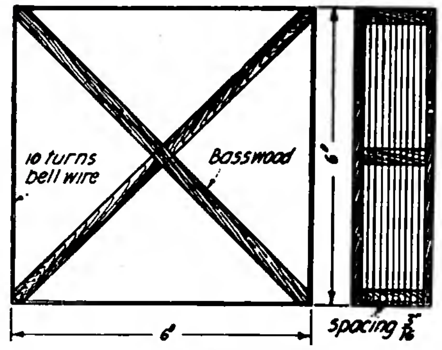


Figure 2—Dimensions and constructional details of the loop

audible with the loop. The loop in this form is not highly directive, having a maximum range of orientation for a given signal of approximately 60° without a noticeable change in signal intensity.

If it is desired that the loop be more directive, it can be wound pancake style.

An Antenna Switch

By F. McGuirk

THIS type of antenna switch is somewhat different from the usual ones in use today. It is a rotary type, as will be seen from the diagrams that accompany this article.

Details of the construction follow:

Procure a rubber or dilecto cylinder 4" long and 1½" in diameter, 6 inches of brass strip, ¼" wide and ⅛" thick, and 3 inches of brass ½" wide by ⅛" thick, and about 3 inches of phosphor bronze strip, 1¼" wide and 1/64" thick. The phosphor bronze must be thin enough to have a kink put in it. Some brass rod 5" long and ¼" thick, and two bakelite strips 4½" long each, and ½" wide and ⅛" thick will also be needed. The cabinet and knobs may be constructed to suit the builder.

First, on each end of the cylinder, draw 4 equal right angles. Cut the brass into pieces (both sizes) of 1-5/32" in length. Draw two lines and bend the brass to fit the cylinder. When fitted snugly, place each piece ¼" apart and screw it down. These are put in place between the lines. Next put the rod through the cylinder and thread the ends for bolts to prevent the cylinder from slipping. Now cut the phosphor bronze into strips ⅛" wide. In the one end cut out about ⅜" in the middle to increase the spring and hammer a kink in it similar to the kink in figure 3. Then take the bakelite strips and drill holes of a size to fit the builder's screws or bolts at ½" from either end and in the center of the strip.

The cabinet is very easy to make; the front should be put in place last. The end of the rod should set ⅛" in, as is shown in figure 1. The bakelite strips should be put in place 1⅛" from the bottom and the phosphor bronze strips stuck in and left ¾" out. When the strips are in place and wires are soldered into them the front may be put in place. The strips should be bent until they bear with force on the cylinder itself to make a still better contact on the brass. When the strips are properly in place and function O. K. then connect the wires to the binding posts on the top, labelling everything carefully. The knob may be placed on the previously threaded rod and the lettering on the front.

This makes a switch that can be shut off and on from the operator's table, and prevents the aerial from having a clear path right through the apparatus. The operation is positive and the builder could arrange a spring to make it impossible to leave the switch only half on.

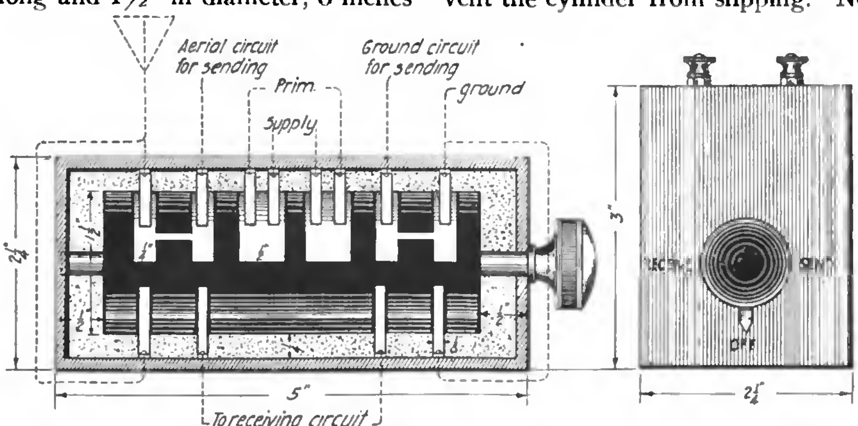


Figure 1 Figure 2

Constructional details and dimensions of the antenna switch

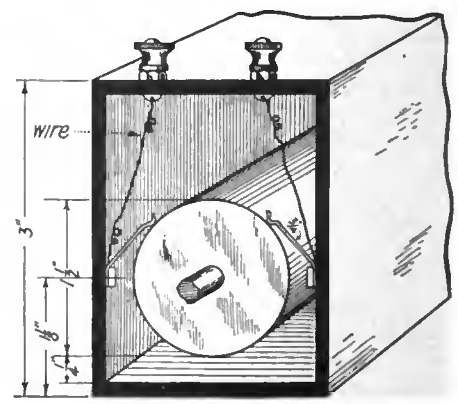


Figure 3—Cut-away view to show method of connecting

A 60-Watt Low Power Transmitter

By L. R. Felder

FIRST PRIZE, $10.00

THE set described in this paper is one which has actually been built and used by the writer and has given the most satisfactory results. Several important considerations which resulted in the choice of this set may prove interesting to the amateur.

A simple set was desired which would transmit about 25 miles, operate at maximum efficiency without making numerous adjustments, and could be built out of material which every amateur already has. A further consideration was that it should not depend for its operation on peculiar differences in the different items of the set. The set which fills these requirements best is one consisting of a battery operated induction coil, properly designed, actuating a closed circuit directly coupled to the antenna.

While vacuum tube sets are coming more and more into use, the writer did not think it desirable to use one in this case, although he has had considerable experience with tube sets. In the first place, with the tube set, the question of life is an important item. Although the tubes that most amateurs are using are of a very high standard they burn out occasionally, especially when they are used for transmitting. Furthermore, too many tubes would have to be used for the powers desired. For the above power rather high voltages would be required. This either means a high voltage D. C. generator which is quite expensive, or using rectified A. C. which involves the building of a transformer with the required smoothing out circuits, all of which means considerable expense, and requires a good deal more experimenting and fussing to get results than most amateurs imagine. Again the tube set depends to a large extent on the constancy of the different items in the set. Those who have had any experience at all with tube sets know that if for some unknown reason the capacity of the antenna has changed the least bit, the adjustments of the set will have to be changed or the set may not operate at all. In other words, the tube set is too critical for good amateur use. This statement applies to any small change that may occur in any other part of the set.

The set described has none of these defects and is very easily built and does not require a large amount of apparatus. The diagram in figure 3 shows all the apparatus needed, and what the set consists of. It consists of a specially designed induction coil the primary of which is operated by means of a key and 12-volt storage battery. The secondary is connected across two condensers in series, which with the spark gap and inductance form a closed circuit. The inductance is directly coupled to the antenna. As seen in figure 4, the assembly is very simple and the items in the set are reduced to a minimum. When assembled and placed in its case, the whole set occupies a space of about 10 x 6 x 6 inches.

The transformer which has been built for this set, is an unusually good one and is recommended to all. The details of the design and construction are given so that any one may build one without having to go through the whole process of designing it. It is intended to be used with a 12-volt storage battery. The secondary voltage necessary to jump the gap is 7,000 volts. The ratio of transformation is, therefore, 600. The primary consists of 80 turns of No. 20 D.C.C. wire wound in 1½ layer along a length of 3 inches. The primary is wound directly on the core. The core is made up of silicon steel strips No. 29 gauge; this is, 0.014 inches, 3¾ inches long. The strips are tied together by linen tape and when built up, occupy a space ½ x ½ x 3¾ inches.

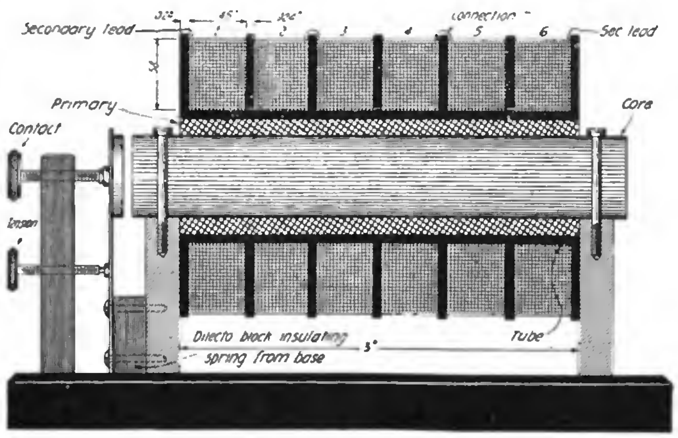


Figure 1—Assembly of the induction coil used in the 60-watt low-power transmitter

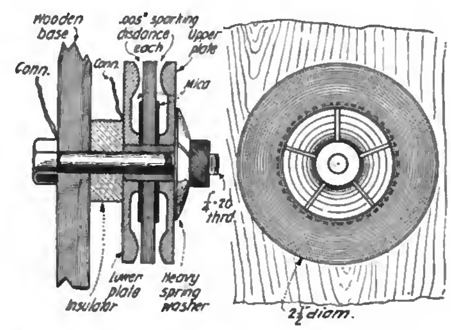


Figure 2—Detailed side and end views of the quenched spark gap

The secondary is wound on a tube ⅞ inch inside diameter and 1⅛ inches outside diameter. The tube is made of paper rolled on a mandrel of the proper size. The paper is thoroughly shellacked and allowed to dry well. The secondary is then wound on the tube. The secondary consists of 6 pies, with 8000 turns per pie, total number of turns being 48,000. The size of the wire is No. 40 enameled. Each pie is 0.45 inches long and has 130 turns per layer, with 61½ layers. The insulation between layers is paper about 0.005 inches thick and about 0.45 inches wide. The pies are insulated from each other by fish paper 0.020 inches thick, 1⅛ inches inside diameter and 1.725 inches outside diameter. In winding the pies it was found that the most convenient way of winding them without running into trouble due to high potential leads crossing low potential leads, was as follows: Wind coils, 1, 3, 5, as shown in figure 1. Then turn winding form around and wind coils 2, 4, 6, always starting at the bottom left. Then solder connection as shown so that one continuous winding is formed. The whole winding should then be covered with one wrapping of bookbinder's cloth.

The assembly of the transformer is seen in figure 1. The base is made of cast aluminum about ¼ inch thick. The spring is made of spring steel, and the armature which is riveted to the spring is made of soft iron. The contacts are silver ⅛ inch in diameter. There are two screw adjustments which are made of brass. The upper screw adjusts the spacing of the contacts and the lower adjusts the tension of the spring. As indicated in the diagram, the spring is insulated from the base by a dilecto spacer.

There are two condensers across the secondary of the induction coil. The object of the two condensers is to prevent possible breakdown and to provide ample capacity over which to distribute the potential. One condenser can of course be built to withstand the voltage generated across the secondary. Each condenser has a capacity of 0.005 mf., the total effective capacity being 0.0025 mf. The size of these condensers can be very easily figured by the usual conventional formulas and is therefore not given here. It is advised that 2 mil mica be used.

The voltage which is built up across the terminals of the condensers discharges through a quenched spark gap and inductance. The inductance used is a flat spiral made up in the usual way. There are three and one-half turns of copper strip ¼ inch wide by 1/32 inch thick. The turns are spaced ¼ inch. The adjustments are made for the proper wavelength by taking taps off the spiral, as shown in figure 3.

The spark gap (figure 2) is of the quenched gap type. There are three plates forming two gaps. The plates are made of ¼ inch brass or copper silver plated. Each of the plates has a clearance hole of ½ inch so that the ¼ inch screw running through the plates does not short-circuit any of the sections. The upper and lower plates both rest on the center plate but are insulated from each other in the center by mica 0.005 inches thick. The sparking takes place at the formed portions of the plates at the outer circumference and the sparking distance per gap is 0.005 inches. The mica insulators are 0.005 inches thick, ¼ inch inside diameter and 1½ inches outside diameter.

The set has proved very successful, is very simple to construct and operates with very little trouble. It puts about ¾ ampere in the usual amateur antenna and can be depended on to send at least 25 miles.

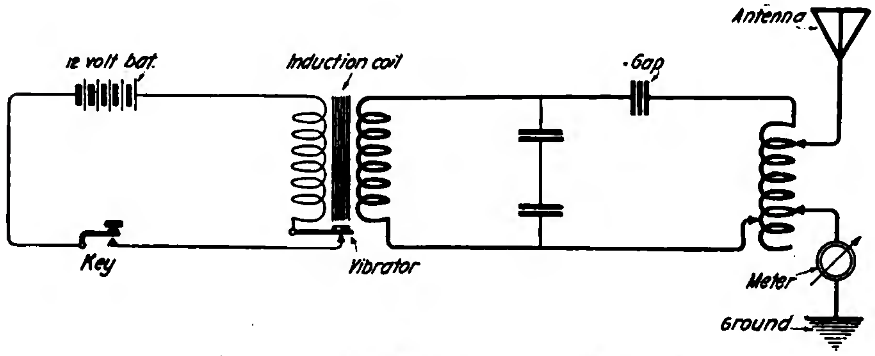


Figure 3—Diagram showing hook-up of instruments

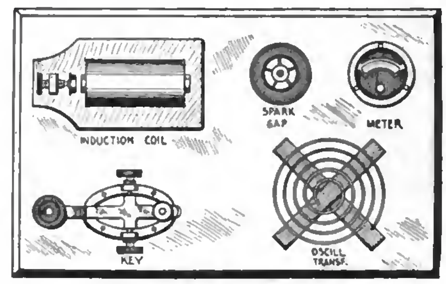


Figure 4—Panel arrangement of instruments

The Design and Construction of a Low Power Transmitter for Local Use

By Walter A. Remy

SECOND PRIZE, $5.00

As operator of 2KV the writer has noticed that in the past two months QRM has again reached the same stage as it did in 1917. It is impossible to do any long distance amateur receiving or relay work until after 10 or 10:30 p. m.

This is not alone due to the spark coil—which has been blamed for interference to such an extent that it is looked upon as a thing only capable of causing QRM—but also the big transformer station. The writer, in fact, has experienced more trouble with the latter than with the spark coil. More than once two stations 5 or 6 miles apart have been heard working with ½ kw. power on each end, and in some cases even 1 kw.

The Government Station License says that only the minimum amount of power necessary to carry on communication should be used. It is the purpose of this article to describe the construction of a spark coil transmitter which serves the double purpose of reforming the spark coil and of providing a transmitter which can be used by the big stations for local work.

Let us first consider the technical aspects of a low power transmitter. There are two types, namely, the vacuum tube or continuous wave transmitter, and the spark coil set. The vacuum tube set has the advantage of having little or no decrement and therefore produces a very sharp wave, causing practically no QRM. On the other hand, the initial expense of this type of transmitter makes it prohibitive for general use, for the builder must purchase the tubes and solve the financial problem of supplying the plate voltage. There are two types of spark coil sets. The one in which a commutator interrupter is used in the primary circuit and a synchronous rotary gap in the secondary circuit is exceedingly efficient, but for economic and constructional reasons this, too, is impractical for general use. Hence, we have left the conventional type of spark coil transmitter with a vibrator and a fixed gap.

The panel type set which is described in this article has been constructed and is in daily use at the writer's station; it is quite efficient, and with 6 watts input on exactly 200 meters, signals from this station have been heard at a distance of 25 miles. Sixteen miles is the consistent working range—ample enough for local work.

The set mainly consists of a spark coil (a Ford ignition coil was used), a fixed spark gap, condenser, and pancake type helix.

The front view of the panel is shown in figure 1. This panel may be of bakelite, asbestos, or hard wood, and is 10" x 16" in width and length, respectively. A small DPST switch is used to connect the power to the set. Above this is the spark gap, and then comes the hot wire ammeter, which is of small scale, with the shunt switch to "short" it when it is not in use.

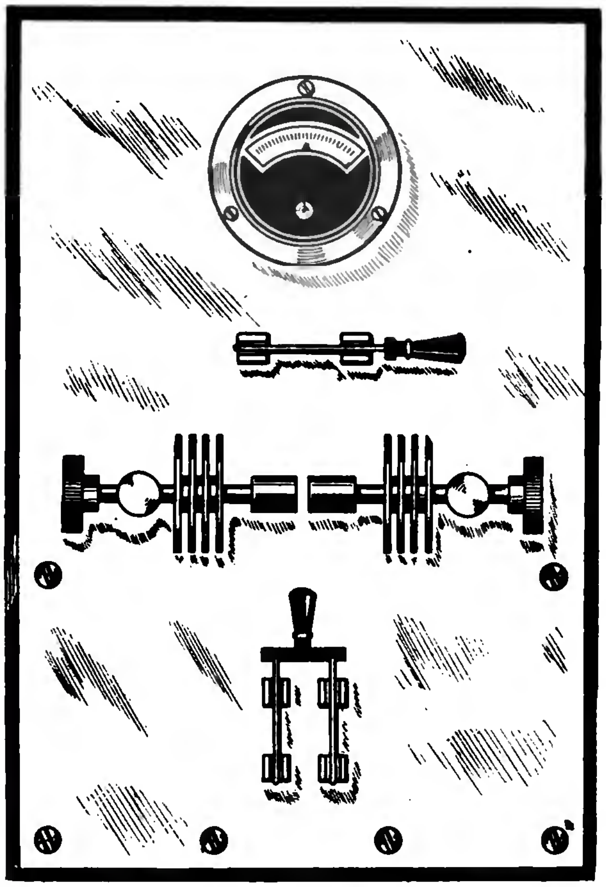


Figure 1—Front view of panel

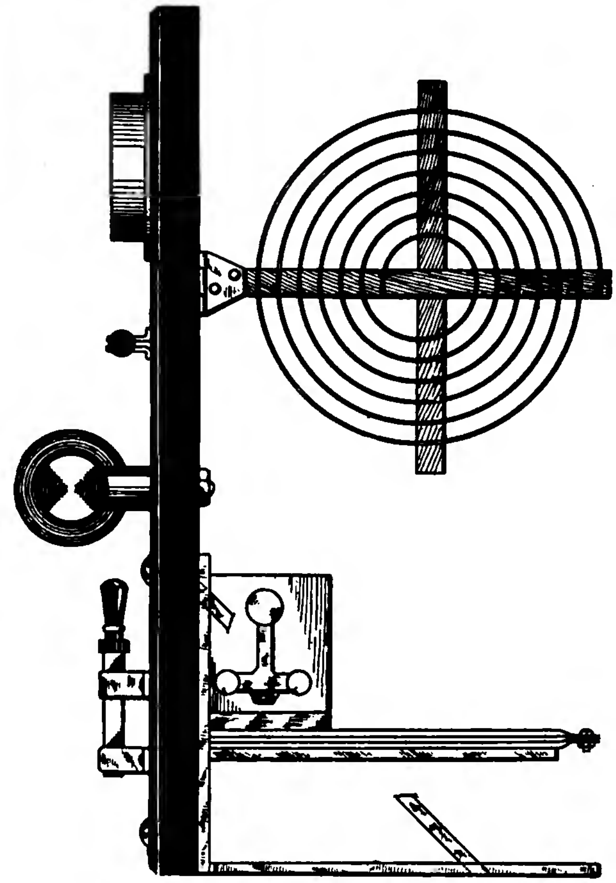


Figure 2—Side view showing layout of apparatus

The side view (figure 2), shows the general layout of the apparatus. The spark coil is mounted on the condenser, and may be of ½" to 2" rating. It is not recommended that the spark coil be built, as it requires a considerable amount of labor to construct one and the expense will not be much less than the manufacturers' selling price.

The spark gap may be purchased or constructed, as the builder may desire. It is mounted on the panel and should have sparking electrodes at least ⅜" or ½" in diameter, depending upon the power of the set. Four cooling fins 1½" in diameter should be provided on each electrode and should be of brass. This offers a large amount of surface which dissipates the heat and keeps the gap cool, making it more efficient.

The condenser consists of three glass plates 4" by 6", coated on either side with tin-foil 3" x 5", connected in parallel. Lugs ¾" x 1½" must be included in each tinfoil conductor. This wound on two cross-pieces 9" long by ½" square. On the supports were wound 9 turns of ½" copper ribbon spaced ⅜" apart. When making the grooves for the ribbon, remember to begin in the first notch on each arm ⅛" further from the end than the preceding arm, so as to form a perfect spiral. The first notch of the first arm is cut ¼" from the end, the first notch of the second arm ⅜" from the end, and so on. Each notch should be ⅜" deep. The helix is then mounted at right angles to the panel by an angle bracket. It will be noted that the various instruments are close together and the leads will be very short.

The conventional transmitter circuit is shown in figure 3. For greatest efficiency the leads should be of braided

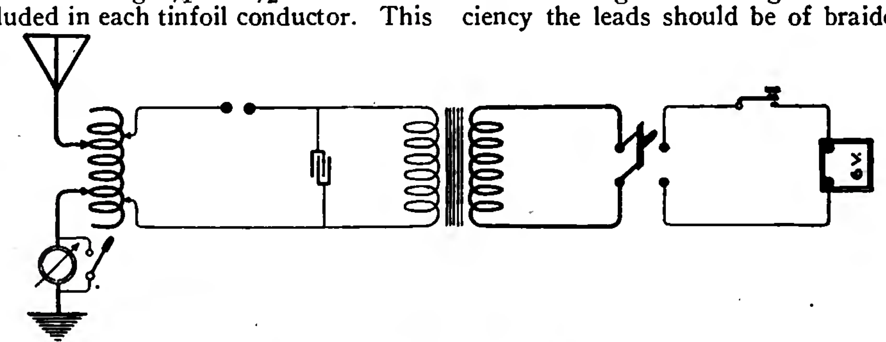


Figure 3—Diagram of the transmitter circuit

condenser is mounted on a piece of bakelite or hard wood of the same dimensions as the condenser, fastened to the panel by means of angle brackets, or it may be placed directly on the operating table. Another piece of bakelite or hard wood about the same size as the base of the spark coil is placed on top of the condenser, upon which the coil is mounted. These pieces insulate the condenser from the other parts of the transmitter.

The helix was chosen in preference to the oscillation transformer, after a little experimenting which showed that there was too much loss between the primary and secondary. The wave emitted when the oscillation transformer was used was sharper, but with the helix in use the emitted wave was sharp enough for all practical purposes, and there was a greater radiation. And again, the helix was used on most of the army's low power spark sets during the war. The helix is copper ribbon, which has a large conducting surface and is quite flexible.

In conclusion, it might be well to note several points in adjusting this transmitter. No one must expect to get the results mentioned in the first part of the article without the use of a wavemeter and, of course, the hot wire meter. As the use of the wavemeter is taken up at length in various text books nothing will be said about its use here. Another point to keep in mind is the vibrator of the spark coil. As long as the vibrator is kept bright and clean the set will have a smooth note, but the minute it is allowed to become pitted or dirty, the note will be scratchy and will lessen the efficiency of the set and also the popularity of its owner. If the builder follows the directions in this article with some amount of care, and he has a good aerial, there is no reason why the performances set forth here cannot be duplicated, as the second district is not especially noted for excellent radio conditions.

Low Power Transmitter for Local Use

By Louis S. Butler

THIRD PRIZE, $3.00

I HAVE used several types of low power transmitting sets, but the one here described has been found the most efficient. To get the proper wave length, together with good results, the aerial should be one of four wires between 40 and 50 feet long, and should be at least 40 feet high. The oscillation transformer is the well-known Murdock hinge type. Any good spark gap is sufficient. The condenser may consist of four Leyden jars, or any good glass plate condenser designed for use with spark coil sets. For power, a 1" spark coil made for radio use is sufficient. The spark coil can be run on six dry cells with very good results, but when run on a 110 v. light line, with an electrolite interrupter, the range of the set can be increased about 10 miles.

I have found this type of low power good ground, and he must have as many connections soldered as possible. The set here described when *properly tuned* is very efficient for local work, and due to its very moderate cost will be found within the reach of most every amateur. A 25 watt 110 v. lamp

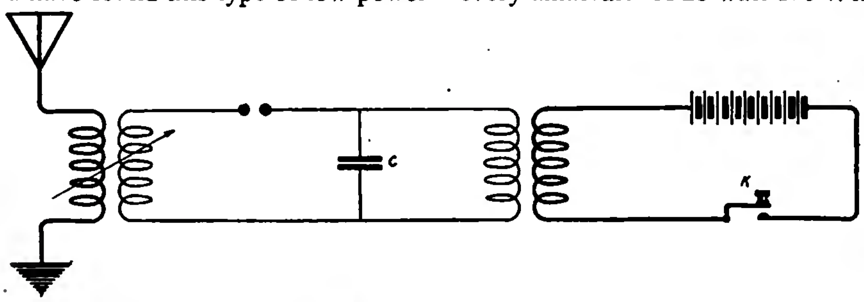


Figure 1—Diagram of circuit for the low-power transmitter

transmitter to be very efficient for sending strong and clear signals from 20 to 30 miles in the day time, the receiving station using a vacuum tube, but no amplifiers. Of course the experimenter must bear in mind that to get the very best results from his set he must have a good aerial and in series with the antenna will be found suitable for determining the antenna radiation where a hot wire ammeter is not available. The great advantage of this set is that it can be tuned sharply so as to cause small interference, which will be greatly appreciated by other operators.

The Monthly Service Bulletin of the

National Amateur Wireless Association

Fonnded to promote the best interests of radio communication among wireless amatenrs in America

A Useful Switch Arrangement

SOMETIME ago I had occasion to build a single unit receiving set, having regenerative features and one-step amplifier. The diagram shows how a single anti-capacity jack switch was used to throw in the audio-frequency amplifier.

Starting at the aerial: the primary of a loose coupler is shown, also a switch for putting the primary condenser either in series with ground lead or shunt to the primary inductance.

The secondary of the coupler has the ordinary detector hook-up when the tickler coil is short-circuited.

When the tickler coil is not shorted, you have the regenerative feed back circuit. Now, when the master jack switch (anti-capacity) is thrown to the left, you have a regular detector hook-up or a regenerative hook-up,

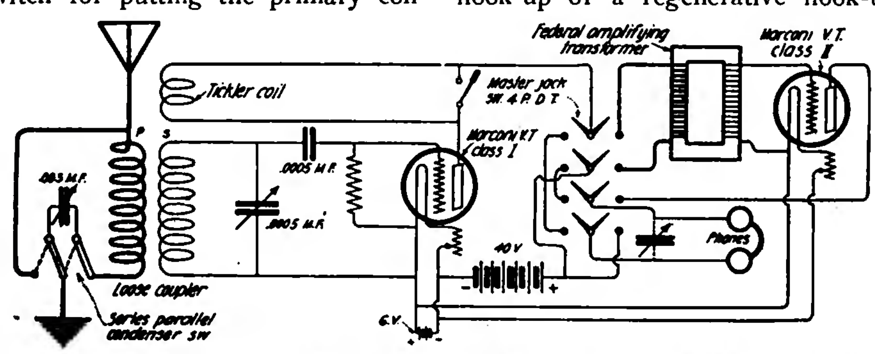


Diagram of single unit receiver having regenerative feature and single step amplifier depending upon whether the tickler is short circuited or not.

When the master jack switch is thrown to the right, the single-stage audio frequency amplifier is connected in circuit.

The advantages of a hook-up of this sort are as follows:

1. All instruments can be mounted on a single panel.
2. Detector hook-up alone can be used.
3. Regenerative hook-up alone can be used.
4. Detector and single-stage amplifier can be used.
5. Regenerative and single-stage amplifier can be used.
6. All these combinations are effected by the throwing of only two switches, namely, the master jack switch and the tickler short circuit switch.
7. Also a single "A" and "B" battery are used.

I have given no dimensions, leaving it entirely up to the amateur desiring a compact flexible receiving set.

The popular "honeycomb" coils may be used for loose coupler and tickler coil.

VINCENT H. BROWN.

A Small Portable Set

By William Holladay

SOME time ago I became interested in a very small set I saw illustrated, for which a wave-length of 4,000 meters was claimed. It was about six inches long and three or four inches high and wide, but at the beginning it was apparent that there were several inherent defects. The coupler was wound with 36 enameled wire, the high resistance of which, coupled with the well-known distributed capacity effects of enameled wire, cut the efficiency down to minimum. The coupling was fixed, and therefore would have to be designed very carefully in order to have the coupling at the proper point for the larger percentage of stations. Of course all stations which are received with very loose or very close couplings would be heard more faintly than necessary, and selectivity would be almost impossible.

The detector was placed on top of the set, where it would be exposed to dust and hard knocks, and could not, therefore, be used for portable purposes.

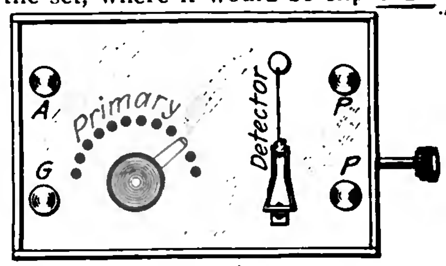


FIGURE 1
Front view of cabinet

A small set designed and constructed by the writer seemed to offer all the advantages of a portable set, with none of the disadvantages referred to above. It is an excellent thing to take along on a vacation jaunt, and may be made

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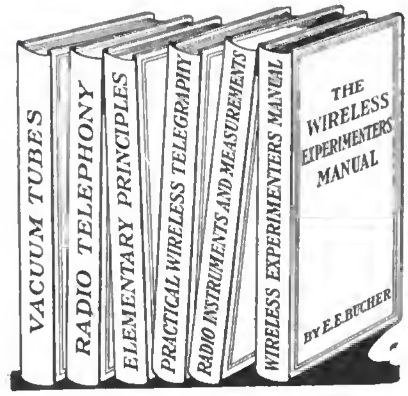

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The set consists of a coupler, galena detector, and fixed condenser, mounted in a cabinet 6 x 5½ x 4. The primary tube is 3" long and 3" in diameter, wound with about 130 turns D.C.C. With silk covered wire it is possible, of course, to wind more turns, but on such a set I believe the extra cost overshadows the benefits. The secondary is 2½" long and 2½" in diameter, wound with 110 turns 32 D.C.C. Such a secondary will respond to wavelengths up to approximately 1200 meters with a 200 meter aerial. The resistance of the wires used is only slightly greater than that of the usual sizes, and the efficiency on the short waves which it will receive is not materially lowered. The primary is tapped to a single twelve-point switch, and the secondary is tapped to a single four-point switch as per the diagram.

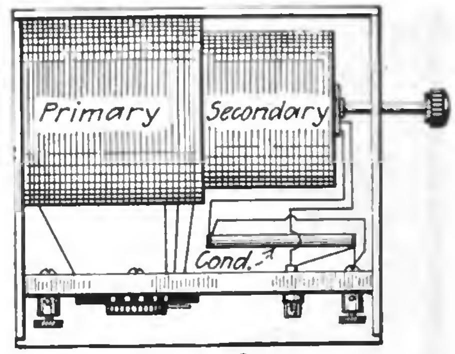

FIGURE 2

Top elevation showing arrangement of apparatus

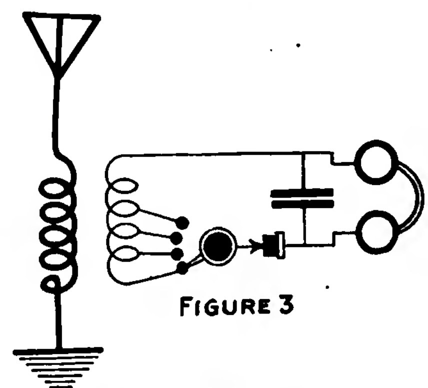

FIGURE 3

Diagram of connections used

The cabinet may be made of cigar-box wood, or if more strength is desired, of ⅜" pine or hardwood. The front is hinged over the panel, which is set back about an inch for protection of the detector and primary switch, which are to the right and left respectively. Excellent switch points may be made of 6 B. & S. copper ¾" long which are driven into holes 5/32" diameter, and spaced ¼" apart. The switch arm is made 1" long so that the entire switch will occupy but little space.

The detector, placed to the right, consists simply of a phosphor bronze spring or clip to hold the crystal, and a catwhisker of 32 bare copper. Connections, soldered to the rear, are made with small stranded wire. Four Clapp-Eastham 4832 binding posts, the smallest manufactured, are provided for aerial, ground and phones. They are mounted on opposite ends of the panel.

A fixed condenser, consisting of two pieces of tinfoil 25" x 2", placed between three sheets of paraffin paper 28" x 2½", and wound on a piece of cardboard 2" x 2½" is placed immediately behind the detector, so that the leads may be short and it will not interfere with the movement of the secondary.

The diagrams show front and top elevations of the cabinet, the arrangement of instruments, and connections.

Convention in Philadelphia

AMATEURS of the Third District are invited to attend a convention and banquet to be held under the auspices of the Philadelphia Amateur Radio Association, in Philadelphia on May 8th.

This convention is intended to strengthen the bonds between the amateurs in the Eastern part of the country and give them a good time while they are meeting the men who handle the three sets. It is proposed to arrange a program for the summer and fall for all amateurs to meet the men they have talked to through the ether. There will be good talkers, plenty of good eats, smokes, music and a rip roaring good time for all who attend. Tickets are $2.00, the big show is called for 7 P.M. at 12th and Girard Avenue, Philadelphia, Saturday, May 8th. Club secretaries are invited to write how many members they will send. Address W. F. Wunder, 3220 Stillman St., Philadelphia.

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Prize Contest Announcement

The subject for the new prize contest of our year-round series is:

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Closing date, June 1, 1920.

Contestants are requested to submit articles at the earliest practicable date.

Prize Winning Articles Will Appear in the August Issue.

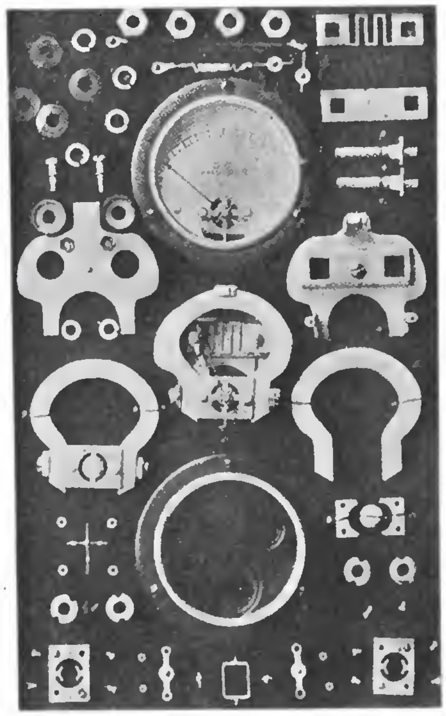
It is very obvious to those who are listening-in a great deal that a great percentage of the amateurs who operate transmitting stations either have never carefully thought about the interference problem, or have no regard whatsoever for their co-workers in the next block, the next city, or the next state. This may be particularly true of the young man who is just taking up the art, and it is with him in mind that we call for suggestions covering the use of the code, calling, handling messages, listening-in, etc., etc. There are a great many amateur operators who have this traffic business down to a fine art. This will give these men an opportunity to very materially help their co-workers and indirectly benefit themselves.

PRIZE CONTEST CONDITIONS—Manuscripts on the subject announced above are judged by the Editors of THE WIRELESS AGE from the viewpoint of the ingeniousness of the idea presented, its practicability and general utility, originality, and clearness in the description. Literary ability is not needed, but neatness in manuscript and drawing is taken into account. Finished drawings are not required, sketches will do. The contest is open to everybody. The closing date is given in the above announcement. THE WIRELESS AGE will award the following prizes: First Prize, $10.00; Second Prize, $5.00; Third Prize, $3.00, *in addition to the regular space rates paid for technical articles.*

All manuscripts should be addressed to the Contest Editor of THE WIRELESS AGE

To meet the growing demand for instruments of smaller size, together with increased sensitiveness and greater accuracy, the Westinghouse Electric & Manufacturing Company has developed this miniature type. It combines extreme delicacy of action with high sensitivity and ruggedness, and the design, construction and materials are such that the instruments are permanently accurate.

A salient feature of design wherein these instruments differ from the other makes consists in the method of supporting the cylindrical core and movable element between the pole pieces of the magnet. Instead of providing for this purpose a casting supported at the back of the instrument, independently of the magnet and pole pieces and requiring, in order to secure accuracy, a high degree of machining, the Westinghouse instruments make use of two simple, easily and inexpensively made bronze alloy punchings securely fastened to either side of the pole pieces. This makes the instrument more compact, greatly simplifies the construction, and lessens the amount of space required within the case, thereby making it practical to construct the instrument to miniature dimensions and secure at the same time accuracy, reliability and sturdiness of design.



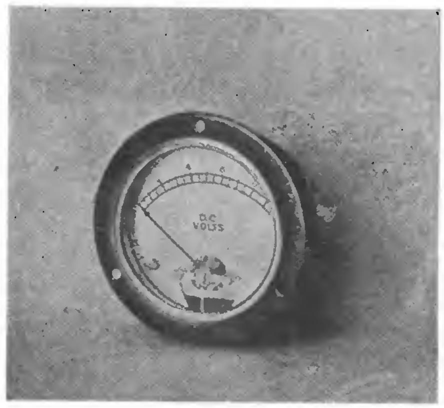
Details of the volt meter

Another departure from a method in common use with other makes consists in the insulation, by oxidation instead of by paper, of the small aluminum frame which carries the coil of the movable element. The oxide of aluminum, thus used, is highly effective as an insulator and greatly facilitates the mounting of the coil.

The fastening of the pivot support

of the movable element constitutes an additional departure from older practice. The base of the support, instead of being cemented directly to the coil, is elongated and clinched around either side of the aluminum frame of the movable coil. This gives a more accurate centering of the pivots.

By combining the milli-voltmeter with a non-inductive heater and thermo-couple, it is made suitable for the measurement of high frequency alternating currents such as are en-



Assembled small panel d.c. volt meter

countered in radio communication. The same instrument can also be operated on alternating current circuits of commercial frequency, provided they are not subject to overloads.

The instruments can be furnished for mounting with the face flush with the panel, or for projection. They are arranged for rear connection. The standard finish is white dial, nickel bevel ring and black marine case. Black dial instruments are furnished if desired.

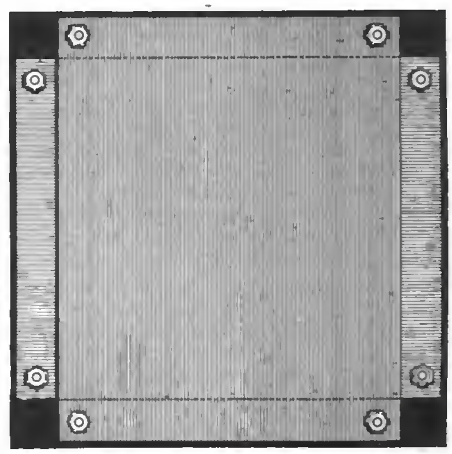
They are checked throughout their entire range for accuracy. The calibration at any point of the scale is within two per cent of full scale reading on direct current and radio frequency current of the frequencies now in use.

These instruments are the smallest of the D'Arsonval type that are being regularly manufactured.

An Oil-Dielectric Condenser

WHY is it that high-voltage condensers using oil as a dielectric have never become popular for amateur stations? Such condensers are self-restoring, even if punctured; the dielectric absorption is low, comparing favorably with compressed air and many times better than bakelite, where this loss is very troublesome and brush discharge is entirely absent. Also the construction is simple and rugged, involving only a little machine work in making the spacers. In all respects this condenser is nearly ideal. Sheet aluminum was used for the plates of the condenser which I constructed. Number 30 sheeting, which has about seven square feet to the pound, is the most satisfactory. About 3½ pounds are required. This was cut into 28 pieces 12" by 10", which are required for a capacity of .008 mfd., and a 3/16" hole was drilled in each corner. For separating alternate plates, 112 spacers are required, ⅜" long, each cut from ¼" brass tubing, with 3/16" inside diameter. The plates are mounted on supporting rods 6½" long, 3/16" in diameter, and threaded ½" on each end. Eight of these rods are required. The whole condenser was then assembled on a hardwood base 12" square, as shown in the accompanying drawing, the plates being alternated, and four 3/16" spacers being placed under the first plate.

From the foregoing it will be seen that alternate plates are spaced 3/16". The best grade transil oil on the market such as "Mineral Seal" or "High-flash," should be used for the dielectric, this grade withstanding 36,000 volts on a 1-10" gap, so that the spacing of 3/16" gives a margin of safety sufficient for all ordinary purposes. The oil should be tested by dropping some



Assembly of condenser plates and base

pieces of calcium carbide into a sample taken from the bottom of the container, and if bubbles are given off, it indicates that water is present, which *must* be removed.

This is accomplished by filtering the oil through calcium chloride several times, and then through several thicknesses of cheese cloth. The oil should then be tested again with carbide. The dielectric constant of this grade of oil is about 2.5, which compares favorably with glass and does not require an excessive area of the plates.

The entire condenser should be placed in an oil-tight container with a cover to keep out the dust. A galvanized tank into which the condenser is placed edgewise will be found very satisfactory, using a top piece of bakelite for a cover and as a terminal mounting. Such a condenser as this will repay any amateur in the satisfaction of knowing that it is both efficient and permanent, and the cost is but a fraction of some of the commercial condensers on the market.

Learn for Yourself

IT HAS often occurred to us that there are a great many amateurs who, rather than provide themselves with the means of finding out things for themselves, will either blissfully go along in ignorance without daily improvement in their knowledge of radio, or who when they desire to know something or other concerning the action of a circuit or concerning constructional details, will depend upon the knowledge of their friends or the help which the editors of the radio publications are able to give them.

Has it ever occurred to the man who experiments with radio that his first requisite should be a thorough knowledge of the textbooks on the subject? For the beginner, perhaps the best book available is Bucher's "Practical Wireless Telegraphy." For the man who is a little more advanced, serious study of Bulletin No. 74 of the Bureau of Standards, "Radio Instruments and Measurements" is recommended.

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. N. G., New Jersey:

The natural wave length of an antenna can be approximated by the use of formula for the capacity and distributed inductance of the wire. Results obtained thus are almost invariably lacking in accuracy. The fundamental should be ascertained by measurement, if at all possible, and we refer you to textbooks on the subject. A rule for the predetermination of the fundamental of an antenna within limits which compare favorably with those of any formula available, calls for the multiplication of the length of the antenna in feet by 1.52 where the antenna is the L of the type used by a great many amateurs, and by 1.6 where the antenna is a T, or fan, type. Thus your antenna, height 35 feet, length 36 feet, total length 71 feet, will have a fundamental of about 108 meters, when used as an L. As a T, whose height is 35 feet and length 18 feet, total length 53 feet, the fundamental would fall around 85 meters.

* * *

W. F., Alabama:

Any type of three-element vacuum tube may be used in a resistance coupled amplifier circuit. If you desire to use only two tubes, your over-all amplification will be greater, providing a transformer is used between the two. Resistance coupled amplifiers are used to greatest advantage where several stages are essential, due to its greater stability and freedom from self-oscillation.

* * *

D. R., Wisconsin:

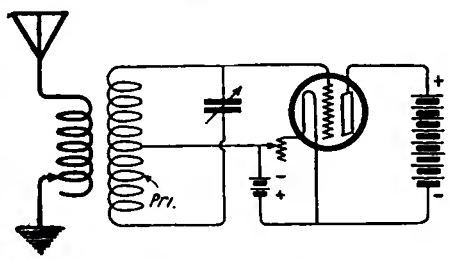
We are sorry to report that we know nothing concerning the detector you mention. The filament of a Marconi V. T. should draw between 0.7 and 0.8 of an ampere, at which current the filament is incandescent. Noises in the telephones when the tube is in operation may be occasioned by gassing of the storage cell, a faulty cell in the plate battery, a loose connection in the circuit, a loose connection in the tube itself, or may be due to the presence of gas within the tube, under which circumstances a hissing sound will be given off when either the filament is too bright or when the plate potential is a little too high.

A .001 mfd. condenser placed in shunt to the telephones will give you the same louder signals which you received from Arlington when you placed your fingers across the terminals. There is a tendency for radio frequency currents to build up in the plate circuit of the vacuum tube. The telephones will not pass them to any great extent. If a path is provided they will be repeated back into the grid circuit to a limited degree, solely by virtue of the filament circuit connections which are common to both plate and grid circuit. This results in increased amplifying action, or regeneration, on the part of the tube, and can be taken full advantage of only when the coupling between the two circuits is sufficient to start self-oscillations in the vacuum tube circuits. If you are not using a regenerative circuit by intent, you should be, and we refer you to textbooks on the subject. If you are using a regenerative circuit bear in mind that a bridging condenser for the telephones is essential for anything like proper action. If you are receiving Arlington—and it should be possible for you to do so consistently—you should also be able to receive Great Lakes. Perhaps you have not properly tuned your receiver. His wave length is 1,512 meters.

* * *

A. L. H., New Hampshire:

A hook-up suitable for the outfit described in the November, 1919, issue by Mr. Pignone is given herewith.



J. A., Porto Rico:

If you are having trouble in adjusting your detector from your test buzzer, we suggest that you try—instead of your present arrangement—the arrangement where a wire is connected to the vibrator of the buzzer, carried to one of the leads from the secondary inductance coil and wrapped around this lead 6 or 8 times, on top of the insulation.

If you are using a variable condenser on the secondary of your receiving transformer, the secondary will tune up to about 15,000 meters. The primary, taken in conjunction with your antenna alone, will only tune up to about 6,500 meters. You may increase the wave length of your primary by shunting a variable condenser across the inductance.

The fundamental wave length of your antenna is about 230 meters. The fact that you connect two receivers on the same antenna and hear signals from a certain station through both of them is not unusual. The signal in either will be greater, however, when the other is disconnected.

As far as we know, it is not the practice under any circumstances to short circuit the secondary tuning condenser. This is often done in the case of the *antenna* tuning condenser where the condenser is connected in series to the antenna, and we presume that it is to this arrangement you refer.

* * *

H. G. G., Pennsylvania:

We presume that by "collapsible aerial" you refer to the loop antennae which were used to such a great extent during the recent war for direction finder purposes and also in the trenches. If so, you will find in recent numbers of this magazine instructions and data which will enable you to construct what you wish.

Or perhaps you were referring to an antenna which is collapsible in the true sense. Such an arrangement has never been used to our knowledge for practical purposes. A two and four wire aerial fills the requirements in every way and is considerably cheaper and more nearly fool-proof. We suggest that you use the latter.

* * *

R. R. W., Pennsylvania:
Any dealer in general hardware and supplies should be able to furnish you with 1½" O. D. fibre tubing. If you are unable to make connections with anyone in your vicinity, we suggest that you write Patterson Bros., Park Row, New York City.

* * *

F. V. B., Alabama:
Any effort to control small movable objects on a table by a radio station concealed in the vicinity becomes a rather complicated matter. This can be done in a very simple manner magnetically, provided there is a movable magnet underneath the table of sufficient strength to control the small steel objects above. To do this by radio would necessitate the use of a radio controlled power unit mounted in the small object which it was desired to move, and, taken as a whole, we consider the idea impracticable.

* * *

W. D. M., Michigan:
After reading your query referring to the diagrams in "Practical Wireless Telegraphy" which you mention, we are unable to understand just what you are driving at, unless it is a combination of the circuit shown by Mr. Bremer in the May, 1919, issue, and some of the magnetically coupled regenerative circuits shown in figures 179 and 181 of "Practical Wireless Telegraphy." There would be no advantage in such an arrangement, since the accomplishments of the one are the same as the other.

* * *

A. S. B., Connecticut:
We are not aware of any "Impact System" which operates without transformers. We presume that you have in some way received the wrong impression as to the operation of an impact transmitter. For particulars as to operation of this type, we refer you to any up-to-date textbook on radio telegraphy.

* * *

R. S. T., California:
If you have followed the instructions covering the long wave receiver in the September issue of The Wireless Age, and providing all your connections are as shown in the diagram, there is no reason why you should fail to get operation. Are you certain that the positive terminal of your plate battery is connected to the plate? With reference to the latter part of the last paragraph on page 36 of this article, the author states: "Any failure of oscillations to start may be due to an incorrect value of bridging condenser, antenna coupling, tickler coupling, filament current, and plate potential, assuming, of course, that the receiver is properly wired." In addition to this, as just mentioned, it is necessary to have the positive terminal of the plate battery connected to the plate of the tube. The fact that you used No. 31 wire instead of No. 22 will not affect the operation of the outfit; only the wave length range, which will have been slightly increased.

It is impracticable to make up a set of this type for operation over shorter wave lengths, with the expectation of getting *best* results. In case you wish to do so, however, you should provide yourself with a secondary coil having about 130 turns, and wound on a form 3" in diameter, 10 turns per layer. The primary coil may be a duplicate of this, taps being taken out to accommodate the switch.

JOIN NOW

H. L. WELKER, Secy., Date....................
National Amateur Wireless Assn.,
68 Broad St., New York.

As I desire to receive full recognition as an amateur wireless worker of the United States, I ask the privilege of enrollment as a Member in the National Amateur Wireless Association and request that you send me the complete Member's Equipment, for which I enclose herewith remittance of $1.50 Initiation Fee, covering Initial Equipment, and $2.00 for First Annual Dues, or $3.50 in all.

I understand that I will receive membership certificate pin, pennant and a copy each of "How to Conduct a Radio Club" and "How to Pass U. S. Govt. Wireless License Examinations," and that the yearly dues entitle me to a year's subscription to THE WIRELESS AGE.

I am / am not now a subscriber to the AGE.

Name ....Age ......
St. Add. ....
City ....State ....

FILL IN ANSWERS TO THESE QUESTIONS

1. Have you a Government License (give number......) or do you propose applying for one?..
2. If you are under 21 years of age, give names of 2 adults for reference as to character:
   Reference ....Address...............
   Reference ....
3. If you are a member of any Local, State or Interstate wireless club or association give its name and name of Secretary with address
   ....
4. Are you now a subscriber to THE WIRELESS AGE?..................
5. Describe briefly your equipment......................................
   ....
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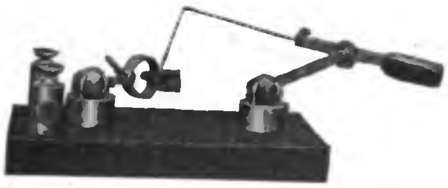


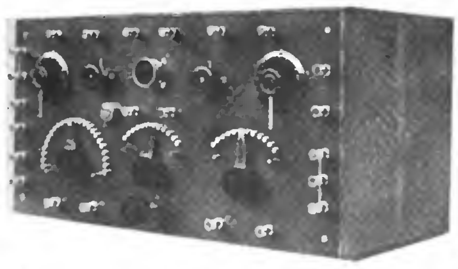
The Jones Patented Crystal Detector

presents six different surfacee of the Crystal to the action of the needle. without changing its position. It keeps you on the LIVE SPOT at all times and thereby givee you the loudest and cleareet signals.

Fonr Dollars net, Postpaid.

Send for new Illustrated descriptive Bulletin describing these and other High Grade Radio Apparatus.

OUR LATEST CABINET VACUUM TUBE RECEIVING SET



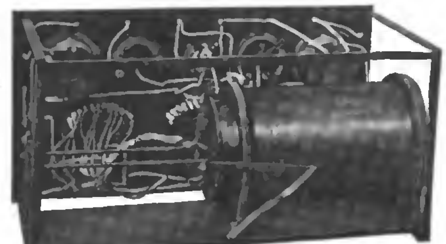
Employing the New MARCONI VACUUM TUBE

Reception range from 200 to 8000 metres.

Can be used for either DAMPED or UNDAMPED waves, without the addition of any other coils or apparatus.

Model "D" $60.00
Model "E" 85.00

Interior view from the Rear, showing Loose Coupler, its action, and Wiring Diagram of the Vacuum Tube Circuit. Also showing how the entire Apparatus is built within the metal frame, to permit its removal from the cabinet for examination or additione.



We reproduce the set in its entirety that yon may see and understand its construction, instead of encloeing it in a Cabinet and allowing you to guess. It is now used in Schools of Radio Instruction where Technical and satisfactory resulte are necessary.

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ARLINGTON TESTED CRYSTALS

Why buy minerals on a gamble? Be SURE when you put a crystal in your detector that it is EXQUISITELY SENSITIVE. Buy Arlington individually tested Minerals. Galena or Silicon, post paid on receipt of price.

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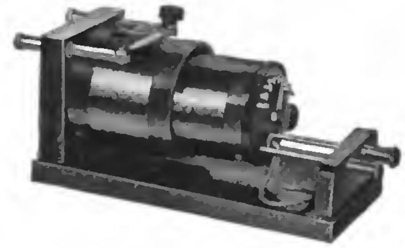
NEW SHORT WAVE COUPLER No. 747

Comes up to the CHAMBERS' usual High Standard. Especially adapted to long distance Amateur work. Tunes to 800 meters. Does away with the dead-end effect so common when large couplers are used for short wave reception.



Mahogany finished woodwork. Brass metal parts. Has new slider feature. Secondary has six taps. Wound with Red Enameled Wire, or, secondary with Green Silk if so ordered. Measurements over all, length 12 inches, width 4½ inches, height 5 inches.

PRICE - - $10.00

F. B. CHAMBERS & CO.,
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Red Head Radio Phone

$7.00

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DE FOREST HONEY-COMB COIL INDUCTANCES

Cat. No.	Solid wire. Appx. wave length range with .001 MF. Variable condenser	Price on plug mounted	Litz wire Cat. No.	Price on plug mounted	Cat. No.	Solid wire. Appx. wave length range with .001 MF. Variable condenser	Price on plug mounted	Litz wire Cat. No.	Price on plug mounted
L-25	170-375	$1.40	LL25	$1.40	L-300	1340-4800	$2.10	LL300	$2.66
L-35	200-515	1.45	LL35	1.45	L-400	1860-6300	2.25	LL400	3.10
L-50	240-730	1.52	LL50	1.64	L-500	2340-8500	2.40	LL500	3.35
L-75	330-1030	1.60	LL75	1.70	L-600	2940-12000	2.65	LL600	3.00
L-100	450-1460	1.70	LL100	1.76	L-750	3100-15000	2.80	LL750	3.20
L-150	660-2200	1.80	LL150	2.16	L-1000	5700-19000	3.00	LL1000	3.75
L-200	860-2850	1.90	LL200	2.28	L-1250	5900-21000	3.35	LL1250	4.16
L-250	1120-4000	2.00	LL250	2.50	L-1500	7200-25000	3.60	LL1500	4.68

Cat. No. LC-100—Inductance coil mounting with gears but without base to hold three coils. Primary, secondary and tickler $9.00
Cat. No. LC-101—Same as above, but mounted on oak base.................... 12.00
Cat. No. ULC-100—Same as No. LC-100, but mounted on Unit panel.................... 10.00

All coils and mountings postpaid to any part of the U. S.
All orders shipped the same day. Give us a trial!!! Send 6 cents in stamps for new catalog just out!!

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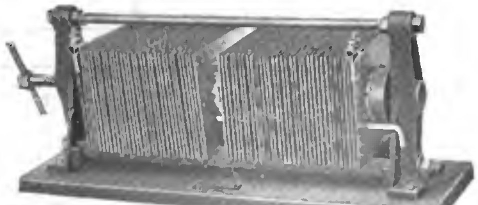
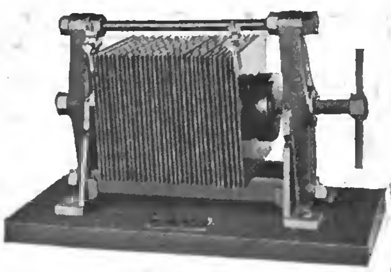
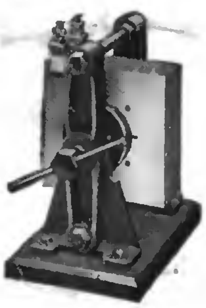
AMRAD QUENCHED GAPS



TYPE G-1—This gap is built to control the energy necessary to do real long distance work, 1,000 miles and over. It has 32 sparking chambers. Designed for use with transformers delivering 20,000 volts up. Maximum power 1,000 watts. Price, $26.50.



TYPE G-2 — Our first gap. Out only four months, it is now in operation in every U. S. A. radio district and in Canada. No inducements offered to introduce this gap; every user a voluntary purchaser. Enthusiastic reports on file in our office. Intended for moderately long distance work, 500-900 miles. It has 16 sparking chambers and is designed for use with transformers delivering over 10,000 volts. Maximum power 500 watts. Price, $17.50



TYPE G-3—Especially designed for use with the Amrad 100 watt induction coil, but is suitable also for use with ordinary spark coils or small transformers delivering over 7,500 volts. This gap will increase the range of any induction coil set and at the same time will permit the operator to comply with the Federal law regulating decrement. It offers the only practical solution to the QRM problem in congested districts. Seven sparking chambers. Maximum capacity 250 watts. Price, $12.50

Why You Should Use The Amrad Quenched Gap

1. Correctly operated, it will radiate more *effective* energy on a given power input than any other type gap. This absolutely assures consistent long distance work.
2. On the above adjustment your decrement will drop below the maximum .2 set by law. You will therefore not illegally interfere with other stations.
3. The Amrad Quenched Gap is silent. No longer need your radio station be a nuisance to your family or neighbors.
4. It puts you and your station on a high-class "commercial" plane. The quenched gap is the most modern gap and its successful operation reflects no mean degree of skill and care on your part.
5. It is reliable. When using the Amrad Quenched Gap there is no danger of your station suddenly being put out of commission by a kick-back burning out motor windings.
6. It is economical. It reduces electric current bills. No moving parts to wear out, break or get out of balance. With careful use the quenched gap gaskets need be renewed only occasionally and then at a trifling cost.
7. It is efficient on 60-cycle supply circuits. Two spark frequencies may be obtained, either 120 or 240 sparks per second. When adjustments are correctly set, both notes are clear, snappy and wonderfully uniform. The gap is equally efficient when used with induction coils.
8. It increases speed of handling traffic. No waiting for motors to come up to speed or slow down. Quick back-and-forth communication over the longest distances.
9. The Amrad Quenched is the *standardized quality* Gap. All plates in the various types are identical and interchangeable. Each gap plate is tested to meet a high standard of accuracy. The entire instrument is essentially a "commercial" product especially designed for private use.

Full descriptions of and specific operating instructions for the Amrad Quenched Gaps, all types, together with description of adjustable resistances, contained in Bulletin Q.

Adjustable Resistances: To operate quenched gaps efficiently on 60 cycles a. c. an adjustable resistance must be used. We furnish three types of adjustable resistances. Prices and description of complete mounted units and parts contained in Bulletin Q.

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Fights QRM **Increases Your Range**

Over 90% of all amateur transmitters are out of resonance. How about yours? Nine chances out of ten you can increase your range by careful tuning.

Too many stations are trying to transmit on wave lengths of approximately 200 meters. You can operate much farther by tuning your transmitter to a lower wavelength. If you are troubled with QRM you can help the situation by encouraging others to do this.

Do you know the wavelength of your antenna system? You must know it in order to secure the most efficient ratios of natural wavelength to loading inductance.

Many amateur stations are transmitting on illegal wave lengths. Don't guess at your wave length. Know it.

For these important purposes use the Amrad Direct Reading Wavemeter. Range 130-230 meters. Always accurate, Bakelite top; built to last. Price, $6.50. If your dealer does not stock, order direct; enclose postage for two pounds. Immediate delivery. Description and directions in bulletin W. Send for it.

Upon request we will enter on our monthly mailing list for one year the names of all active radio amateurs. To these we will send our catalog, now in preparation, and all our latest bulletins as rapidly as printed for insertion therein. An extensive line of Amrad apparatus is under development. If there is no radio dealer in your town, ask for our list of Amrad retailers who stock our goods.

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