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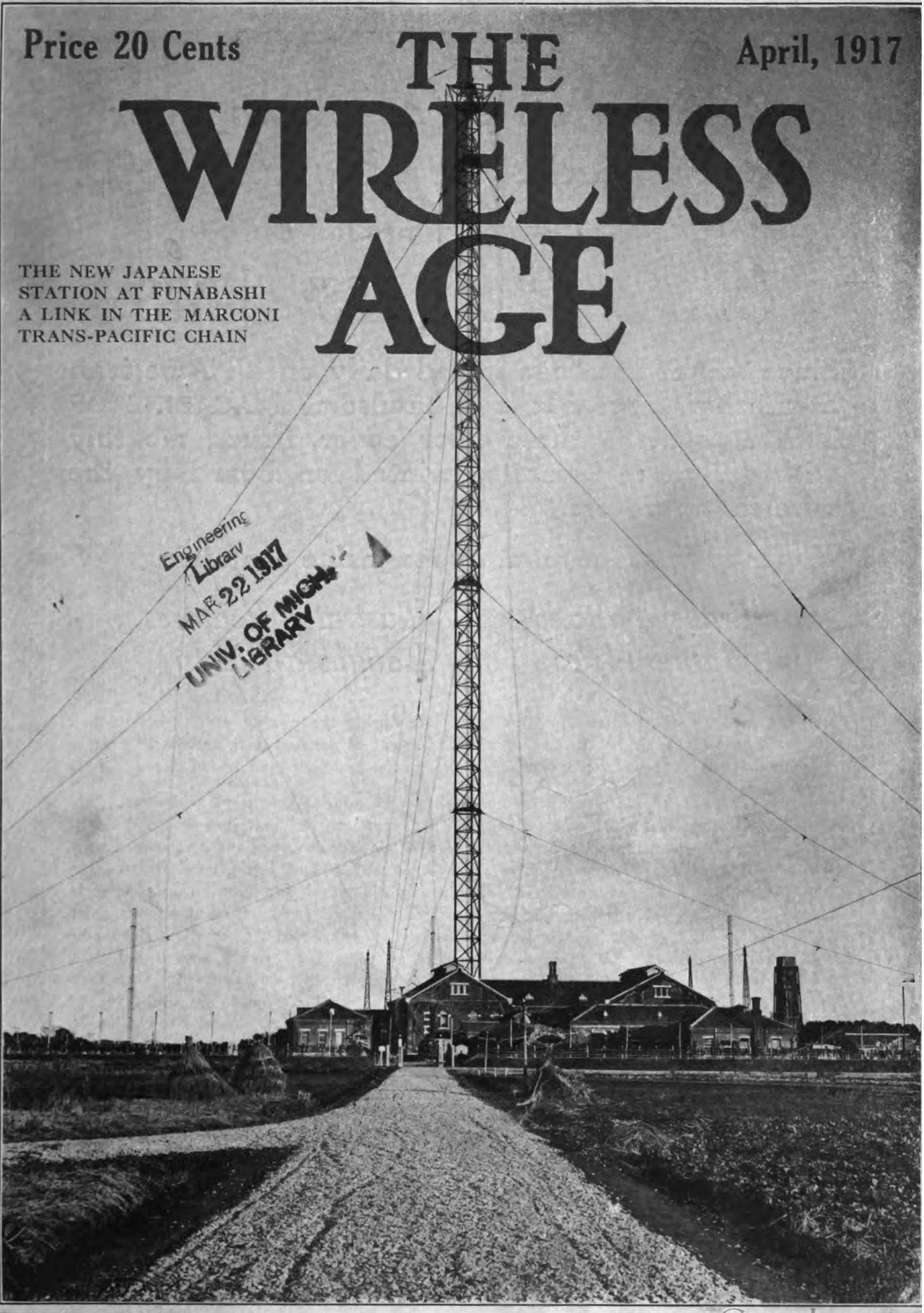
THE WIRELESS AGE

THE NEW JAPANESE STATION AT FUNABASHI A LINK IN THE MARCONI TRANS-PACIFIC CHAIN



THE WIRELESS AGE

Owing to the fact that certain statements and expressions of opinion from correspondents and others appearing in these columns from time to time may be found to be the subject of controversy in scientific circles and in the courts, either now or in the future, and to sometimes involve questions of priority of invention and the comparative merits of apparatus employed in wireless signaling, the owners and publishers of this magazine positively and emphatically disclaim any privity or responsibility for any statements of opinion or partisan expressions if such should at any time appear herein.

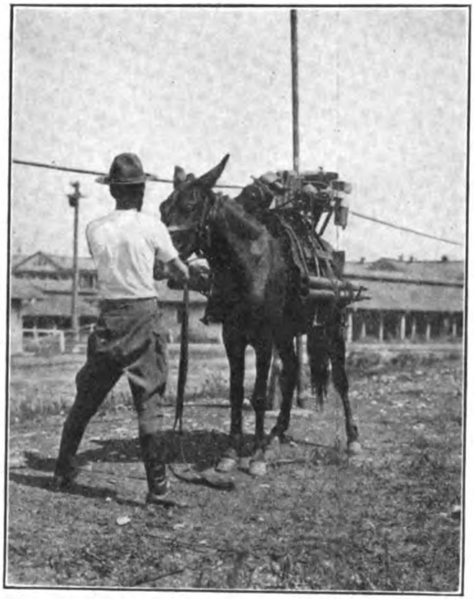
APRIL, 1917

On the Texas Border With a Pack Set

A Story of Actual Observation by a National Guard Signal Corps Member and a Description of the Apparatus

What it means to undergo experience on the Texas border with wireless equipment has been interestingly told for the readers of THE WIRELESS AGE *by George T. Droste, master signal electrician of Company A, First Battalion Signal Corps, National Guard, New York. A comprehensive analysis by him of the pack sets in use on the border follows the story of his actual observations.*

IN my earliest experience during July, when we did nothing but listen in for whatever went through the air and without any definite policies, using different operators, experienced and inexperienced, in the art of radio propagation, nothing of any glory was accomplished. By sending out different sections on detached service to Mission, Pharr and surrounding districts from McAllen, and conducting a main business of about three to four messages a day, consisting of reporting "present" in the morning and "good night" in the evening, we finally were put on details that carried on a more substantial business. My detail, in charge of Sergeant Upson, at Sterling Ranch, and acting as the relay point between Young's Ranch and McAllen, was a month of anxious and heartbreaking work, trying to make a ⅛-k.w. pack set do the work of a 1-k.w. headquarters' station, reporting arrivals and leaving of regiments; O. M. supply reports and personal messages, to say nothing of company orders.



The generator and frame of the apparatus on a pack mule

Our distances between stations being about eighteen to twenty-five miles, was a larger stretch when the poor detectors and the enormous amount of man power expended is considered. However, we triumphed by covering the work, if not by radio completely, then partly by radio and buzzer—that being our duty to get the work through. So by using private telephone lines as buzzer wires without any special orders, we succeeded in establishing records for the ⅛-k.w. sets under continuous service conditions that were never known to the New York Signal Corps before, being heard continuously by regular Army stations at Hidalgo, Fort Ringgold and Brownsville—distances of about twenty-eight, forty and sixty-eight miles, respectively.

My final detail was to conduct the station (NYA) at McAllen. This started a new era for pack set work, as we were called upon to work with the main army stations which were established for some years and carrying on a daily business that required experience to keep up with. To do this I was provided with an experimental engine and generator never before tried out with any continuous success.

Numerous heartbroken attempts to make various belts stand the strain of transmitting the energy from the engine to the generator, and preventing the engine from getting hot, took up our time, and we still carried on the entire official business for the Sixth Division, which passed between Fort Sam Houston at San Antonio, 250 miles away, and Brownsville, Tex., by intercepting it and acknowledging receipt of it. This demanded undenying attention and sacrifices from all the operators in the station as repetitions were not forthcoming. For us they came only once and we showed that we were able to cope with the situation and seldom lost a message. Our record consisted in not having lost a message by interception for a continuous stretch of a month with an average of ten to twenty-five messages a day, each consisting of fifty words or more.

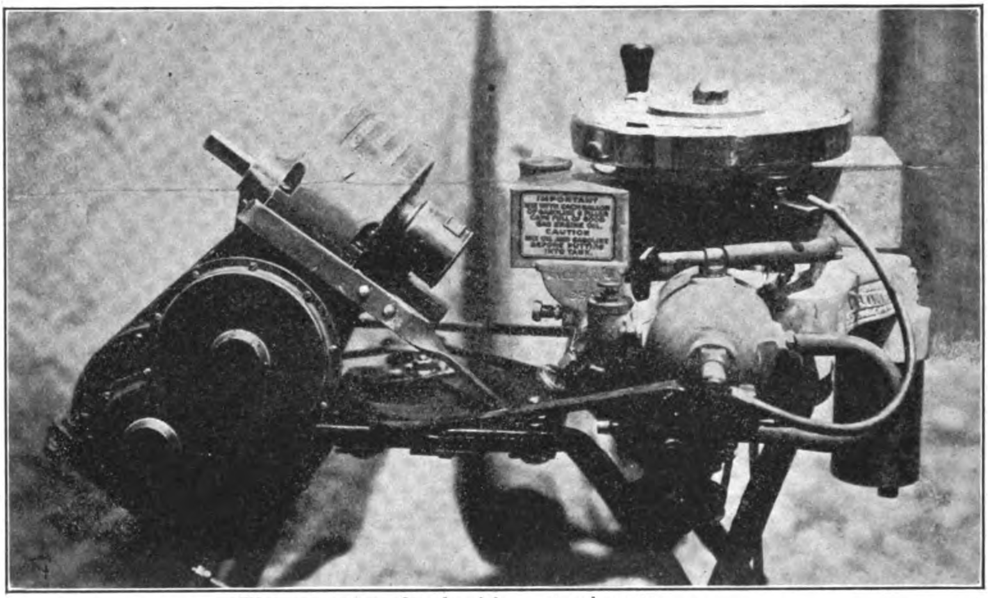
This service finally established us in the eyes of the regular army station at Fort Sam Houston and Brownsville, although militia stations were established at Fort Ringgold, Harlingen, Hidalgo, Lanogrande, Del Rio and other points on the border. They never were heard reliably for any length of time and the New York Division was always to be counted on for being alert.

On the night of December 11, 1916, we were forced to close the station, owing to the fact that we were about to be sent to our homes in the North and much to our regret had to sever our aerial connections with the men of the regular Army, principally WUJ and WUZ, with whom for two months we had been in continuous radio communication. We felt that we had gained their confidence because of being fully able to handle their work direct, notwithstanding the handicaps of experimental apparatus. This was confirmed by the friendly relations set up between the operator in my charge, namely, Corporal Schuster, and Private Leason and the regulars in charge of the station at Fort Sam Houston.

Summing up the entire experience, we feel that so far as radio work goes for the Signal Corps, we established ourselves in the eyes of the regular Army and that our successes will go down in the archives of their experiences of working with the militia.

Readers will be interested in an analysis of the radio pack sets in use on the border, as made by Electrician Droste, in which he says that for portability, the pack radio sets, consisting of wood masts, so arranged that one section can be placed on top of another and stiffened by metal ferrules, are used. The pack sets are provided with a four wire umbrella antenna, using insulated wire, the same being connected at the top and a lead-in brought down to the instruments. This insulated wire is more serviceable than the old bare three-strand plated phosphor bronze wire, as it does not kink so easily and the metal is protected from burring, the insulation also providing additional electro-static capacity.

The counterpoise or ground is also of four wires (insulated) and serves the purpose of distributing the electro-magnetic impulses over the covered area of earth when laid out. The chest or instrument contains a transformer for raising the low voltage to a higher potential, and consists of two windings, one heavy, called the primary, which excites the magnetic field, by conducting the alternating current and passing the same in a helical coil around a cluster of soft iron wires, causing them to be periodically magnetized, this rising and falling magnetic field being cut by finer windings of wire in sufficient quantity to increase the ratio of voltage about one to a hundred and called the secondary. The magnetic field above mentioned produces an induced current in the secondary windings which then charges a high potential condenser. The condenser is constructed of tin-foil sheets, separated by a dielectric of mica sheets and holds the electro-static charge until the potential reaches a breaking down point, at which



The generator fitted with a speedometer

time the current discharges through a gap.

The gap consists of flanged plates, separated by mica rings and a number of these gaps being placed in series and air-cooled, each air gap or sparking surface being about .001 of an inch. A well-designed gap is one which will be a perfect non-conductor while the condenser is charging and a perfect conductor is discharging, thereby producing a strongly quenched oscillation. The current is discharged through turns of inductance called an oscillation transformer, which is mounted on the inside of the cover of the chest. This transformer consists of three coils or pancakes, two of which having the outside turns connected to a common terminal forming the hinges, these two acting as a primary and secondary, the additional coil being used for extra loading inductance for increased wave-lengths. These coils can be coupled together and the resonant point found between the closed circuit which is formed by the condenser, gap, and primary of the oscillation transformer and the open antenna circuit, which consists of the secondary of the transformer, the antenna for aerial inductance, the hot wire ammeter for registering the output in mili-amperes and the ground or capacity. These coils are connected together by flexible wires with clips at the ends for placing in any desirable position, on the coils.

The antenna and ground are separated from the above sending circuits by a transfer switch for changing the same to the receiving circuits as the antenna and ground are used for transmitting electromagnetic oscillations and receiving them. The transformer is applied to a low voltage five hundred cycle A. C. current of 110 volts pressure, the medium being a generator consisting of two units. The A. C. generator having twelve poles for the 250-watt type and eighteen poles for the 125-watt type, the direct current exciter, the armature of which is mounted on the same shaft with the A. C. armature. The mechanical energy for turning this generator armature is either by hand, two to four men being required to turn handles, which by gearing to the armature shaft turns it to 5,000 R. P. M. for the 1/4 k. w. type and 3,333 R. P. M. for the 1/8 k. w. type, the men turning the handles about 33 R. P. M.

These generators are provided with suitable stands on which are mounted a two cycle marine Evinrude engine, which turns up to about 1,750 R. P. M. and is belted to the generator. Difficulty is experienced with this method of transmission of the energy due to slipping belts, and also the breaking of the same and the clip which makes the connection, all of which is due to the high speed, vibration and heat caused by the friction between the belt and the pulley. This belting must be round and not larger than 3/8 of an inch in diameter as it revolves over an idler sheave for taking up the slack and as the alignment of the pulleys is such that it changes the direction of the drive from horizontal to vertical, thereby causing the belt to come in contact on all sides.

The engine is supplied with gasoline by a small tank mounted on top, and a vaporizer with needle valve controls the inflow of the gasoline. A high tension magneto is mounted in the fly-wheel, the making and breaking of the current for igniting the gas being caused by a cam which actuates the contact spring, or vibrator. This vibrator is so mounted that it can be moved for advancing or retarding the spark, thereby being one of the means for controlling the speed of the motor.

The cylinder of the motor is water-cooled and a small pump circulates it through the water jacket. If a continuous supply of water is not available, a container will be required to hold an initial quantity of water, which must be re-circulated. This re-circulation of water is a serious drawback when the motor is required to do considerable work, as it quickly heats to a boiling point, causing the overheating of the engine, which prevents the same from running.

The primary current from generator to transformer is interrupted by a key which, when closed and opened according to the Morse characters, allows the current to flow into the transformer. On some sets this key is placed in the field circuit of the A. C. generator, interrupting the latter, on others it is placed in series with the current from the A. C. brushes, the latter being the better method, as it allows the A. C. field to be continually energized. Upon pressing the key, the armature winding revolves in an already strongly-built up magnetic field, thus producing an even and unchanging note, otherwise, when the key is in the field circuit and is pressed, the magnetic field has to build up, causing a varying note due to a low potential spark, which cannot charge the condenser to maximum capacity to break down the gap until the charging current has reached its maximum amplitude.

Connecting the generator to the chest is accomplished by flexible cords with plugs attached at the ends, which fit into receptive sockets.

The sending side is calibrated to a number of standard wave-lengths and by adjusting the clips on the oscillation transformer to points indicated by the calibration chart, and watching the needle on the hot wire ammeter, the resonant point can be detected when the ammeter shows its greatest deflection, making it known that the energy circulating in the primary windings of the oscillation transformer has been brought to a harmonic or in tune with the period of vibration of the secondary, antenna and ground.

The high frequency oscillations which are being forced into the antenna and ground discharge periodically into the ether and produce wave trains which apparently travel parallel with the earth's surface, and when they strike some other object which has the same or nearly the same fundamental oscillating period at the distant sender will induce currents therein of a frequency corresponding to the wave motion.

These impulses are then carried into a receiving tuner, which is also in the chest, and consists of electro-statically coupled inductances.

The incoming impulses are carried into the primary windings of the receiving transformer and produce an oscillating electro-magnetic field, oscillating at a frequency which can be altered by adding or removing inductance through multiple switches, thus causing the circuit to be brought in tune or resonance with the incoming wave train.

The oscillations then charge small fixed capacity condensers made of aluminum plates with an air dielectric and in turn discharge across a secondary inductance, which is thereby caused to oscillate. This circuit may be placed in or out of tune with the primary and thereby cause the induced electro-magnetic field to be made stronger or weaker, by a rotary switch arm, which places these inductances in series with the circuits and the wave-length accordingly.

The impulses having been transformed through induction and amplified, are then rectified by passing through detectors, which are of different types, as explained later. The detector serves the purpose of rectifying the current from an oscillatory current to a pulsating direct current. The properties of the crystal detector, such as galena, silicon, ferron, carborundum, etc., will retard positive or plus current in one direction and allow negative or minus current to pass from the opposite direction during the same alternation. The rectified current then enters the high resistance telephones and the impulses representing dots and dashes actuate the diaphragms by the energizing of the small magnets.

Another type of detector is the vacuum valve which emits electrons from a lighted filament and relays a local battery current which has large amplifying properties. This local current energizes the head 'phone magnets and thereby causes the diaphragms to vibrate accordingly.

The Evinrude engine, which is mounted on a pack frame, is not designed consistently to work with the generator, considerable energy being lost in the driving mechanism due to slipping belts, small diameter pulleys and idlers which should all be eliminated. The engine should be designed, together with the generator, as one unit. This plan will eliminate a considerable quantity of castings and metal, lightening the load and lessening the vibration, due to the fact that the load is top heavy and has inadequate foundation and possible loosening of parts. The driving medium from the engine to the generator can best be accomplished by housed gears running in oil, similar to the driving mechanism from an automobile engine to the pump and magneto shaft. The engine can be air-cooled to eliminate the trouble with the water cooling system previously referred to, the fan or blower being driven by a similar driving gear.

Rope, thicker and thinner leather, belting fibre packing, wire and steel spring were all tried for weeks with no success. In one case the speed would make the belt slip; in another, where the belt held to the pulleys, the strain was too great and either the clips or the belt itself broke, making the entire outfit useless for rapid service—the most essential item in a portable mobile outfit. If, in an emergency, it should be desired to crank the engine by hand, it and all its braces, including the bed plate, would have to be removed to allow the setting up of the generator on the stand for hand cranking purposes. This would take some time and, as pack space is limited, and the engine would have to be salvaged, the operation would involve the burdensome necessity of carrying the loose parts. The generator and engine should be so designed that they will be proof against damage during transportation.

At an inquest abroad into the death of the master of a merchant vessel, which was sunk with a loss of seventeen lives, the jury requested the coroner to suggest to the proper authorities the advisability of installing wireless on all ocean-going vessels.

The International Telegraphic Bureau has been notified by the Japanese Administration that Baron Kenjiro Den has been appointed Minister of Communications to succeed M. Katsuto Minoura, who has resigned.

Wireless communication has been established between Australia and Tulagi, near the coast of the Island Florida in the Solomon group, and Ocean Island, the Gilbert Islands.

Building Stations on Shipboard

Installations That Have Been Made in Record Time

WIRELESS telegraphy has succeeded in introducing revolutionary methods in establishing the means of long distance communication. This is aptly demonstrated in the speed and thoroughness with which vessels are outfitted with radio apparatus. In twenty-four hours it is possible for the Marconi Wireless Telegraph Company of America to establish a complete wireless apparatus on shipboard, and in emergencies such installations have been completed in eight hours. This is rapid work, especially when one takes into consideration that such an installation signifies the equipment of a complete telegraph office, ready for instant service. Contrasted with the time requisite for the equipment of a wire telegraph office, or that consumed in installing telephone service in a building, which requires at least a week, one is a position to appreciate the improvements represented by the wireless service over the older forms of communication.

The construction of wireless stations on vessels has been organized and simplified to an extent that it can be executed with remarkable speed and precision. The mode of procedure may be best illustrated by that carried out on the Spanish steamer, Joaquim Mumbru, on February 18th. The construction department of the Marconi Company, in the Edison Building, received notice that the Joaquim Mumbru would be at her dock at Yonkers on Saturday, noon, and that a wireless station was to be installed in a hurry, since the vessel was expected to leave for Europe on the following Monday.

The Spaniard, however, did not arrive at her dock until nine o'clock on Sunday morning. The apparatus was promptly assembled in the stock room, and loaded on a motor truck, which sped to Yonkers. On his arrival at the ship, the superintendent of construction gave to the men under him the necessary orders for the carpenter work needed in fitting up the wireless cabin and equipping the vessel with the gear needed in hoisting the aerial. The man in charge of the layout of the wireless equipment had the apparatus hoisted on board and the work on the aerial was immediately begun. The work as a rule begins with the construction of the aerial, unless the weather is rainy or stormy, when the aerial work is postponed in the hope for a clear-up.

The transmitting apparatus as a whole is a unit, and was quickly arranged, with the exception of the motor-generator, which had to be installed. The receiving apparatus was then put in place and all the necessary wiring for connecting the transmitting and receiving apparatus was then attended to. Connections were made for changing from receiving to transmitting and vice versa. Means were then adopted for insulating the aerial where it passed through the bulkhead on deck and the erected aerial was then connected.

Finally the construction engineer was in a position to state the time when he would complete the equipment, whereupon a Marconi inspector was sent to the ship to oversee the installation and make out the necessary license application required by the United States Radio Service. Meantime the superintendent of the operating division was notified, and an operator was assigned to the ship.

So the work, which was begun at nine o'clock on Sunday morning, was completed by one o'clock Monday afternoon, when the wireless station was ready for tuning.

In the instance of the Joaquim Mumbru, the wireless station was installed within a period of twenty-eight hours, but in three previous instances such stations were built on rush orders within twelve hours. In the case of the steamship Chalmette of the Southern

Pacific steamship lines a telephone message came to the Marconi construction department at four o'clock in the afternoon that the Chalmette was to sail at daylight, and wished a wireless station installed on board in short order. The apparatus was taken from the stock room and sent to the ship, which lay at her pier in Jersey City at the time. Work was continued at a rapid rate and by two o'clock in the morning the set was ready for tuning, thus establishing a record of ten hours for the building of a station on shipboard.

A still quicker installation was accomplished on the steamer Old Colony, of the Eastern Steamship Corporation. The Old Colony was to take the place of a sister ship that had met with an accident, and the company at nine o'clock in the morning decided to send out the steamer at five o'clock that afternoon. It was necessary to have a wireless station installed, and before the vessel sailed a 2-k.w. 240 cycle synchronous rotary gap set was installed and tuned, and the vessel sailed three minutes later. As the gangplank was raised the construction engineer and the inspector, who had just completed their work, barely had time to pass over to the dock.

Another record was made in equipping the steamer Bunker Hill of the same steamship line. This steamer got in at eight o'clock in the morning and sailed at six o'clock in the evening. Within those hours the Marconi construction department installed a complete ½-k.w. 500 cycle panel set and in addition installed a wireless telephone apparatus intended to be used for a demonstration to be given to a body of electrical engineers, of whom 400 were going on the steamer to attend the dedication exercises at the Massachusetts Institute of Technology, in Boston.

Achievements such as these show what may be accomplished by determination and organized effort when emergencies arise.

The Re-equipment of The Herald Station

In the presence of federal officers and officials of the Marconi Wireless Telegraph Company of America, the wireless station of the New York Herald, equipped with Marconi apparatus, was formally returned to commission on February 28 in its new quarters atop the United States Barge Office in New York City. After testing and tuning of the apparatus the key was pressed down and the first official spark of the station flashed out on a 600-meter wave-length, ringing into the ears of all operators at ship and shore stations with a radius of many hundred miles.

David Sarnoff, commercial manager of the Marconi company, sent out the first call, and the Marconi station at Sea Gate responded with the first message to the new WHB—a message of congratulation from a sister station.

Sea Gate's message, the initial despatch to be filed on the new station's receiving hook, was as follows:

"Congratulations on the opening of Marconi station at the New York Herald. (Signed) Weaver."

The Wanamaker Marconi station at Philadelphia was the second station to answer the call sent out by Mr. Sarnoff. It came in:

"Congratulations on opening of the new station. The successful working of same is already assured by the type of installation.

(Signed) D. J. Heilig."

A moment later the same station came back with the following:

"The spark is very good and sharp. Best note I ever heard. Get you fine."

The opening of the new station was witnessed by John Bottomley, vice-president, secretary and treasurer of the Marconi Wireless Telegraph Company of America; Captain Godfrey L. Carden, United States Coast Guard; Thomas Lawler, assistant custodian of the Barge Office, and others.

Dudley Field Malone, Collector of the Port, who is also custodian of the Barge Office, was to have been present, but he was hurriedly called to Washington. Mr. Lawler acted as his representative.

It had been intended to send, as the first official business of the new station, a message from Governor Whitman to President Wilson, but this program could not be followed because of the fact that by special orders the naval radio station at Arlington, which was to be the receiving station, has been detailed to watch for signals from naval stations only.

While the station was being opened a detachment of Coast Guardsmen, detailed by Captain Carden, mounted an honorary guard in front of it, in recognition of the close alliance between the station and the Coast Guard service for the protection of lives and property at sea.

After Mr. Sarnoff had sent out his first call and had received the response from Sea Gate and from Philadelphia, the station was turned over to the regular staff of operators.

The new station is situated on the roof of the Barge Office, commanding the entire bay, and its aerials, of which there are two, run from the Municipal Ferry Building, at the Battery, to the Barge Office Building. There are two aerials —one for commercial use on 600 metre wave-length, while the other, which is much larger, is used for the press bulletins, sent out twice daily, on a wave-length of 1,700 metres, where the powerful spark will not interfere with commercial business between vessels and ships at sea.

The transmitting apparatus consists of the latest type Marconi 5-k.w. set and a receiver of the latest design of the Marconi Company. The installation of the Marconi apparatus was under the supervision of John B. Elenschneider, construction engineer of the company.

The station is one of the three links in the chain of radio stations that send out into the ether nightly the wireless press service issued for the benefit of seafarers on the Atlantic and Pacific oceans. The other two stations are the Marconi high-power stations at South Wellfleet, Mass., and Hillcrest, San Francisco, which send out to the North Atlantic and the Pacific, respectively, WHB takes care of ship reports, sends out information to mariners, and in the press service, issued in the early morning and in the evening, gives the news of the day to vessels, particularly in the coastwise service and the West Indian and South American traffic.

Record Broken in Trans-Atlantic Test

Remarkable Results With the Aid of Marconi Timed Spark in Establishing Communication

Another record-breaking achievement in the wireless art has been accomplished by the Marconi system in establishing strong, direct and continuous communications over twelve-hour periods between the station of the Marconi Wireless Telegraph Company of America at Chatham, Mass., and that of the English Marconi Company at Carnarvon, Wales. The signals received at Chatham from Carnarvon where from three to eight times as strong as those obtained from any other European station. These tests were successfully carried out on January 29 and January 30.

The Marconi system has thus again shown itself to be a pioneer in radio communication, and its feat was made possible by the practical application of an entirely new system of continuous wave generation—none other than Marconi's timed spark, which has recently been developed into a useful form. The station at Carnarvon was equipped with the new Marconi transmitting apparatus, and its sending power is regarded as nothing short of marvelous. The station at Chatham also accomplished wonders, in the opinion of the wireless engineers who supervised the test, owing to the fact that it was but temporarily outfitted for the test, having been equipped on a couple of days' notice.

The distinctive accomplishment of this test lies in the power and continuity of transmission and in the large number of words accurately received on the American continent in the specified time, from a European station. The test began at seven o'clock in the morning of January 29th, and continued until seven o'clock of that evening. The second trial was made at seven o'clock the following morning. Thus two twelve-hour periods were covered, embracing the various influential phases of the day and night.

The messages transmitted consisted of press matter, the total number of words copied in the combined twenty-four hour period amounting to 15,000. The speed varied from twenty to thirty-five words a minute.

During the first six hours of the Monday morning test, every letter was received plainly and not a skip of any kind occurred to mar the initial communication between the British and American stations. During the period of the second day's test a total of about 9,000 words were received.

It was the opinion of the engineers that the initial test of the new Marconi system was carried to a highly successful conclusion. It was also taken into consideration that the conditions that prevailed were unusually disadvantageous for the winter time. The results obtained, however, are regarded in authoritative quarters as having established a new wireless record, both in the continuity of words received and the number obtained within the specified period.

MEXICO REPORTED IN WIRELESS TOUCH WITH BERLIN

Information has reached the United States Government, says a Washington correspondent, that through the perfection of a powerful wireless telegraph plant in Mexico City direct communication between the Mexican capital and Germany has been established.

Officials realize that, if confirmed, this news is of great importance. Sea raiders and submarines might be directed and full information concerning the leaving of ships from American ports furnished.

ARMY RADIO COMPANY PLANNED FOR CANAL ZONE

The organization of a radio company as a unit in the regular army for duty in the Panama Canal zone and other foreign service is planned at Fort Leavenworth. Captain J. O. Mauborgne, is to organize the company and will have command of it when it goes on foreign service. Aside from a few soldiers with experience in drill an effort will be made to get recruits, who have taken up radio work.

HARVARD IN PREPAREDNESS MOVEMENT

A new phase of army and navy preparation was introduced at Harvard University recently when fifty students gathered to learn of the work performed by the radio corps during war time. Lieutenant Blakeslee, U. S. N., of the Charlestown navy yard, and Captain H. G. Galler, United States radio inspector for New England, addressed the men.

In connection with the reserve officers' training corps the Harvard men with a knowledge of wireless telegraphy are to take a special course of training to prepare them for service. The work will be carried on under the direction of the Harvard Wireless Club, which has headquarters in the Harvard Union. Classes will be held three times a week for the radio students. A score of students have enrolled in the wireless corps.

A wireless telegraph station has been established at Alamos, an important mining camp in Southern Sonora, and regular communication is now going on between that place and Chapultepec, Guadalajara, Salina Cruz, Merida, Vera Cruz, Matamoros and other points.

Professor Michael I. Pupin, inventor of electric tuning and a world renowned authority on communication

Shall Parents Raise the Infant Wireless or Place It In a Government Institution?

The Opposition to Proposed Legislation made by the President of the Institute of Radio Engineers

PROFESSOR M. I. PUPIN of Columbia University in no uncertain terms expressed his decided objections to the proposed bill to regulate radio communication at the recent hearing before a Committee of the House of Representatives. His cogent reasoning and emphatic statements and illustrations, comprise so effective an indictment of the proposed measure that his entire testimony, as given to the Committee, is now placed before the readers of THE WIRELESS AGE.

"I am not a parent of the wireless art," said Professor Pupin, "but I am a very close blood relation to it, because I am the inventor of electric tuning, the only means they have today of preventing interference between different stations receiving signals or transmitting signals at the same time."

There are not many whose words carry more weight than those of Professor Pupin, when the subject of wireless is under discussion, and in the imminency of legislation affecting the science, his views and counsel deserve attentive consideration. Professor Pupin's qualifications as an authority may be gauged from his activities and affiliations. He is professor of electromechanics of Columbia University; director of the Phoenix Research Laboratory in Physics of the same university; president of the Institute of Radio Engineers; president of the New York Academy of Sciences; president of the National Academy of Sciences; member of the National Advisory Committee for Aeronautics, and member of the National Research Council, organized at the request of President Wilson.

Professor Pupin invented the art of electric tuning and sold the patents to the Marconi Wireless Company of America in 1902. He is also the inventor of the electrolytic detector, and was the first to suggest the advisability of rectifying the received electrical oscillations. He suggested this before the American Physical Society in November, 1899, and showed the apparatus, namely the electrolytic rectifier, by means of which the rectifying of received electric oscillations can be and was effected. This rectifier was used for a long time as one of the methods of receiving wireless messages. It has been superseded by better apparatus, but the rectification of received electrical oscillations is one of the fundamental elements in the modern or recent developments of wireless telegraphy, and the idea was that of Professor Pupin.

The foregoing record, however, is sufficient to emphasize the fact that the opinions of Professor Pupin represent expert testimony.

Professor Pupin informed the members of the Committee that he had never been interested financially in any of the companies manufacturing wireless apparatus. He appeared before the Committee, he said, for the purpose of demonstrating, if possible, that the bill under consideration would be most detrimental to the development of the young wireless art, since it would inevitably lead to Government ownership. He likened the art to a very promising, healthy baby, which had a great future before it.

"A great future," repeated Professor Pupin, "provided this healthy, robust and most promising baby receives the proper training and the proper bringing up. And the question in my mind is simply this: Who is to be responsible for the training of this wonderful baby? Its parents or a Government institution?

"It has been represented by the heads of our Government departments, namely the Secretary of War, the Secretary of the Navy, the Secretary of Commerce, Commander Todd and by other Government officials interested in the national defense, that it is advisable and necessary that the Government should control, in fact, that the Government should own, wireless telegraphy, I am interested in the national defense as much as anybody, and for that reason was appointed as a member of the National Advisory Committee on Aeronautics, which is a Government institution. I am convinced that if we are to use any art and particularly the wireless art for the national defense, the best thing for us to do is to develop that art. If interferences exist, as has been pointed out in the several depositions here before you, on account of the present imperfection of the wireless art, then these interferences should be eliminated not by legislation but by perfection of the art.

"If you will be indulgent with me, I will illustrate that by describing as briefly as I can the experiences that the world had in the development of other arts which are very closely related to the wireless. Take the ordinary telegraphy and telephony by wires. What was the experience in their early history? Exactly the same as we have in the wireless art. From 1845 to 1860 the men interested in the development of telegraphy, electromagnetic telegraphy, invented by Joseph Henry and commercially developed by Morse, spent most of their time in quarreling among themselves on the subject of how to get around the inductive disturbances. They had inductive disturbances just as much as we have to-day in wireless telegraphy, and they were of two different kinds: Inductive disturbances produced in a wire by the operation of other wires and inductive disturbances produced by God. Inductive disturbances produced by God have not been discussed in the depositions so far, but under certain conditions they are a great deal more serious than inductive disturbances in wireless telegraphy produced by man. And although it is possible—I do not say it is advisable, but it is possible—to get around the inductive disturbances produced by man through legislation, you cannot get around inductive disturbances created by God by means of legislation, because God says, 'My acts can be eliminated in the operations of man not by brute force (and that is what legislation in many cases is) but by intelligence.'

"What are these interferences produced by the acts of God? We did not realize them until electro-telegraphy was invented. And we never realized them to such an extent as we do to-day, since the wireless telegraphy was invented. Wireless telegraphy is communication between two points on the surface of the earth, or between a point on the surface of the earth and a point in the air, as in the case of the aeroplane, by means of electric oscillations. You create an electric oscillation at the sending station; that electric oscillation goes to the receiving apparatus and creates there an electric oscillation which affects a receiving instrument.

"We know to-day that these electrical oscillations are produced in the atmosphere by God for purposes that are known to Him. We can explain how they are produced, but we do not know yet what is the real intention of the Creator in producing them. They are called statics, and statics are the blackest enemy of the wireless stockholder. Statics have prevented the wireless stockholder from reaping any benefit from his work. The wireless art is not quite yet, excepting in some of its features, a commercial art; in other words, it does not return dividends, principally because the statics prevent it —these disturbances, these electric waves that go up and affect, in fact, every receiving instrument.

"In April, 1914, when our bluejackets had landed in Vera Cruz, and it looked as if we were going to have a war with Mexico, I was here in Washington attending a meeting of the National Academy of Sciences. I happened to meet Dr. Austin, who is the director of the Wireless Research Laboratory of the Navy, and he told me that they could not force a message through between Arlington, or even Key West, and Vera Cruz; it was impossible. Why? Not because the Mexicans had a wireless apparatus which interfered with ours and not because anybody else had it, but because the static was going on in the Gulf of Mexico and prevented our messages from reaching Vera Cruz. Interference in wireless telegraphy due to static, due to the acts of God, is so serious that sometimes a wireless station cannot receive a message for forty-eight hours or even twice forty-eight hours. For days in succession they cannot receive a thing. Not on account of interference of other stations but on account of the static, on account of the electric waves, the electric oscillations, which God sends from an infinite number of stations located anywhere in the atmosphere between the North and South Poles. These are the acts of God, and I do not see that these interferences have even been touched upon in all of these depositions. And these are the most serious interferences that we have, and you cannot get rid of those by any act of the legislature. The only way to get rid of them is by the perfection in wireless, by the proper training and bringing up and education of this healthy, robust baby, the wireless art.

"But the heads of the Government bureaus propose that this baby should be put into a Government institution, should be taken away from the loving arms of its parents and relations (and I am one of them). Now, it seems to me that would be almost a crime. We would suffer, the United States would suffer— the people of the United States; the Army and Navy would suffer, because they would not have an efficient art with which to defend themselves in time of war.

"When it comes to getting rid of the acts of interference produced by legislation, we can do that to a certain extent, provided we are legislating against the acts of our own citizens. But what legislation is going to prevent the enemy from interfering with us in time of war? It is told by the English wireless operators who took part in the battle off Falkland Islands that the Germans, as soon as the battle started, went up and down the scale of their wireless sparks for the purpose of making it impossible for the English ships belonging to that squadron to communicate with each other. Now, I would like to know how any act of legislation, how any act of Government ownership, can prevent that. Of course, mind you, I am proceeding from the hypothesis that Government ownership is inefficient in the development of a new art."

At this point the Chairman of the Committee inquired whether it would help the situation any if citizens or wireless stations in our country were to intensify that condition of interference?

"If I had my own way," replied Professor Pupin, "I would produce as many interferences as I possibly could, for the purposes of development of the art so that no ingenuity of man could interfere with a wireless operator when he receives. And that is possible. Things are being done to-day by well-organized industrial research laboratories which will undoubtedly lead to wonderful results so far as preventing interferences produced by the acts of man are concerned. Things are within the reach of those who are studying the situation which will transform the whole aspect of the wireless art. Now, these things, I say, are being done because the Government does not own the wireless. And if the Government owned the wireless they would not be done. Why? I will tell you the reason why. I have the greatest respect for the Army and Navy. I have a great many friends among the officers of the Army and Navy. And I would not for the world do anything which would hurt their feelings. But we are here to be frank and open and aboveboard, and we must say what we think is right, what we think is best for the wireless art and for the people of the United States.

"How does the inventor feel with regard to the Army, and particularly the Navy—I mean the wireless inventor? I will describe it briefly for the purpose of explaining what I mean when I say that if the Government owned the wireless, the men who are interested in the development of wireless probably would drop out—drop their interest in the development of the wireless. I may be wrong, but that is really my opinion. I refer now to a man who made a very beautiful invention. In 1910 Dr. Austin, director of the Wireless Research Bureau of the Army and Navy, and whose station is on the grounds of the Bureau of Standards, published a paper in which he compared the efficiency of various types of receivers. Among the receivers he examined was a new receiver, the so-called audion, invented by Mr. de Forest, the very audion receiver which is used to-day almost universally. Dr. Austin found that this audion receiver was one and a half times as good as the best receiver they had prior to that time—one and a half times, mind you. At that time a young inventor, to whom I refer, was a student in Columbia University, a sophomore. That was in 1910. In 1912, when this student graduated, He got a patent—or I do not know whether he got a patent that year, but he had the invention anyhow, a very simple thing, which consisted of taking the audion tube and by a simple transposition of the circuits, making it 5,000 times as sensitive as the one which Dr. Austin examined. This young student, by a simple transposition of circuits, made the same audion 5,000 times as sensitive. With what result? With the result that everybody is using it to-day and all the operating companies pay the young man a modest royalty. Not a very large royalty, because the operating companies are not making money—not much anyhow. They cannot afford to pay more than a very modest royalty. But it enables this young man to support his mother and two sisters. The United States Navy uses this invention more than anybody else. According to the information which an officer of the Navy gave to myself, they have been using it since January, 1914. And they had it at this time—and this was a year ago—in something like forty stations. They have not paid a cent to the young man, and they do not intend to. They all tell him, You can go to the Court of Claims."

The Chairman inquired whether anyone were contesting the right to the invention.

"The right has not been contested," replied Professor Pupin, "and it is proved that it is not contested, because the wireless operating companies pay this young man a royalty, which is the best proof that an invention is valid; you cannot have a better proof. The wireless operating companies know more about the art than anybody else. And if they did not have to pay the royalty, they would not pay it; but they are paying it. But the Government has never paid a cent, and probably never will until the Court of Claims decides in favor of this young man. Now he is poor and cannot go to the Court of Claims. It costs money, and he cannot afford it. His lawyer tells him, 'You had better not go to the Court of Claims; you will spend a lot of money; you will spend everything you have, and God knows when you will get any return from it.' And the result is that the young man has no other claim for his rights.

"I am sorry to be compelled to testify to that effect, but that has been the policy of the United States Navy. And I am afraid that if the United States Navy takes control over the wireless art that will be the policy still, unless the laws are very much amended. In other words, if this bill passes through, you will have to pass perhaps five, six, perhaps ten other bills for the purpose of protecting the inventor and protecting the art.

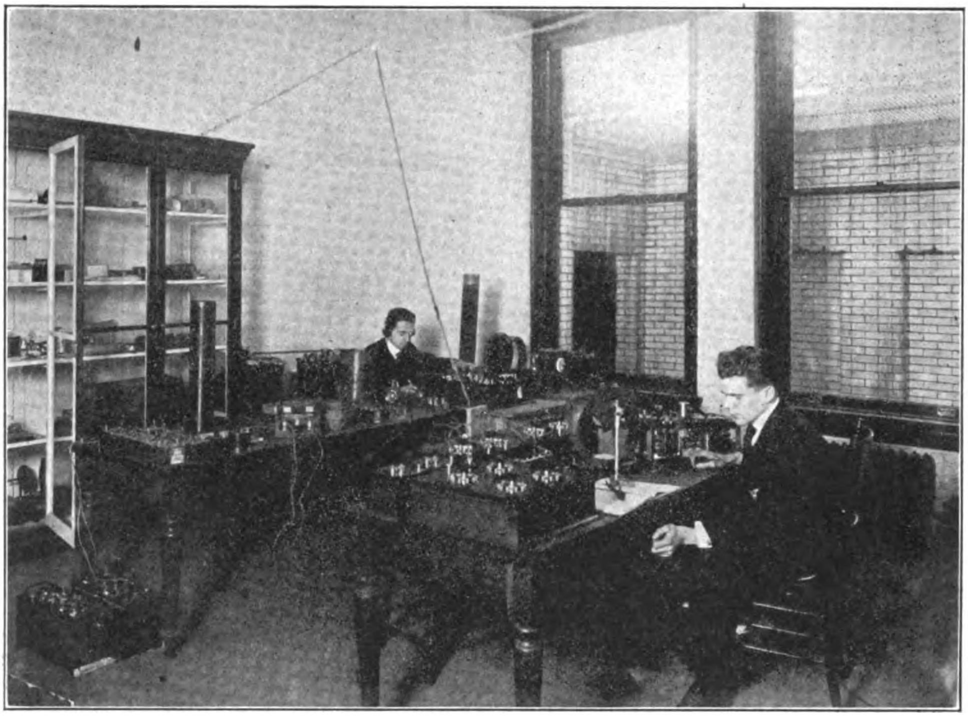
"But brushing that aside with the argument that these things can be fixed up in such a way that the inventor will be protected and that he will be very anxious to work for the Government, offer to the Government his inventions and help in the development of wireless, I still maintain that the Government is not and never will be in a position to develop a new art. That must be left to private enterprise and private initiative. Why? Well, it is a question of psychology, and there is no use arguing about that. It is a fact well understood everywhere that a new art is not developed and cannot be developed by the Government. Even the German Government has not taken possession of the wireless art and will not take possession of the wireless art for some time to come. Why? Because the German Government understands that this is a young art, and should not be intrusted to the Government for its development—for its bringing up. It leaves it to private enterprise. Moreover, the German Government very wisely subsidizes private enterprise. It pays so much a year to develop the wireless art. And I should say that if the United States Government is anxious to prepare this art for the national defense, the wisest thing for the Government would be to subsidize private enterprise to develop the art for the national defense as much as possible and as soon as possible. That would cost a great deal less and give very much better results than Government ownership.

"To go back again to the history of telegraphy, electromagnetic telegraphy and telephony: I said a little while ago that their experience was the same as the experience of wireless operators today. They had interferences from men and interferences from God. The inductive effects of one line upon another line were felt then. And if the United States Government at that time had decided to take the new art of electromagnetic telegraphy into Government ownership, because there were interferences between wires, they would have done probably this: No telegraph wire, should be near another telegraph wire—nearer than, say, a mile or 2 miles. That would have been their way of overcoming interferences, because that is the way they propose in this bill, that the wireless stations should not be placed except here and there, and the Government is to decide that. The heads of the departments are to decide that. The wireless engineers and the wireless experts and the men capable of building up the wireless art have nothing to say about it.

"Now, if that policy had been pursued in 1845 and 1846, up to 1860, we would have been compelled to place the telegraph wires at a distance, say, of a mile apart or perhaps ten miles. And you can easily imagine what would have become of interferences then, as far as the acts of man are concerned, and what would have become of interferences then as far as the acts of God are concerned, because the statics in electromagnetic telegraphy would have been just as bad, no matter how far apart the wires are from each other. But that was not done, thank God! The inventive genius of the American mind and American enterprise went on and solved this problem in a most satisfactory way by the Wheatstone automatic system. The Wheatstone automatic system enabled the wires to be placed right alongside of each other, if you please, within eighteen inches. So that you can have any number of wires on a one-pole line to-day. That means a tremendous saving in expense of installation of telegraph lines.

"It was found in the early history of telephony, from 1876 on, that we had cross talk between telephone wires; you would be talking on one wire and another man talking on another wire, and you could hear each other's conversation; and if ten wires were near by you would hear ten persons at once talking to each other, owing to the inductive interferences.

"It has been testified in this case by Government officials that wireless telegraphy is different from other methods of electric signaling, because they use the same medium, the air, the ether, whereas



Professor Pupin's laboratory in Columbia University, New York

in telegraphy and telephony each man has his own circuit. Well, a school boy, a sophomore at Columbia University, knows that that statement is absolutely incorrect. There is nothing in it. They do not use the same medium in wireless telegraphy any more, nor any less than they do in ordinary telegraphy and ordinary telephony. It is very true that in ordinary telegraphy and ordinary telephony you have one wire so that as far as the motion of electricity is concerned you have only one path. But the electric force is not the only force used in signaling; there is magnetic force. In fact, it is the magnetic force that enables us to set our detecting apparatus into motion and not electric force. It is magnetic force with which they operate. Now, as I said, every schoolboy knows about that. But, as far as magnetic force is concerned, we use the same medium in ordinary telephony and ordinary telegraphy as we use in wireless. They all use the atmosphere; they all use the infinite medium. The same medium serves the telephone, the telegraph, and the wireless. They all use the same medium for the ordinary transmission of the magnetic force. And there is no distinction between the two methods at all. And for that reason, as far as interference by the acts of man and the acts of God are concerned, both had the same difficulties, both had to go through the same history of development—the electromagnetic telegraph and the electromagnetic telephone.

"In the electromagnetic telephone, we had interference between wires. We had cross talk, so that you could hear any number of people at once interfering with other people. To-day we use a cable with a sheathing, say, of four inches in diameter, and we place inside of that sheathing 600 definite circuits, and we can have 600 different people talking at the same time through these circuits without any cross talk; without any interference at all, whereas if the Government had owned that art from 1876 to 1895, or 1900, we would have had to separate those wires and the art would have never reached that point where it can have in a small space 600 different circuits; it would have been impossible."

When asked why he was so positive that Government ownership would have precluded the further development of telephony, Professor Pupin replied that, had the legislature passed a law that telephone wires should not be placed so close together as to cause interference, there would have been no incentive to the inventor for seeking to overcome the limitations of telephony.

"But the Government," interposed the Chairman, "is the most generous purchaser and pays the largest price."

"To whom?" demanded Professor Pupin.

"To the inventor," was the reply.

"When?" retorted the wireless authority. "A lieutenant in the Navy told me to my face that the Government never paid any inventor more than $7,000 for an invention. I received from the American Telephone & Telegraph Co.—well, I won't say; but certainly not $7,000, but probably seven hundred times that. The invention is worth to the company hundred, perhaps a thousand, times as much as they paid me. Certainly a hundred times. And it is worth to the people of the United States a hundred times as much as it is worth to the company. It is the people of the United States who profit by it. We can telephone to-day from any point in the United States to any other point in the United States. You can be on a ranch in Texas or Arizona and telephone to the Waldorf Astoria at any time—at any time of the day or night. You can call up anybody in the United States. Why, you can not only talk to one man, but you can talk to an audience of a thousand hearers in the Waldorf-Astoria. I was one of an audience of 2,500 people in the Symphony Hall, of Boston, last June, when the voice in San Francisco was heard by every one of the 2,500 hearers. I candidly and openly confess that if the telephone had been in Government ownership, we should never have reached that point; never. Why haven't they reached that point in France or England?"

"Who was the inventor of the process by which this was possible?" asked the Chairman of the Committee.

"I was the inventor," was the reply.

"Of the process by which you can magnify the voice?"

"No," corrected Professor Pupin, "by which you can preserve the character of the speech. When you preserve the character of the speech that has been transmitted any distance, say from San Francisco to New York—if you preserve it so that it is not distorted—then you may easily magnify it to any amount you please.

"Now, if the Government means to take possession of the wireless art and establish industrial research laboratories and go into this art of manufacture—because that is the only way that you can develop an art—to manufacture yourself and not have somebody else manufacture it for you—then well and good. Then perhaps this bill would have some meaning. But this bill as it stands, with the other conditions—with the other laws existing and the other historical conditions of Government work existing—this bill means nothing else than a blow to wireless telegraphy."

The Chairman, interposing, called the attention of the speaker to the fact that the bill under discussion did not provide for Government ownership, although there was an amendment suggested to that effect.

Professor Pupin admitted that the bill itself did not provide for Government ownership, but he reasoned that it inevitably led to that eventuality, since Mr. Baker, the Secretary of War, the Secretary of the Navy and Commander Todd all had favored Government ownership in their testimony before the Committee.

"Mr. Chairman," he continued, "I can not read anything else in this provision, sections 5 and 6, than that it does mean Government ownership. And section 20 and other sections which refer to regulation by the Government, if the Government is going to impose arbitrary rules upon wireless operators, upon private enterprise operating wireless stations, why that control will kill the art, even without ownership. If we are to control the transmission and reception of wireless signals I believe the Government should do it, but I believe the Government should do it in conjunction with well-known recognized electrical authorities —wireless authorities. Let them together devise a method of preventing interference. The patriotism of this country is not all centered in the Army and Navy and the administration. There is some patriotism in the rest of us who are not in the Government service, and we will do our best to prevent interference with the operations of the Army and the Navy —do our best. And we will do it for the same motives that the Government has, namely, pure and simple patriotism. But don't let the Government, independent of anybody else, prescribe rules of operations so as to avoid interference. This thing can be done and would be done and should be done."

The members of the Committee requested the speaker to outline his views as to the nature of the regulation which, in his opinion, should be adopted.

"I suggest," replied Professor Pupin, "the same thing the Government has done in the case of aeronautics. The Government has appointed a committee of twelve, the so-called National Advisory Committee for Aeronautics. It is a committee, I believe, of twelve. I am a member of it. There are four Army and Navy men, two from the Army and two from the Navy; four from the Government bureaus, and four from the universities—Johns Hopkins University, the Columbia University, the Leland Stanford University, and the Northwestern University. I represent Columbia University. Now, with twelve men—four civilians, four Government officials, and four Army and Navy officers—we are getting along beautifully, and we are fixing up the aeronautic arrangements for the Army and Navy in a most friendly and successful way. We have done a lot of work. We are doing the work, and everbody is just as loyal to it as the Army and Navy men are, and I am sure in a short while we will have accomplished great things. And the Government has perfect confidence in it. Let us have the same thing for wireless; let us have four Army and Navy men, four Government officials, and four university men. And I think it would be all right to have some men representing operating companies. Let us have a committee, and let that committee meet once a month, as the other committee meets, through arrangements made by its executive board, and go over the field carefully and advise the Government what should be done. A committee of that kind would do wonders—wonders. And whatever they decided to do, it would be a decision not of the Army and the Navy alone, of the Government officials alone, but the Army and the Navy and the Government officials, together with the universities and the operating companies. Certainly advice of that kind would be acceptable to everybody, and I think it can be done and should be done, and we will have magnificent results. I could almost guarantee them, if my guaranty was worth anything.

"That is the way to do it, in my opinion, and not by legislation," added the speaker.

"Wouldn't you need legislation," suggested Mr. Hardy, of the Committee, "to enforce the rules of the committee as against outside parties?"

"Yes," agreed Professor Pupin, "but such legislation would be recommended by this national committee for the wireless. Legislation, to be sure, but not of the kind that would hurt the art."

"Do you think," persisted Mr. Hardy, "that such a committee could possibly devise a conclusion, a harmonious set of rules, that would not meet with as much opposition as this bill? I was wondering whether you couldn't agree on something on which there would be a unanimity of opinion."

"You will never get a unanimity of opinion among the people of the United States," retorted Professor Pupin. "It is quite impossible; you can not do it, and it has never been done yet. You can not have a unanimous opinion. But among the members of a well-trained, intelligent, patriotic committee—I will say like the National Advisory Committee on Aeronautics, we have had some unanimous decisions. They were good. They were for the good of the aeronautic art of the United States. The President thinks well of them, the Government thinks well of them, and the Army and Navy think well of them, and the House of Representatives thinks well of them, because they have given us appropriations. That is the best proof of what they think.

"I know we had a meeting at the Smithsonian last May between the members of this committee and the manufacturers. The question arose of how to get a first class, large-power motor for the Army and the Navy for flying machines —for aeroplanes. You know at that time we had the Mexican trouble, or we were looking ahead and seeing that probably we were going to have trouble there. And we had no aeroplanes that could fly very high in that rarefied atmosphere of Mexico, because we did not have high-power motors. And the Navy men, like Captain Bristow, told us that he had tried his very best to get a good motor over 100 horsepower, if possible 200 horsepower, with no success. Now, he said, what shall we do? It was suggested that we should have a meeting between the executive board of this National Advisory Committee for Aeronautics and the representatives of the manufacturers. They came and we had a meeting at the Smithsonian under the presiding chairman, Mr. Walcott, the Secretary of the Smithsonian. Well, you may say that if there ever was a meeting of men where there were conflicting interests it was at that meeting; because we had something like fourteen or fifteen manufacturers, one advocating one type of motor, the other man advocating another type of motor, and so forth. And yet when the thing was presented to them in the right light—that we should, for patriotic reasons, brush aside all of our personal likes or dislikes and personal interests, you know you never saw such a meeting. Unanimous; perfect unanimity of opinion. I never attended a meeting in my life where everybody was trying to do his very best as in that meeting. And we did succeed in getting some of the manufacturers, notably Mr. Algers, of the Packard Company, who is a rich man and who does not care whether he spends $200,000 or not in the development of a motor—he told me personally 'I will spend $200,000 to develop a motor satisfactory to the Army and Navy, and I do not care whether I get a cent of that back or not.' Such was the result of that meeting.

"I only mention this to illustrate what was the motive, the moving spirit of that meeting," concluded Professor Pupin. "It was patriotism. And so it is in wireless telegraphy. When it comes to regulating the wireless art for the purpose of avoiding interference with the operations of the Army and Navy we will have one motive in every member of that committee, the motive of patriotism, which will sweep everything else aside. And we will have decisions that will actually help the Government. I am just as sure of that as I can be. They will help the Army and the Navy. We want to help the Army and the Navy. We do not want to interfere with them. Every scientific man to-day wants to have the best Army and the best Navy in the world, and he will do everything he can to help the Army and the Navy."

It is needless to add that these patriotic assurances had their effect upon the members of the Committee of the House, especially as coming from a man whose achievements in scientific pursuits have given him a reputation that is world-wide.

Cross-Continent Relay Successful

The Transcontinental Relay conducted by the National Chief of Relay Communications, National Amateur Wireless Association, and announced in our March issue was a complete success. The westbound message from Mayor Mitchell, of New York, crossed the continent in an hour and a half, starting from (2ZK) G. C. Cannon, of New Rochelle, and being delivered to the mayor of Los Angeles by Seefred Brothers (6EA). The greeting of Mayor Woodman, of the latter city, reached New York by the same route in an hour and three quarters. Full particulars will be published in the May issue of THE WIRELESS AGE.

THE SHARE MARKET

New York, March 5.

Bid and asked quotations in Marconi shares today:

American, 2⅜—2¾; Canadian, 1¾—2¼; English, common, 11—15; English, preferred, 10—14.

Radio Telephony

By ALFRED N. GOLDSMITH, PH.D.

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

ARTICLE IV

AN arc system of radio telephony distinguished by simplicity rather than by efficiency or perfect reliability in practice has been developed by the Telefunken Company, though it has been superseded by their radio frequency alternator-frequency changer methods to be described later.

The arcs used by the Telefunken Company were burned either six in series on 220 volts direct current, twelve in series on 440 volts, or twenty-four in series on 880 volts. They burned practically in the open air. The lower carbon electrode rested in a depression in the base of a large, hollow, copper cylinder filled with water, which cylinder formed the other electrode. The water naturally served for cooling, and the carbon dioxid formed by the slow combustion of the carbon remained partially in the depression mentioned, and prevented the further and free access of air to the arc. No magnetic field was used with the arcs in question, and the efficiency was low. With an energy consumption of 6 kilowatts for 24 arcs in series, only about 10 per cent. of the available energy was converted into the radio frequency form. However, the carbon electrodes which were 3.5 cm. (1.4 inches) in diameter burned nearly 200 hours for each half inch of length.

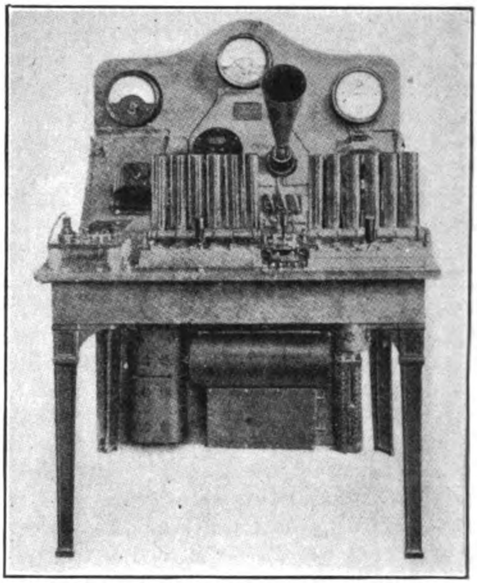


Figure 26—Telefunken Company series arc radiophone transmitter

The arcs were arranged as illustrated in Figure 26. It will be seen that all six could be struck at once by the right-hand handle, and that the length of each arc could be adjusted individually by a separate adjustment screw (not shown in the illustration). The actual wiring of the set is shown in Figure 27, and presents some valuable features. To begin with, there is a switch, *X*, which not only transfers the antenna connection from the transmitter to the receiver, but short-circuits the receiver while transmission is going on, by the use of auxiliary contacts, not shown. The switch, *Y*, connects together the points, *Q* and *S*, while sending is going on and the arc is oscillating. While receiving is going on, the oscillations are stopped by opening the connection between *Q* and *S*. At the same time, the resistance, *R*, becomes operative in holding down the direct arc current. During transmission the alternating current generated by the arc passes through the condenser, *C*, while only the direct current passes through *R*. In this ingenious way, the arc current is prevented from rising markedly when the oscillations cease, which is otherwise the case. The microphone is seen to be connected across the antenna tuning inductance, which also serves for coupling. Consequently, the microphone has the triple purpose of diminishing the coupling, shortening the radiated wave-length, and diminishing the antenna current by dissipating a portion of the available energy.

On November 15, 1907, using the apparatus just described, radiophone speech was transmitted from Berlin to Rheinsberg, a distance of about 45 miles (75 km.), the mast heights being 85 feet (26 m.), and the input power 440 volts and 5 amperes.

In 1908, a system of radio telephony developed by Lieutenant and M. Jeance V. Colins of the French Navy was first thoroughly tried out.* There were used three arcs in series supplied with 600 volts, the three being regulated

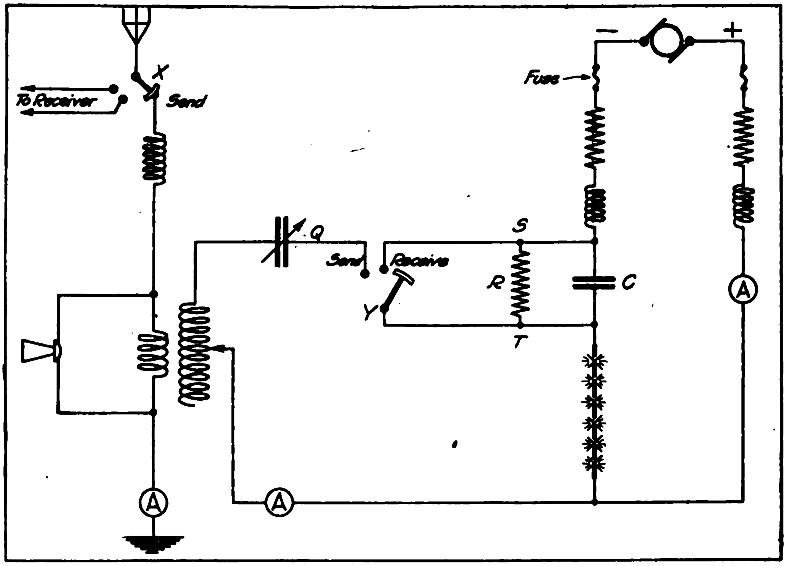


Figure 27—Telefunken series arc radio transmitter

simultaneously (and in later models automatically). An oscillatory circuit is shunted around the arc, and coupled to an intermediate circuit, to which the antenna is coupled in turn. The positive electrodes are heavy copper cylinders with cooling (usually by an interior stream of kerosene), and the negative electrodes are carbon rods of extremely small diameter (1 or 2 mm., i. e., 0.04 to 0.08 inch), the arcs taking place in an atmosphere of some hydrocarbon such as illuminating gas, acetylene, gasoline, alcohol, heavy oils, etc.

Under these conditions, the positive electrodes are not attacked at all, and the negative (carbon) electrodoes merely increase slowly and regularly in length because of the deposition thereon of a fine layer of carbon from the hydrocarbon atmosphere. Consequently, the arc does not tend to wander about the electrodes as is usual.

In order to ensure purity of the radiated wave and freedom from over-

* For much of the information here given, the Author is indebted to the "Bulletin de la Societé Internationale des Electriciens," for July, 1909.

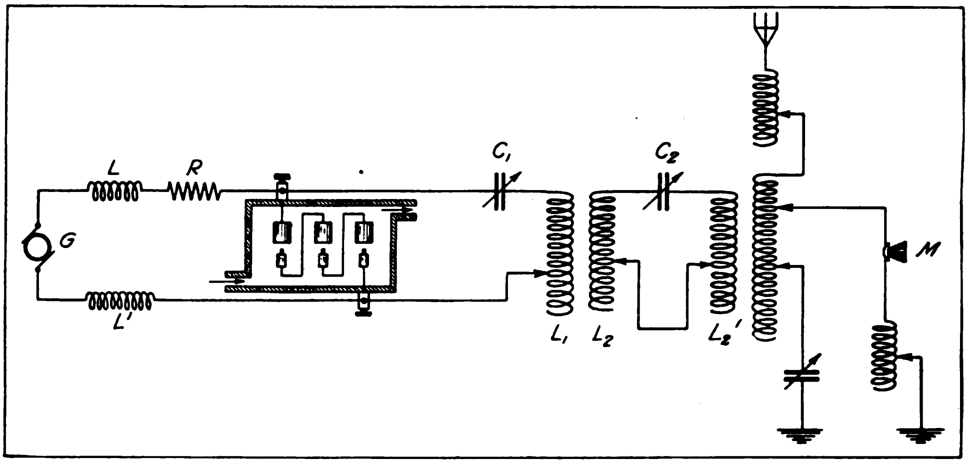


Figure 28—Colin and Jeance radiophone transmitter

tones (which are apt to prove troublesome, particularly for arcs in powerful magnetic fields, or arcs from which excessive energy is being drawn), the arc oscillating circuit is coupled to the antenna by means of an intermediate tuned circuit which, in turn, is inductively coupled to the antenna.

The microphone transmitters are of special design and contain no combustible material, the grain carbon being placed in cavities cut into sheets of marble or slate. The vibrating diaphragm is held at a suitable distance from the carbon support by a metal washer.

The actual circuit employed during some tests in 1914 is shown in Figure 28. Here G is a 650 volt direct current generator, which furnished in the tests in question 4.2 amperes (that is, 2.73 k.w). This current passed through the choke coils L and L', and the large regulating resistance, R, to the arcs which are shown schematically in cross section. The relative size of the electrodes and the method of admitting the hydrocarbon gas atmosphere are indicated. The potential difference across the arcs in this case was 350 volts, and consequently the energy consumption in the arc was 1.47 k.w., leaving 1.26 k.w. to be absorbed in the circuit of the generator, G and probably mainly in the resistance R. The intermediate circuit, $L_2C_2L_2'$, was very slightly damped, the capacity, C_2, being large. It will be noted that the microphone, M, is shunted across a portion of the antenna coupling and tuning inductance, being itself in series with an inductance. It will thus have the triple function of altering the coupling to the intermediate circuit, altering the radiated wavelength, and absorbing intermittently a portion of the available radio frequency energy. The main antenna current was 3.2 amperes at a wave-length of 985 meters, and the current through the microphones was 0.5 ampere. Nine microphones in series were employed, and two sets were provided for alternate use to avoid overheating.

The arc carbons in these tests were 1.5 mm. (0.06 inch) in diameter, and the arc took place in at atmosphere of acetylene (from calcium carbide and water) mixed readily in proper proportions with hydrogen (from calcium hydride and water). Under these conditions, the arcs were not burnt away; in fact, the carbons increased slightly in length with operation. Independent arc length regulation was provided for each arc, but was not found necessary.

Flat spirals of copper strip were employed in the various circuits, and either air variable condensers or glass fixed condensers. An auxiliary tone circuit shunted around the arc was provided (not shown in the figure), whereby musical note telegraphy could be easily accomplished. Since the

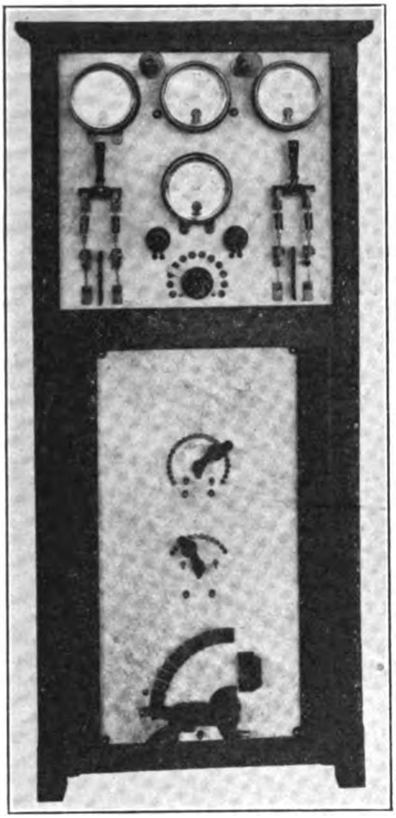


Figure 29a—Motor generator control panel of Compagnie Générale de Radiotélégraphie-Colin-Jeance radiophone transmitter

total terminal arc voltage dropped from 350 to about 150 when not transmitting, an auxiliary resistance was provided in the supply circuit which was automatically shunted into circuit whenever reception was begun.

With the equipment shown, communication was maintained between Paris and Mettray, a distance of 200 kilometers (125 miles).

In Figures 29 a, b, c, and d are shown the various assembled portions of a modern complete set of this type, as manufactured by the Compagnie Générale de Radiotélégraphie. The panel of Figure 29a supports the motor and generator switches, measuring instruments, and control rheostats. The three arcs and their enclosing chamber together with the arrangement for their gas supply are illustrated in the upper part of Figure 29b. An automatic regulator for the arcs is mounted directly in front of them. In the lower portion of the table are mounted the supply circuit choke coils and resistances. The means for tuning the primary, intermediate, and secondary (or antenna) circuits are provided in the cabinet shown in Figure 29c. The hot wire ammeter at the top is in the intermediate circuit. The two couplings between the pairs of circuits are controlled by the projecting handles. Figure 29d illustrates the operator's table. The measuring instruments are the antenna ammeter, the microphone, shunt circuit ammeter, and a voltmeter across the arcs. The resistance to the right is in the microphone circuit. The two microphone mouthpieces and reversed horns and the change-over switch

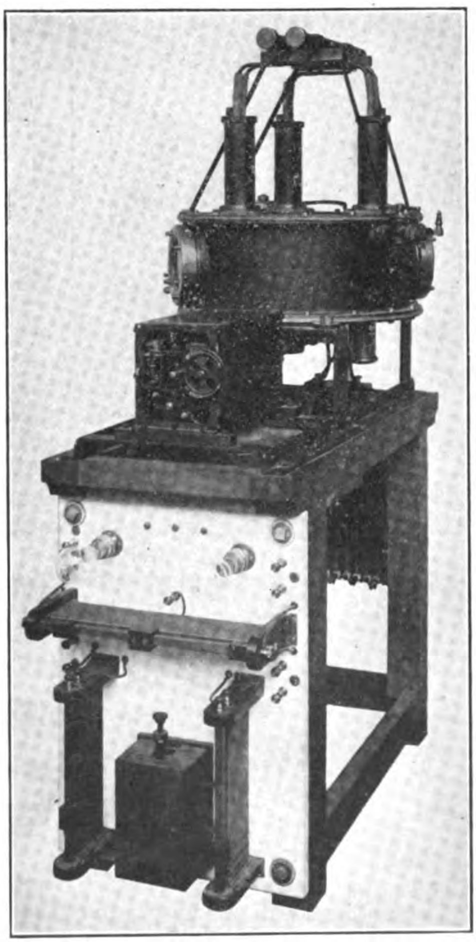


Figure 29b—Colin and Jeance series enclosed arcs, automatic regulator, and control apparatus

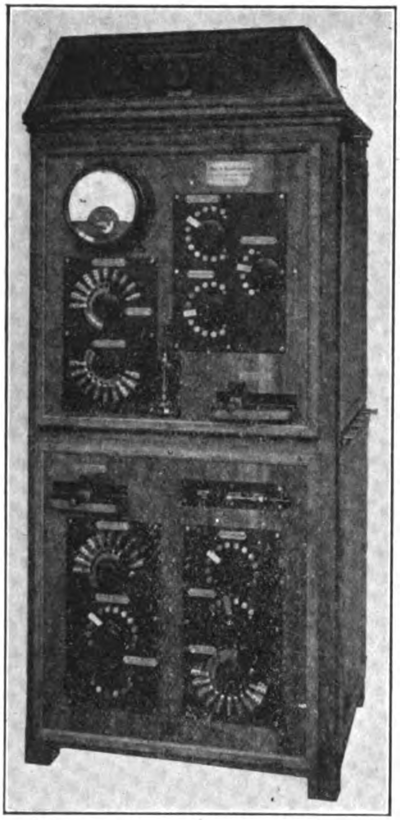
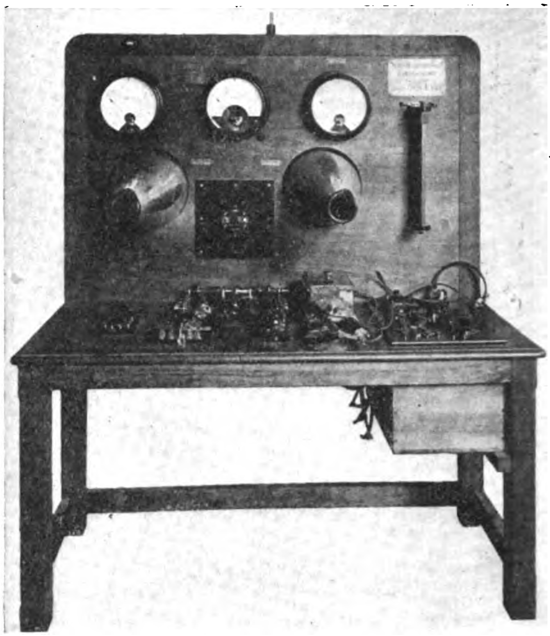


Figure 29c—Colin and Jeance primary, intermediate, and secondary control panel

Figure 29d—Colin and Jeance transmitting and receiving operator's table for radio telephony



between sets of microphones are also on the back panel. On the table top are the antenna switch, a change-over switch from telegraphy to telephony, the sending key, the enclosed detectors, and a complete receiving apparatus. This last is of normal type, having inductive coupling between the antenna and secondary circuits, a tuned secondary, and crystal detector.

(b) **RADIO-FREQUENT SPARKS.** It has occurred to a number of investigators that practically sustained radiation could be secured in an antenna by using spark transmitters, but having these transmitters so arranged that the extremely high frequency of the sparks (above the limits of audibility) would render the usual "spark tone" inaudible. If, then, the antenna energy were modulated by a microphone or otherwise, radio telephony would become possible. To specify in further detail, imagine a special form of spark gap and associated circuit so arranged that discharges occurred more or less regularly across the gap at an average frequency of, say, 50,000 sparks per second. If the circuit in which these sparks occurred were connected inductively to an antenna, there would be produced in the antenna practically sustained radiation, susceptible to suitable telephone modulation by a microphone transmitter or otherwise.

In Figure 30 is given a graphic delineation of the effects. It will be noticed that highly damped oscillations occur rather irregularly in the primary circuit, and that each of these short oscillation groups starts a decadent wave train which has still a large current amplitude when the succeeding spark takes place. Inasmuch as the sparks follow each other so frequently and since the antenna circuit damping is low, the effect at the distant receiver would be appreciably that of sustained radiation at the transmitter, and paricularly is this the case since the changes in antenna radiation occur above audio frequency. Most of the radio-frequent spark transmitters for radio telephony operate in the fashion indicated, but there is a second special case, which has certain interesting features. It is illustrated in Figure 31a, and occurs with the Chaffee "arc" (which is really a spark phenomenon). To begin with, in this case the spark gap has such excessively high intrinsic damping that the spark discharges in the primary circuit tend to be aperiodic. (The structure of the Chaffee arc will be described hereafter.)

The tendency toward aperiodicity just mentioned is enhanced by Chaffee in that he couples the secondary circuit very closely to the primary, thereby obtaining a "quenching" action through the secondary reaction on the primary. In addition, the direct current feed circuit of the arc and the coupling to the energy-absorbing secondary are so arranged that the spark frequency is an integral fraction (e. g., one-half, one-third, one-fourth, etc.) of the frequency of the oscillations in the secondary circuit. Thereby it occurs that the successive discharges come at just the right time to be in phase with the secondary (or antenna) oscillations, and not at random (with possible interference) as is the case for the conditions illustrated in Figure 30. In Figure 31b are shown oscillo-

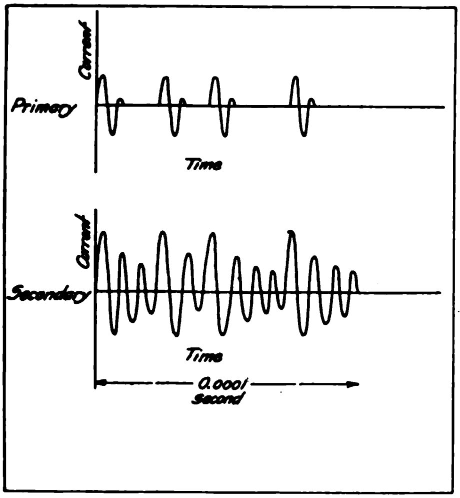


Figure 30—Irregular radio-frequent spark excitation of antenna

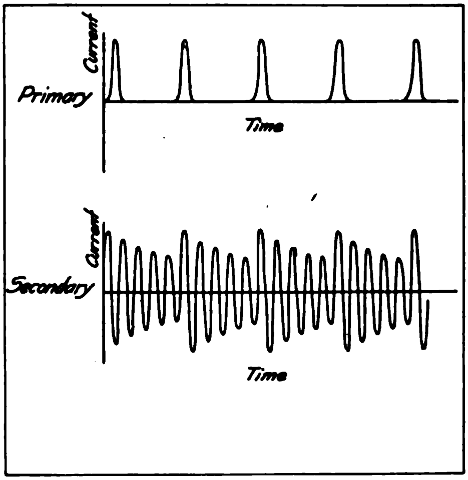


Figure 31a—Regular radio-frequent impulse excitation of antenna

grams of the actual phenomena.* Chaffee uses the term "inverse spark frequency" for the ratio between the radio frequency in the secondary circuit and the spark frequency in the primary circuit. The inverse spark frequency is a whole number for the Chaffee arc.

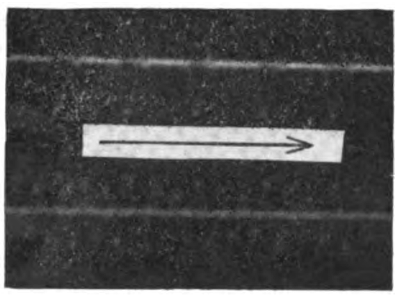


Figure 31b—Primary and secondary current with Chaffee gap (Inverse charge frequency = 3)

In general, spark methods of radio telephony are open to very serious objections. Unless the sparks not only follow with great regularity but also have nearly equal current amplitudes (neither of which conditions are easily fulfilled, particularly in steady operation), there will be produced in the receivers of the distant station an annoying hissing sound, which will interfere seriously with clear articulation in the speech. This accounts, naturally, for the frequently poor quality of spark radiophone transmitters.

Nevertheless, many investigations have been carried on in these directions,

* By courtesy of Mr. Bowden W...

and in some cases with marked success, and these will now be considered.

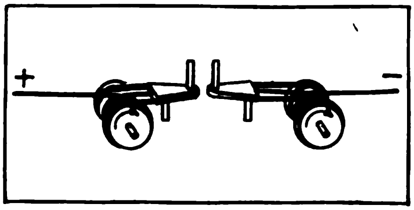


Figure 32—Ruhmer moving wire arc for radio telephony

In the fall of 1900, working with a special interrupter enabling him to obtain as many as 10,000 regular sparks per second, Fessenden succeeded in transmitting speech over 1 mile (1.6 km.), but the quality was poor and there was much side tone. By 1903 better speech was obtained, though the extra noise was still present. It does not appear that Fessenden developed this method further, although he describes a special rotary gap (with 40 per cent. platinum-iridium studs) operated on 5,000 volts direct current and arranged to give 20,000 sparks per second by the successive charging and discharging of a condenser.

One of the earlier workers with radio-frequent spark systems was Ernst Ruhmer. Ruhmer used as his gap terminals two moving metallic wires which passed over water cooled prismatic surfaces at the sparking point. The apparatus is shown diagramatically in Figure 32, which shows clearly the reels on which the moving wire is wound and the water-cooled prismatic gap guides. The paramount advantages of Ruhmer's arrangement are that a fresh and clean surface is constantly presented for the arc, that excellent cooling (and consequently quenching) is obtained, and that the arc length should remain quite constant. Ruhmer's apparatus is shown complete in a hitherto unpublished photograph* in Figure 33. The arc mechanism is shown on the table near the extreme right. The reels from and to which the wire passes, the driving motor, and the two cup-shaped containers on the top of the apparatus just over the arc are visible. These cups surmount the gap bearings. At the right end of the table are the controlling rheostats and lampboard resistances which regulated the supply of high voltage direct current. On the table can be seen the microphone transmitter, antenna and closed circuit ammeters, coupling and inductance coils, and in the foreground a wave meter.

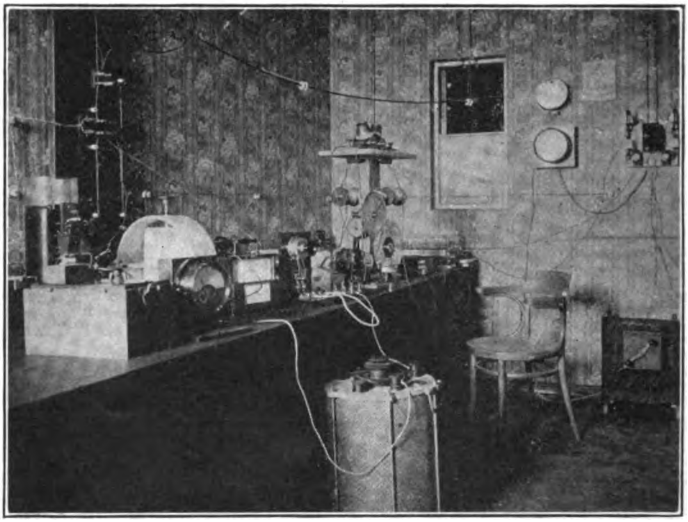


Figure 33—Ruhmer's radiophone transmitter

Another early system (1911) of radio telephony with what the inventor, Mr. William Dubilier, called a "quenched arc" (really a radio-frequent spark) transmitter, is indicated in outline in Figure 34. The arc is indicated at *A*, and is fed with moderately high tension direct current. Shunted around the arc is the oscillatory circuit, $C\ L_1$, which is opened automatically by a simple switch during reception. The oscillatory circuit, or primary, is coupled to the antenna

* Which photograph, together with a number of others shown herein, I owe to the courtesy of Mr. William Dubilier.

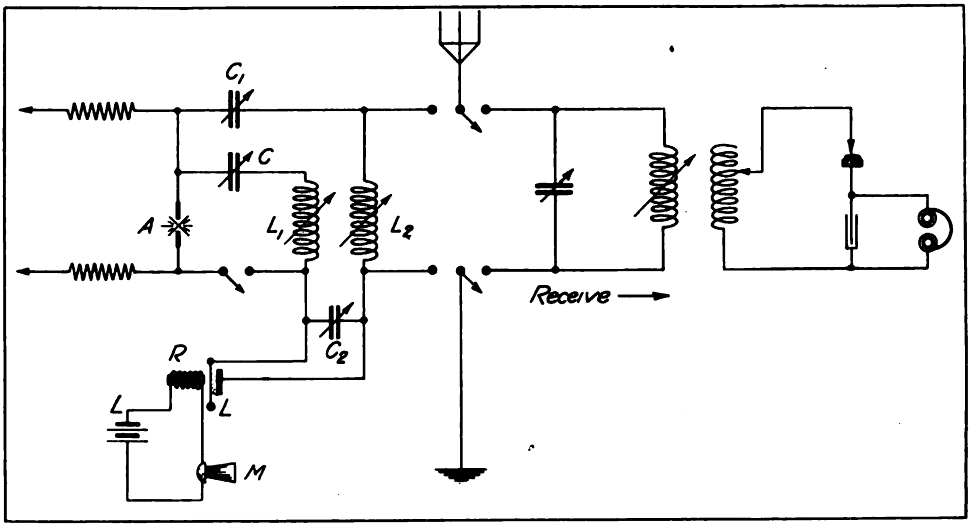


Figure 34—Dubilier radiophone transmitter and receiver

by means of the inductive coupling between L_1 and L_2, and also by means of a capacitive coupling through the condensers C_1 and C_2. Shunted across the condenser C_2 is the telephone relay R of special construction to be described hereafter. It is practically a heavy current microphone transmitter coupled to an ordinary receiver electromagnet, the electromagnet in question being energized from the master microphone M. Mr. Dubilier has pointed out that the terminals of an ordinary telephone line may be substituted for the local microphone connections at L, L, thus causing the incoming energy from the telephone line to control the heavy current telephone relay, R, and enabling direct

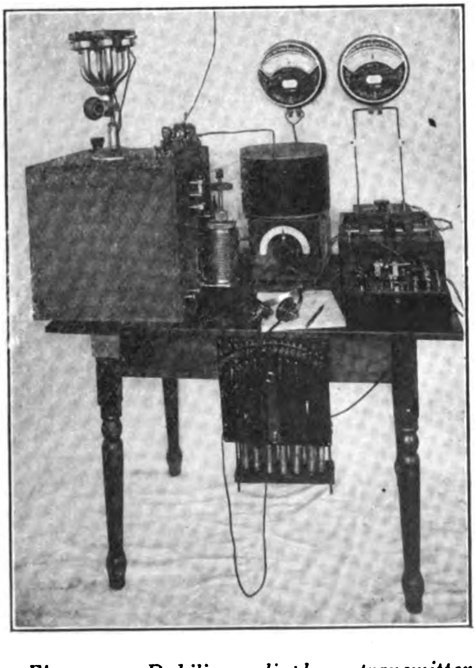


Figure 35—Dubilier radiophone transmitter and receiver

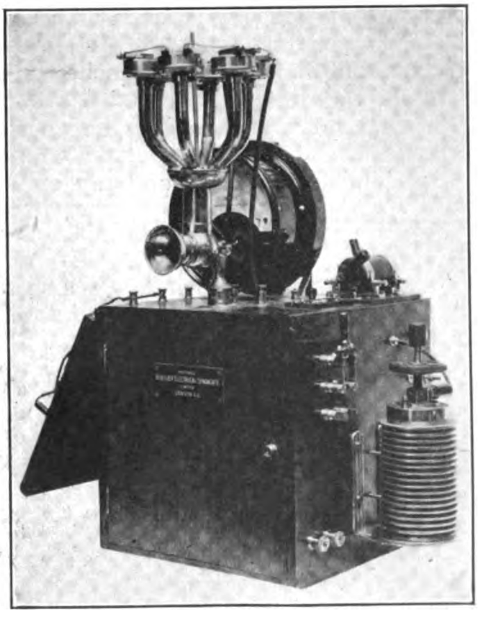


Figure 36—Complete Dubilier radiophone transmitter

communications from any usual land line telephone station to a ship at sea.

The receiving set is indicated at the right of Figure 34, and is an inductively-coupled, aperiodic secondary, crystal detector receiver of fairly conventional design.

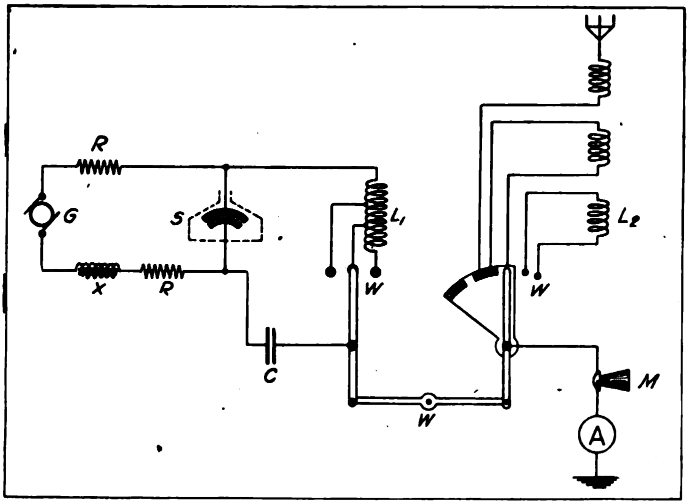


Figure 37—Lorenz radiophone transmitter

In Figure 35 is illustrated a complete radiophone station of this type. The box at the left of the table contains most of the transmitting equipment. On the right rear corner of the top of the box is the multiple contact commutator for changing from transmitting to receiving. This commutator perfoms all the necessary functions indicated by the switches in Figure 34. On the top of the box is a moderately heavy current, multiple microphone transmitter, consisting of a number of transmitters (7) in series. At the right of the box is mounted the special gap or discharger. It consists of one heavy, well cooled metal electrode and one small uncooled electrode. The antenna inductance and coupler is shown in the middle of the table and, at the right of the table, the receiving set.

A later and improved type of set is shown in Figure 36, which is the entire transmitter self-contained. The antenna commutating switch has been somewhat improved, and the antenna ammeter is mounted on the top of the apparatus box. The details of the gap, including the horizontal fins for air cooling, are clearly shown. This particular set has an input of about 3 k.w. and has enabled radio telephony 250 miles (400 km.) on one occasion. The containing box is only 14 inches on a side (35 cm.). The tilted side at the left of the box has mounted on it one of the spiral coils of the antenna coupling, so that merely changing the angle of inclination of the exterior tilted side varies the antenna-to-primary coupling.

The C. Lorenz Company of Berlin has developed through its engineer, Dr. H. Rein, a system known as the "multitone" system. Though primarily intended for low and medium power, variable tone, radio telegraph transmitters it has also been employed in radio telephony. The circuit diagram of the set is given in Figure 37. Here *G* is a moderately high voltage direct current generator, *R* and *X* are feed circuit resistances and choke coils *W* is a wave changing switch, which, after a preliminary and final adjustment of the taps on L_1 and L_2 enables choosing instantaneously any one of three wave-lengths. The microphone is placed in the antenna as indicated. Dr. Rein pointed out

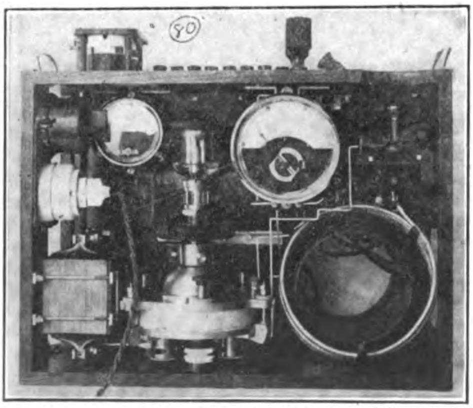


Figure 38—Lorenz aeroplane multitone transmitter

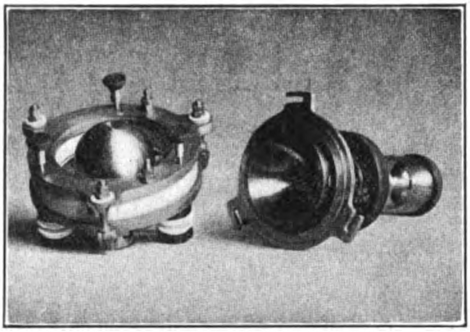
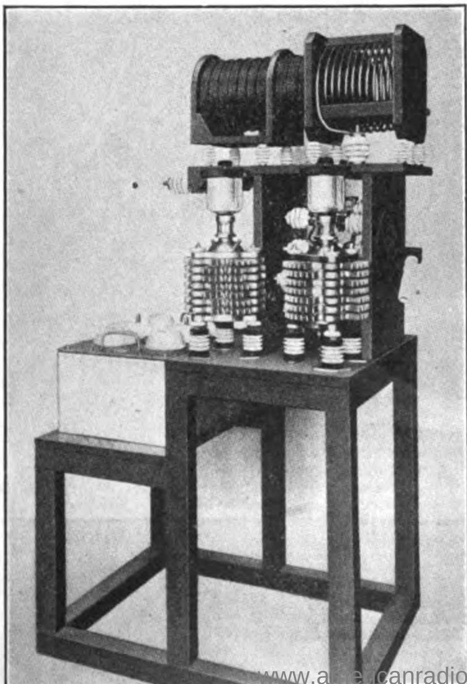


Figure 39—Interior of Scheller "multitone" gap

shown in Figure 38. The gap, which is the most interesting portion of the set, is seen in the left corner. It consists of two nearly concentric spherical segments, one fitting within the other. The construction is given by Figure 39, which is the dis-assembled gap. The discharge takes place in an atmosphere of alcohol vapor, the alcohol being supplied by the top sight-feed cup. The gap was devised by Scheller. A complete ship station of this type is given in Figure 40, and a semi-high-power station in Figure 41. This last has gaps for high tension, low frequency alternating current, the gaps being assembled in groups of six in series. In



(as had also, and independently, Dr. Seibt) that the resistance of the microphone for best modulation should be equal to the total resistance of the remainder of the antenna circuit. This would imply that one-half the available energy would be consumed in the transmitter microphones, a rule that obviously limits the available modulated output of sets of this type.

A small aeroplane set of this type (intended for telegraphy, however), is

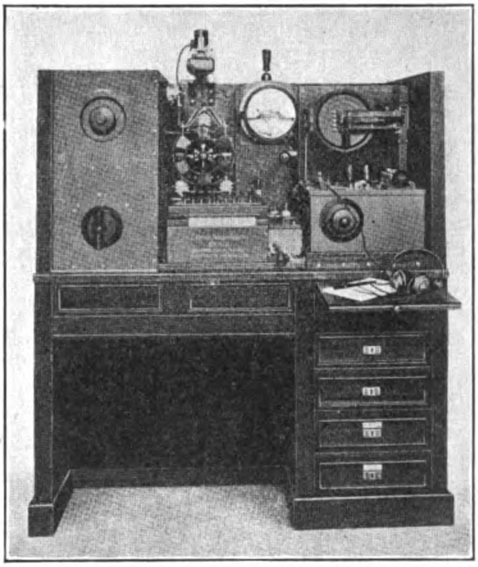


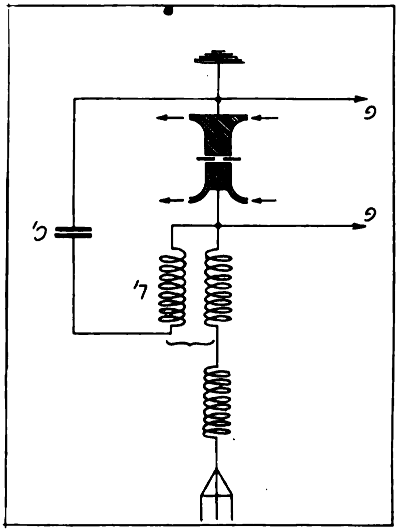
Figure 40—Lorenz "multitone" ship set

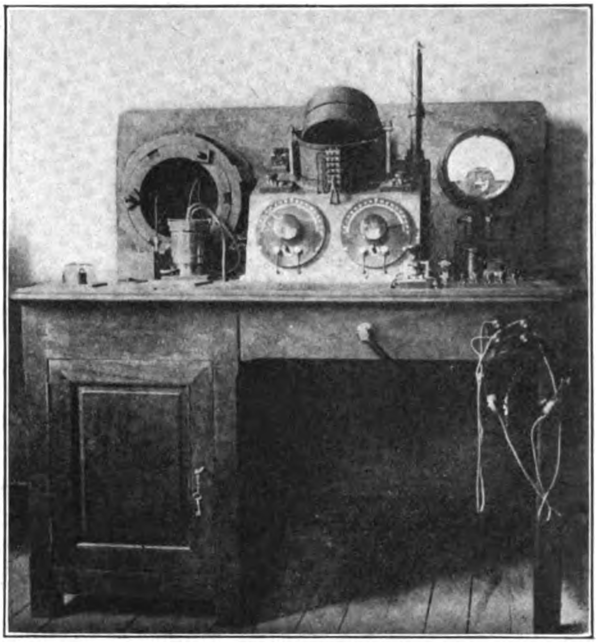
radio telephony, Rein states that in general carbon grain microphones having resistances between 4 and 10 ohms were used. If necessary, these were coupled to the antenna through a suitable transformer or otherwise in such fashion that the equivalent resistance they interposed in the antenna circuit was equal to the remaining antenna resistance.

Another system of radio telegraphy that has been adapted to radio telephony in quite a similar manner to the latest mentioned is that due to E. von Lepel. The circuit used is identical with that of Figure 37 in some cases, though in the recent 2 kw. sets the circuit used in Figure 42 is used. This is analogous in action to that shown in Figure 14 (but with L, R_1 and C_1 omitted), and operates in the manner there explained, at least to some extent. The spark gap shunt cir-

Figure 43—Lepel station at Harfleur

Figure 42—Lepel transmitter





The Lepel gap consists of a plane bronze negative electrode separated from a plane copper positive electrode by a thin sheet of "bond" paper, say 0.002 inch (0.05 mm.) thick. The center of the paper sheet is perforated, and when approximately 500 or 600 volts direct current is applied between the electrodes, the discharge bridges the gap. It then continues rambling outward and slowly burning up the paper sheet, in a spiral path starting at the center and ending at the edges. This action is probably due to the deflecting action of the electrostatic field between the plates on the discharge current.

The Lepel gap is usually shunted by an audio frequency oscillating or "tone" circuit, when used for telegraphy. When used for telephony, however, the gap is unshunted and a very rapid succession of discharges occur, each setting up its train of waves in the antenna, as indicated in Figure 30. In the receiver there is then heard a faint hissing sound. By inserting a microphone in the antenna, this hissing is drowned out by the speech, and telephony becomes possible. A Lepel radio telegraph set (at Harfleur, France), is shown in Figure 43. The spark gap, which is water-cooled, is seen just to the left of the large coupler. It can easily be dis-assembled for cleaning and replacement of the paper separator.

This is the fourth of a series of articles on "Radio Telephony," by Dr. Goldsmith, an eminent authority on the subject. In Article V, in the May issue, he continues the discussion of radio telephony by means of radio-frequent spark transmitters, considering a system developed by Dr. E. Leon Chaffee in conjunction with Professor George W. Pierce. A system developed by Lieutenant W. T. Ditcham is also described, as well as one devised by Messrs. Wichi Torikata, E. Yokoyama and M. Kitamura. The article, describes, in addition, with details of experiments, a recent radiophone method of the radio-frequent spark type, using the Moretti arc.

Theoretical Determination of Signalling Range

By Charles S. Ballantine

A QUANTITATIVE estimation of the range that a transmitter will cover under certain conditions is sometimes very valuable to the radio experimenter or engineer. This calculation, while sought for very extensively, is not, unfortunately, one of the easiest to make. In view of this fact, and also that the average radio man does not care to make long computations, the writer has come to the conclusion that an outline of a method to be used would be welcomed in radio circles. The following method possesses simplicity and accuracy or at least all the approximation that may be expected from our incomplete knowledge of the subject. The subject of transmission of electro-magnetic waves over the earth's surface is very broad and even at the present time scientific men are not agreed upon the various theories that have been proposed to explain the observed phenomena. The contents of this paper, therefore, will be limited to a general review of the features encountered in determining the signalling range of a given transmitter. A specific method of solving for this factor will be presented which should be valuable to the amateur field.

The mathematical theory of the radiation from a Hertz oscillator has been completely given in a number of standard works on the subject. It is unfortunate for the average engineer that most of this material has been presented in such a way as to be unintelligible to him. In most of these theories the use of the higher mathematics and quaternions is found which in some cases will not conclude in a form adaptable to rapid calculation. The theory of radiation from a Hertzian oscillator has received the treatment of Dr. Louis Cohen and in the Journal of the Franklin Institute, April, 1914, a very clear and concise analysis of the problem in elementary mathematics is given. Those interested in the mathematical aspect of the subject are referred to Cohen's paper. The problem has received the attention of other eminent mathematicians among whom might be mentioned Sommerfeld, Poincare, Nicholson, March and von Rybczynski. The treatment of Sommerfeld is perhaps the most interesting from a practical point of view.

The equation deduced by Sommerfeld expressing the relations between the received current, sending current, antennæ heights, distance and wave-length is given below:

$$I_r = 377 \frac{h_1 h_2 I_s}{\lambda d R} \cdot \epsilon^{-\frac{.0019d}{\sqrt[3]{\lambda}}} \qquad (1)$$

In this equation the received current is represented by I_r, the sending current by I_s, the wave-length by λ, height of the receiving antenna and sending antenna by h_1 and h_2, respectively, and the effective resistance of the receiver by R. The heights in the foregoing equation represent the heights to the center of capacity. This is defined as the total height times the form factor, which is the ratio of the average value of the current at all heights to the maximum measured at a potential node. (See Standardization Report of the Institute of Radio Engineers, page 14.) It is customary in theoretical treatment of the problem to employ this unit of h because it gives a very definite idea of the length of the equivalent oscillator in the Hertzian system. Since the length of the equivalent oscillator is then 2h and the energy of the electric field at a distance from the radiator is proportional to this length, the occurrence of this term in the theoretically derived equation is explained.

It will be observed that there are two distinct parts to this equation. The first part

$$377\,\frac{I_s h_1 h_2}{\lambda d R} \qquad \text{(a)}$$

is simply the theoretical expression for the energy in the field at distance, d. The exponential term

$$\epsilon^{-\frac{.0019d}{\sqrt[3]{\lambda}}} \qquad \text{(b)}$$

may be called the dispersion factor since it expresses the loss of energy in the emitted wave due to the tangential flow of the waves into the upper atmosphere. At night some of this energy is returned to the earth by reflection and refraction from the upper ionic layer and gives rise to some of the vagaries of transmission which have been so widely observed. For this reason it is only possible to regard a definite equation as expressing the facts during a stable period. Daylight working furnishes this state of affairs and the expressions that will be given hereafter must be understood as expressing *the average daylight working range.*

In addition to the factors contained in equation (2), in cases where the wave trains are damped and discontinuous, the denominator will be modified as shown below

$$I_r = \frac{377\, I_s h_1 h_2}{\lambda d r \sqrt{1+\frac{\delta_1}{\delta_2}}}\;\epsilon^{\frac{-.0019d}{\sqrt[3]{\lambda}}} \qquad (2)$$

Here δ_2 and δ_1 are the decrements at the receiver and transmitter, respectively.*

In 1911 the problem of long distance transmission was taken up experimentally by Dr. L. W. Austin† and the data collected enabled the selection of an empirical formula to express the results of these experiments. The equation obtained by Austin, widely known as the Austin formula, is an extremely useful one. The original formula was given as

$$I_r = 4.25\,\frac{I_s h_1 h_2}{\lambda d}\;\epsilon^{-\frac{.0015d}{\sqrt{\lambda}}} \qquad (3)$$

where the lengths are expressed in kilometers and the currents in amperes. It will be noticed that the factor expressing the absorption is somewhat different from that given by Sommerfeld. In reality the exponential term of this expression is more useful since it expresses the loss of energy under actual operating conditions, while the theoretical term was determined on the assumption that the ground was perfectly conducting. The discovery that the absorption varied inversely as the square foot of the wave-length was made by Dr. Louis Cohen, while assisting in the work started by Austin. The above equation fully expressed the results obtained during the original tests made in 1910, but later when the work was again taken up in connection with the acceptance tests of the Arlington station, it was found that a much closer agreement could be obtained by combining the first part of the theoretical formula with the empirical exponential term found under actual conditions.

The resulting expression, referred to as the "semi-empirical expression" by Austin, is given below

$$I_r = 377\,\frac{I_s h_1 h_2}{\lambda d R \sqrt{1+\frac{\delta_1}{\delta_2}}}\;\epsilon^{-\frac{.0015d}{\sqrt{\delta}}} \qquad (4)$$

This equation is by far the most accurate one that has been given, and fits quite closely the graphical data obtained under all conditions. Wave-lengths from 300 to 4100 meters have been tested, heights ranging from 40 to 600 feet and distances up to 2000 miles. In all cases the received energy obtained from the foregoing equation is in close agreement with that taken from the smoothed curve of observations.

As stated in the previous section the distance covered is that during the average day over water. While some data have been obtained for conditions during the day with land absorption, this

* L. W. Austin—Scientific Papers of the Bureau of Standards, No. 226, p. 78, 1914.
† L. W. Austin—Bulletin of the Bureau of Standards, Vol. 7, No. 3, p. 315, 1911, or Scientific Paper, No. 159. 1911.

is not yet complete enough to warrant its conversion into mathematical form. The experiments that have been made indicate a wide range of values in the absorption term over the various sections of the country. In view of these facts it is concluded that the best expression available at the present time is the semi-empirical equation of Austin. This will be used in the following section in the determination of the range of a given transmitter.

A glance at the equation (4) will reveal the fact that simple algebraic solution for the distance factor, d, is not possible since its variation is simultaneously linear and exponential. A very convenient method of solving a transcendental function of this sort is to rewrite the equation parametrically in terms of the arbitrary constant, p. The simultaneous couple obtained may then be solved graphically as usual. The intersection of the loci of the two functions will determine the value of d sought. We have then

$$\frac{212 I_s h_1 h_2}{I_r \lambda d} - \epsilon^{\frac{.0877d}{\sqrt{\lambda}}} = 0 \quad (5)$$

Now writing $\frac{212 h_1 h_2 I_s}{I_r \lambda d}$ as a function of a third, variable, p, then $\epsilon^{\frac{.0877d}{\sqrt{\lambda}}}$ will also be a function of p and we may write

$$\begin{cases} d\,\dfrac{I_r \lambda}{212 I_s h_1 h_2} = p \\ \dfrac{1}{\epsilon^{\frac{.0877d}{\sqrt{\lambda}}}} = p \end{cases} \quad (6)$$

where p is the parameter. The solution of the above equation is very readily accomplished graphically. We may first plot the values of each equation against the common abscissa, p, representing the parametric axis. The intersection of the two curves will evaluate d. Calculate the values of

$$\frac{1}{\epsilon^{\frac{.0877d}{\sqrt{\lambda}}}}$$

and tabulate them as shown in Table I.

TABLE I

d	200	300	400	500	600
40	.780	.729	.840	.855	.865
60	.690	.736	.769	.790	.808
100	.525	.601	.645	.675	.700
140	.419	.491	.540	.577	.605
180	.325	.402	.454	.493	.525

The wave-lengths are 200, 300, 400, 500 and 600 meters, these being assumed to be the most useful to the readers of this publication. The figures from the foregoing table are used to plot the curves shown in Figure 1. Now plotting the values of the ratio

$$\frac{I_r \lambda d}{I_s h_1 h_2 212}$$

on the same abscissa, the straight lines shown will be obtained. The values of d corresponding to the intersection of these systems are found as ordinates.

In using these curves to rapidly estimate the range of a transmitter the following procedure may be followed:

(a) calculate the value of the ratio

$$\frac{\lambda}{I_s h_1 h_2}$$

(b) locate this value on one of the straight lines in the figure.

(c) follow along this line until it intersects the curve for the wave-length used.

(d) from this intersection follow horizontally to the left hand side of the figure and locate the value of d sought.

Perhaps the foregoing explanation may be made clearer by means of a practical example. Assume the following values for the factors:

TRANSMITTER

Radiation current .... 4 amperes.
Antenna height .... 60 feet.
Wave-length ....300 meters

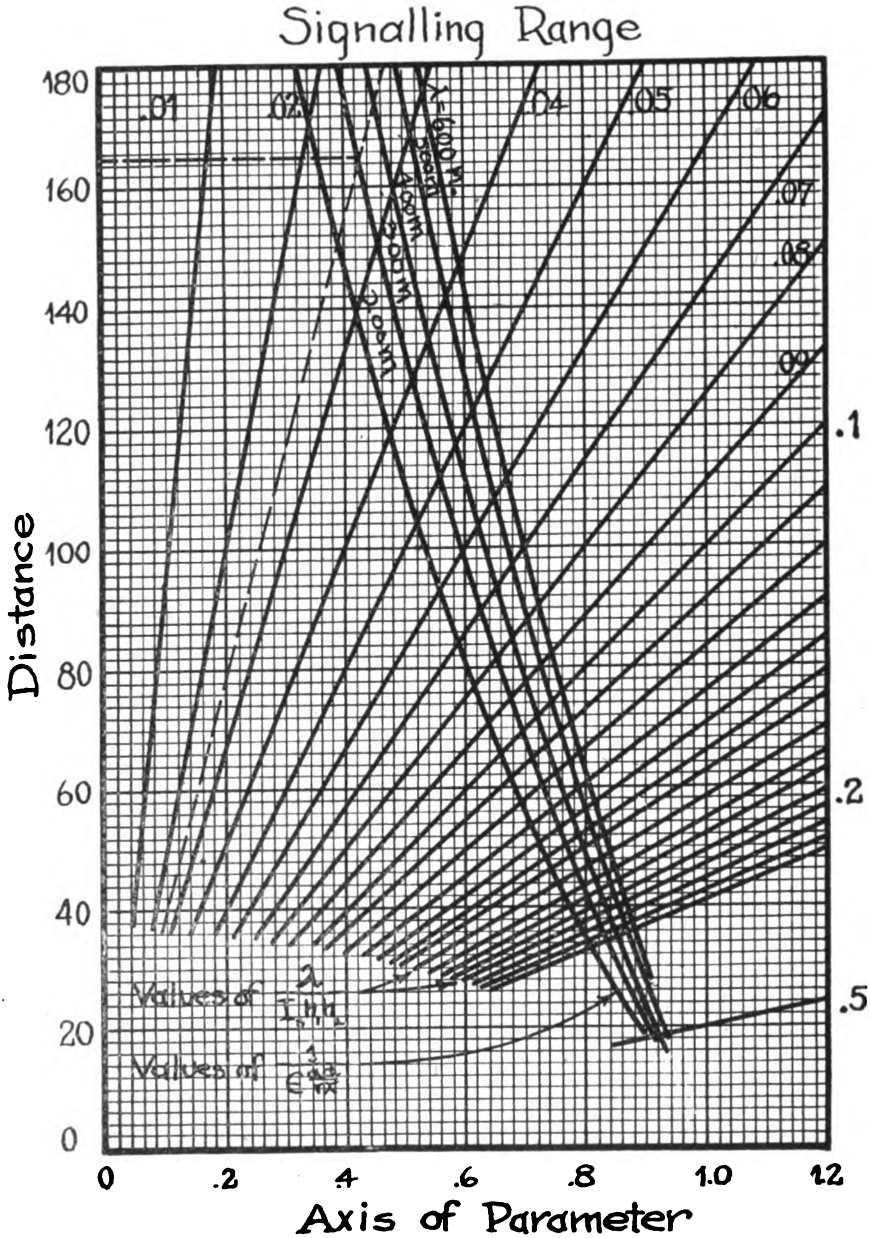
RECEIVER

Antenna height ..... 50 feet.
Received current ... 21.2 micro-amps.

Calculating the value of the ratio we have

$$\frac{\lambda}{I_s h_1 h_2} = \frac{300}{4 \times 60 \times 50} = .025$$

The position of this curve may be judged and is indicated by the dotted line in the



accompanying drawing. Now following along this line until it intersects the wave-length curve for 300 m. and turning to the left we find the value of d as 165 miles.

It might be mentioned that the curves given in the figure represent the current necessary at the receiving station for reliable communication through an effective receiving resistance of 25 ohms. This includes the actual resistance of the antenna system, the ground resistance and the resistance represented by the component of the decrement caused by the absorption of energy through coupling with the detector circuit. It is evident that the arbitrary figure will not afford great accuracy in the determination of signalling range since at small wave-lengths it will be too low and at the longer ones, too great. However, when working near the fundamental of the antenna, even though the resistance of the tuning inductance is not great, the radiation and absorption resistance is very large, which partially compensates for this extremity. The figure is representative of average conditions.

The figures given by Austin for a "good" signal and a barely audible signal are 40 and 10 micro-amperes through 25 ohms. These figures were obtained with the electrolytic and crystal detectors. With the heterodyne receiver of the National Electric Signaling Company, 7 micro-amperes will give an audible signal. At this point it will be evident that the personal equation of the operator will have a great influence upon the results that may be obtained with a given receiver. The working distance then will vary approximately within these limits with the ability of the operator, the amount of interference, etc. In the present case it is supposed that the crystal detector has given its place to the newer regenerative circuits with the electron relay, as curves obtained on this assumption are thought to be of more practical value than if the original conditions of Austin were supposed. The writer has found that readable signals may be obtained through moderate interference with 12 micro-amperes in the antenna and a good electron relay used on one of the Armstrong circuits. The foregoing figure is rather critical and it is believed that some latitude in this connection would be more representative of all-around working possibilities. The foregoing graph is therefore drawn to 21.2 micro-amperes, this figure being used for convenience.

In the solution for the working range, no account has been taken of any transitory phenomena such as drifting ionic fog or freaks of any kind and the results obtained represent the average daylight range with the average absorption. After sufficient time has elapsed after nightfall for the dissipation of the ionic fog, the exponential term may be neglected and the solution becomes very much simplified. The range then becomes

$$d = \frac{212 I_s h_1 h_2}{I_r \lambda} \qquad (7)$$

It might also be mentioned that in the case of land stations the heights represented in the equations given may not be as great effectively as it would seem. This is generally true of stations erected on a ground that is not a good conducting medium. For example, in the Arlington experiments, after the signals had been measured at short distances, at Washington Navy Yard and the Bureau of Standards, and the calculations were made, it was found that the results were twice as large as the actual measurements. This indicated that the effective height of Arlington was only half its height to the center of capacity. This has also been observed at numerous other land stations, and this fact may help to explain the great differences in the transmission conditions on the East and West coasts. Independent measurements of specific ground resistance do not substantiate this conclusion, but even in cases where the ground conditions are ohmically very different it is found that the effective height is not changed. The writer has made extensive investigations of earth resistance and its effect on signalling range and has found that the condition of the soil has very little effect upon the energy in the electric field. Observations made during wet weather only indicate a loss due to the standard carona loss increment as pointed out by Peek.* This, of course, results in an increase in the decrement of the emitted waves which will have the effect indicated by the occurrence of the decrement term in the denominator of equation (4) but the change occasioned in this way is not of sufficient magnitude to explain the great difference observed. As far as the writer knows no adequate explanation of this phenomena has been offered.

It is rather unfortunate that there are no theoretical or empirical methods for taking into consideration these various changes in the value of the factors and thus add to the degree of approximation of our formulæ, but the above method of determining the signalling range of two stations is very useful. The equa-

* F. W. Peek, Jr.—Journal of the Franklin Institute. December, 1913, page 680.

tions given also afford an estimate of the influence of the various factors on the results to be expected.

In this connection a few remarks on the subject of wave-length may be of interest. It has been concluded in certain exceptional cases where large distances have been covered on certain wave-lengths that there is an optimum wave-length for a given combination of factors. If this conclusion is an accurate one it would certainly be an advantage to be able to determine mathematically this optimum wave-length. An inspection of the equation will reveal the fact that at night when the exponential factor is dropped the functions being simply hyperbolic and linear will have no maxima or minima except at zero and infinity. Therefore we must look to the exponential for a condition whereby a singular point might be determined. Let us consider the problem analytically. Solve the equation for the term to be made maximum. This is obviously the ratio $\frac{I_r}{I_s}$

Solving then

$$\frac{I_r}{I_s} = \frac{212 h_1 h_2}{\lambda d} \cdot \epsilon^{-\frac{.0877d}{\sqrt{\lambda}}} \qquad (8)$$

Now it is required to determine the critical wave-length to produce either a maxima or minima in the value of this ratio. This is very readily accomplished by differentiating (8) with respect to λ and after equating the coefficient to zero, solving the resulting expression for real roots. Replacing the numeric coefficient in the exponential by ∞ and denoting the ratio I_r/I_s by I, we have the result shown by the equations on the following page.

In other words the critical value of the variable corresponding to either a maximum or minimum in the Austin equation solved for I_r/I_s will occur at a wave-length equal to the square of the distance divided by the numeric 4 multiplied by the square of the absorption. In order to determine whether this critical value of λ corresponds to a maxima or minima, we may substitute the value

$$\frac{\propto^2 d^2}{4}$$

in the second derivative. This causes a reversal of sign and determines the point as a maxima.

A very interesting conclusion may be drawn from this result, e. g., that the value of this optimum wave-length will vary greatly with the absorption. From daylight, when the absorption is maximum, until solar midnight when we may neglect this term, the absorption will vary and in order to keep abreast of this change and secure a maximum working range, it will be necessary to vary the wave-length in accordance with these changes. At sunset the optimum wave-length may be higher than the wave-length to which the transmitter is adjusted, but as the absorption approaches zero the exponential term will approach unity and the maxima will shift to zero, so that at some time during this period it may be possible to secure an extended range at the point where the absorption is reduced to correspondence with the wave-length to which the transmitter is adjusted. Large variations in the absorption from moment to moment are also noticeable, especially at this time of the day and this may account to some extent for the great variations in range that have been observed from time to time. As pointed out in a preceding paragraph, this may be caused by the reflection and refraction from the upper ionic strata and from physical reasoning would be expected to be rigidly connected with the length of the waves used in transmission.

At this point in the discussion of the subject we emerge into speculation, which the present writer will avoid until further experimental verification of this hypothesis is available. The writer has been engaged for some time in research work in connection with the subject of transmission and hopes to outline the results of this work in another paper. It is hoped that the few and necesasrily incomplete remarks made here, may be of some value to those interested in the subject. The derivation of the equation

$$\frac{d}{d\lambda}\left(\frac{212h_1h_2}{d\lambda\epsilon^{\varphi d\lambda - \frac{1}{2}}}\right) = \frac{-212h_1h_2\frac{d}{d\lambda}\left(\lambda d.\epsilon^{\varphi d\lambda - \frac{1}{2}}\right)}{\lambda^2 d^2 \epsilon^{2\varphi d\lambda - \frac{1}{2}}} \qquad (9)$$

But

$$\frac{d}{d\lambda}\left(\lambda d.\epsilon^{\varphi d\lambda - \frac{1}{2}}\right) = \lambda d.\frac{d}{d\lambda}\left(\epsilon^{\varphi d\lambda - \frac{1}{2}}\right) + \epsilon^{\varphi d\lambda - \frac{1}{2}}\frac{d}{d\lambda}(\lambda d) \qquad (10)$$

and

$$\frac{d}{d\lambda}\left(\lambda d\right) = d \qquad (11)$$

also

$$\frac{d}{d\lambda}\left(\epsilon^{\varphi d\lambda - \frac{1}{2}}\right) = -\frac{\infty d\epsilon^{\varphi d\lambda - \frac{1}{2}}}{2\lambda 3/2} \qquad (12)$$

so that

$$\frac{d}{d\lambda}\left(\lambda d.\epsilon^{\varphi d\lambda - \frac{1}{2}}\right) = \propto \lambda d^2\epsilon^{\varphi d\lambda - \frac{1}{2}} - 2\lambda 3/2 d\epsilon^{\varphi d\lambda - \frac{1}{2}} \qquad (13)$$

Hence

$$\frac{d}{d\lambda}\left(\frac{212h_1h_2}{d\lambda\epsilon \propto \varphi d\lambda - \frac{1}{2}}\right) = \frac{h_1h_2 424\lambda 3d\epsilon^{\varphi d\lambda - \frac{1}{2}} - 212h_1h_2 \propto d\lambda\epsilon^{\varphi d\lambda - \frac{1}{2}}}{\lambda^2 d^2 \epsilon^{2\varphi d\lambda - \frac{1}{2}}} \qquad (14)$$

Simplifying

$$\frac{dI}{d\lambda} = \frac{424h_1h_2\lambda^{\frac{1}{2}}}{\lambda d} - \frac{212h_1h_2 \propto d}{\lambda d} \qquad (15)$$

Equating to zero

$$\frac{424h_1h_2\lambda^{\frac{1}{2}}}{\lambda d} = \frac{212h_1h_2 \infty d}{\lambda d} \qquad (16)$$

Solving for λ

$$\lambda^{\frac{1}{2}} = \frac{\propto d}{2} \qquad (17)$$

Finally

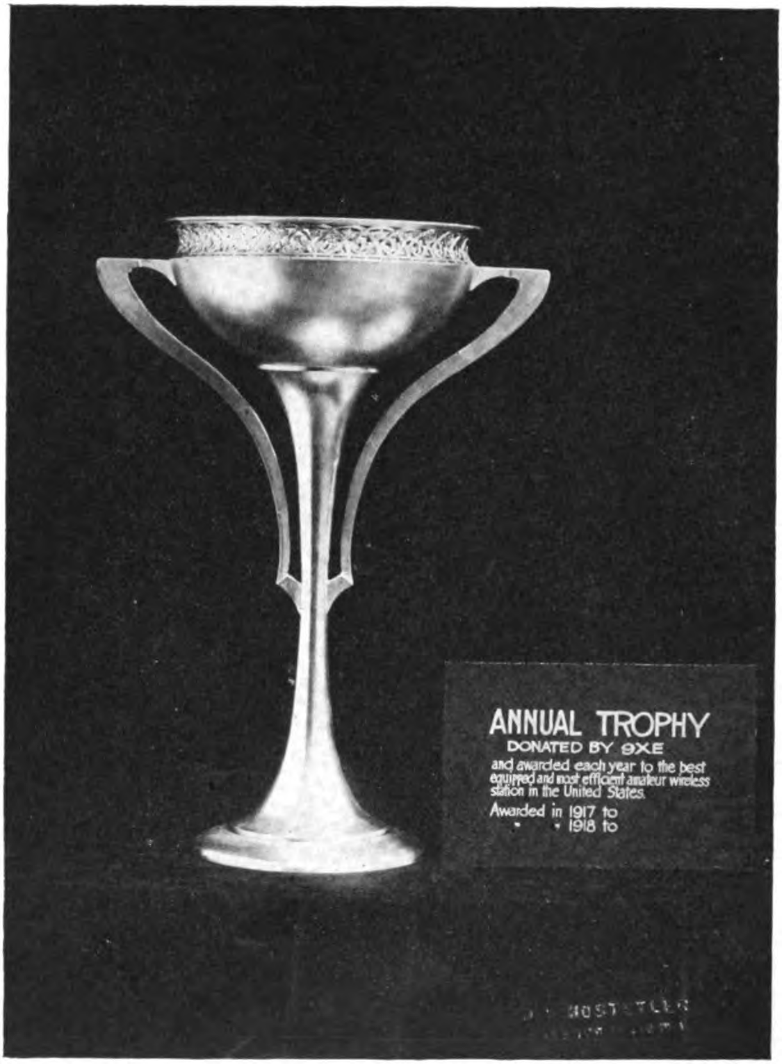
$$\lambda = \frac{\propto^2 d^2}{4} \qquad (18)$$

for the optimum wave-length has been given in detail as modern tendencies in mathematical work is to show each step in the evolution of the final result so that the conclusion may not necessarily have to be accepted on faith without knowing the limitations and assumptions involved in the work.

LITTLE REFUGEES AIDED

When the liner Nieuw Amsterdam was nearing New York recently with nearly 1,000 refugees from Russia, Poland and Belgium, it was discovered many of the children had no proper clothing. A wireless call was sent to the Red Cross headquarters in New York and officers of the society took complete outfits for 250 children down the harbor to meet the vessel.

Prize Donated by N.A.W.A. Relay Chief



The handsome silver trophy illustrated above is to be presented at the close of the working season to the best equipped and most efficient amateur station in the United States. It is the gift of 9XE, National Chief of Relay Communications, N. A. W. A., and stands 21 inches high. The selection for its presentation will be made by a committee appointed by various clubs throughout the country, perfection of equipment and lack of QRM being among the important points taken into consideration in the award. The winner will hold it one year, when the committee will consider the merits of all contenders. If the cup is awarded to an amateur station two years in succession, possession will be permanent.

Plan To Facilitate Amateur Relays

By W. E. Packman

WITH the object of learning the cause of the interference which seems so detrimental to amateur radio stations and the failure of the operators to conduct satisfactorily their relay chains, I recently investigated this much discussed question. The operation of various stations was carefully observed and information as to the results that were being obtained in different quarters was acquired. In addition a number of the best amateur radio receiving sets, complete receivers with vacuum valve detectors attached and several of the best types of loose couplers which seem to be more widely used by amateurs than others, were submitted to tests. The results of the investigation are contained in this article, together with a summation of some of the more important factors concerned with the subject of interference in radio telegraphy.

These are the three main causes of interference among radio stations:

1—Promiscuous sending.

2—Lack of knowledge of the principles of tuning.

3—Improperly designed instruments.

Any one of these factors alone is sufficient reason to cause undue interference when a large number of stations are operating within range of each other, but when all three of these conditions exist nothing but interference can be expected, and this, in certain localities, seems to materially retard amateur wireless operation at the present time. In discussing the causes of interference, the term interference is taken to mean interference from radio transmitters and not static or other interfering, uncontrolable, vagrant waves. It is further presumed that the operators are all capable of receiving telegraphic signals, which is, of course, not the case and may lead to interference. It is also presumed that all radio transmitting stations emit wave trains having a decrement of 0.2 as required by the regulations of the Department of Commerce.

"Promiscuous sending," although disposed of in the present article in a few words, is probably the principal cause of interference. It might better be known as interference due to lack of judgment on the part of amateur operators. It has been observed many times by station operators that when you are working with a distant station the signals of which are not loud at best, that the operator of some powerful station nearby will break in, calling a station in some remote part of the country which he has heard or believes he has heard. This is nothing more or less than lack of judgment on the part of the interfering station. It is assumed that he does not know you were receiving, otherwise he would be violating the law in sending, and if he did not know you were receiving he should have listened in long enough before transmitting to assure himself that he would not interfere with another station that was engaged in receipt of some message addressed to him.

It is not essential for an operator in a wireless station to call every distant amateur whom he may hear and in most cases it is more to his discredit to work with a station a thousand miles away than it is to his credit. It has long been known by persons versed in the art of radio telegraphy, in fact, ever since Marconi's voyage on the Philadelphia in February, 1902, that the distance a radio station can be heard is usually greater at night than during the day and that occasionally a station using very low power can be heard at extremely long distances. Such feats are now known in commercial circles as "freaks" and no longer excite wonder, interesting though they are. The distance at which a station may be heard under such conditions is no criterion as to the efficiency of the station.

The success of an amateur relay chain will be more certain if every amateur station is included in the chain or is under its control, and certain stations are designated to work with certain other stations and *not* to work with any other station. Can you imagine the existence of a successful commercial system if, for example, every operator on Atlantic coastwise vessels attempted to work WGO or any other ship or land station in the Great Lakes District, which he might pick up under freak conditions? For the information of some, whose experience does not date back to the beginning of commercial wireless in this country, it might be added that this was attempted at one time, when all commercial operators were amateurs in a new art, and it was learned that it would not succeed.

Rapid Receiving Apparatus

In the foregoing paragraphs interference caused by poor judgment on the part of sending operators has been discussed, and in what follows it is the purpose to cover the two other causes of interference by discussing some of the important points in the design of radio receiving apparatus and emphasizing certain features of the operation of such apparatus which make for interference or its prevention.

The term radio receiving apparatus, is meant to cover all apparatus required in the reception of radio signals, namely: the antenna, earth, primary and secondary tuning inductances, condensers, detectors, telephones, etc. In commercial receivers there are two objects to be attained, the first of which is to absorb the greatest amount of energy from the wave trains of the station which it is desired to receive and to transfer this energy to the telephone receivers with the least possible loss; the second is to prevent the apparatus from picking up and transferring undesired signals to the telephones. It appears that in the design of amateur receivers this latter feature of the receiving equipment has been eliminated, probably because of the fact that most amateurs are more interested in hearing as many stations as possible than in copying from any one. If, however, amateur relays are to become successful it will be necessary for amateur stations to have receivers which are capable of selective adjustment.

Commercial Field Practice

In commercial systems it is customary to have two possible circuit arrangements in the receiver, one of which is suitable for receiving signals varying over a long range of wave-lengths, and the other capable of being adjusted so that it will respond but very slightly or not at all to wave-lengths which differ from that to which the circuit is tuned. In the Marconi service the first of these circuits is called the "Stand Bi" circuit and any wave-length within the commercial range can be received. The second circuit is known as the "tuned" circuit and this is capable of very close adjustment to the exclusion of other frequencies than that desired.

In practice it is impossible to construct a receiver which is one hundred per cent. efficient, that is, one which will transfer a given number of microwatts of received oscillating energy in the aerial circuit to the telephones without loss; in any conversion system there will be some loss. As a matter of fact, in any radio receiver involving a rectifying detector, whether of the crystal type or a vacuum valve, the efficiency cannot exceed fifty per cent. It should be the object of the designer, however, to reach the limit of efficiency as nearly as possible.

It is likewise equally difficult to construct a receiver which is absolutely immune from interference, but if advantage is taken of the fundamental principles in designing the receiver and if the operator is well versed in these same principles, interference may be greatly reduced without resorting to other than simple standard circuits.

In all modern receiving systems there are at least two distinct circuits used. One is the open aerial circuit and serves to absorb the oscillating energy from the passing wave trains. The other is a closed circuit which receives energy from the open circuit and delivers it to the detector and telephone receivers. These two circuits are coupled together either electromagnetically, as with an oscillation transformer, or electrostatically as in the case of the Cohen tuner where the energy is transferred from the aerial circuit to the closed circuit through small condensers. The aerial circuit is adjusted by means of variable inductances or variable condensers, so that its period of electrical vibration is the same as the period of the oscillations in the wave train which it is desired to receive. The circuit is then said to be in tune or in resonance with the oscillations and the current that will flow in the circuit is limited only by the e.m.f. induced in the antenna by the passing wave train and the impedance of the circuit. If the tuner is wound with wire which has small resistance, the current and the resulting signal will be relatively strong, while if the resistance is large, the current and resulting signal will be weak. Again, in order that a maximum current be induced from the aerial circuit into the closed circuit, it is necessary that this circuit be tuned to or brought into resonance with the primary or open circuit and, furthermore, it too must be of low resistance. When this condition of resonance between the two circuits and between the circuits and the wave trains has been brought about and the coupling is not too close, the maximum response will be given in the telephone receivers.

Factors in Signal Strength

In summing up the factors or points of importance in the production of strong signals we have the following:

1. The two circuits must be capable of exact adjustment to the frequency of the desired wave train.
2. Both circuits must be of low ohmic resistance.
3. The coupling must not be too close.

A fourth cause for decreased signal strength lies in the so-called dead end effect wherein certain unused portions of the tuning coils may in themselves, or in conjunction with other parts of the circuit, have periods of free vibration which correspond to the frequency of the waves being received and will therefore absorb energy from the system.

Delivering Electrical Energy

It is not the purpose of this article to give a technical exposition of the relations existing in the circuits of a radio system, nor to discuss at length the phenomena associated therewith, but merely to point out and discuss in the briefest way those factors which are mainly responsible for the existence of interference in radio receivers. Interference may be due either to a lack of sharpness of tuning in the circuits or to the other factors which will be discussed.

If electrical energy is delivered in any one of several ways to an oscillatory circuit such as is found in radio telegraph apparatus, that is a circuit containing inductance, capacity and resistance, electrical oscilltions of high frequency and gradually decreasing amplitude will be set up. These oscillations will persist until the energy has been expended in the generation of heat, or until it is transferred to another circuit or radiated, or dissipated as a result of a combination of all three effects. If the resistance is high, or if the energy is otherwise absorbed rapidly, so that the energy is expended in a few oscillations, the damping of the system is said to be high, while if the resistance is low or the energy is drawn out slowly so that there will be a large number of oscillations, the damping of the system is said to be low.

The term, damping, here means the logarithmic decrement of the damping, which is the Naperian Logarithm of the ratio of the amplitudes or any two successive oscillations, in the same direction. The logarithmic decrement, then, or simply the "damping," is a measure of the rate of decay of the oscillations in any circuit. If the logarithmic decrement is 0.2 or less, the damping is said to be low, while if it exceeds this amount it is said to be high, this figure having been taken as the dividing point since it is found in practice that sharp tuning at a receiving station is impossible if the logarithmic decrement of the transmitter is greater than 0.2. A transmitter then which emits waves having a decrement of 0.2 or less is said to be "sharply tuned," and if the decrement of a receiver is 0.2 or less, it is said to be a sharply tuned receiver.

Sharpness of Tuning

As defined by the Institute of Radio Engineers, sharpness of tuning is the measure of the rate of diminution of current in transmitters and receivers with detuning of the circuit which is varied. This may be explained as follows: If a receiver is tuned to a transmitter whose emitted waves are, say, 600 meters in length, a certain amount of current will be received, while if the receiver is detuned slightly, that is, adjusted to a wave-length which is a little greater or a little less than that of the incoming waves, a somewhat weaker current will be received. In fact, if a micro-ammeter is connected to the receiver, and the receiving circuits are adjusted to a series of wave-lengths and at each adjustment the received current is measured, a complete resonance curve of the system can be plotted. The steepness with which this curve rises as the receiver adjustment approaches the wave-length of the transmitter is a measure of the "sharpness of the tuning." It will be found from experiment and can be shown otherwise, that if the logarithmic decrement of either transmitter or receiver is high, the resonance curve will rise slowly forming a broad curve, that is, a relative large change in the receiver wave-length adjustment will result in comparatively small change in the received current. On the other hand, if the logarithmic decrement of both transmitter and receiver are low, the resonance curve will rise steeply and we have what is known as a "sharp curve," and if a very small change is made in the wave-length adjustment of the receiver, the received current will decrease very abruptly.

The significance of low damping in both transmitters and receivers is very clearly shown by an observance of such resonance curves. It must be borne in mind that the curves show not the damping of either transmitter or receiver alone, but the sum of the dampings of both. No matter how sharply tuned the transmitter may be, the resonance curve will be broad if the receiver is highly damped and, conversely, no matter how selective is the receiver, the resonance curve will be broad if the incoming waves are highly damped. The practical effect of a highly damped transmitter, such as a plain aerial transmitter, is well known, but the effects of high damping in a receiver, though less fully recognized, are equally pronounced. If the damping in a receiver, due to resistance or other cause, is high, sharply tuned waves from transmitters of widely varying wave-length will be received almost equally well at any adjustment of the receiver. Assuming, therefore, as we did in the premise, that all transmitters in use at the present time are so arranged that they comply with the regulations as to logarithmic decrement, we will be able to accomplish selective receiving if the receivers used are of low decrement.

Damping In Receivers

The damping in receivers is due in part to the resistance of various portions of the circuit and in part to the coupling between the primary and secondary circuits. The resistance of both primary and secondary circuits should be kept as low as possible. The inductances should be wound with conductor having low resistance and the earth connection and aerial itself should be of low ohmic resistance. There will, of course, be damping in the aerial system due to reradiation of the received energy. From the well-known formula for the damping of a single circuit,

$$\delta = \pi_2 R \sqrt{\frac{C}{L}}$$

it is apparent that the inductance, L, to the capacity, C, should be as large as possible. A circuit, whether it be the antenna circuit or the secondary closed circuit, which has a large amount of inductance and small value of capacity for any given wave-length adjustment, will not respond readily to waves which differ even slightly from that to which the circuit is tuned. Such a circuit is referred to as a "stiff circuit" and should be used in all cases where interference is impending.

The Loosened Coupling

The damping in receivers due to coupling is less well understood, but is one of the most predominant causes of interference. The wave train in passing the aerial of a radio receiving station induces in the aerial system an oscillatory current which increases in amplitude until the wave train has completely passed the aerial, after which the current begins to decrease in amplitude. If the damping of this circuit alone were small the oscillations would persist for a considerable time, but, as a matter of fact, the energy is partly transferred to the secondary circuit through the coils of the loose coupler. If the coupling between these two circuits is close the energy in the aerial circuit is very rapidly drawn out of the aerial circuit, causing a high damping in this circuit. During this time the energy is building up in the secondary circuit which finally receives all the energy absorbed from the passing wave train except that which has already been lost in heat. Now, the aerial circuit being still closely coupled to the secondary, rapidly draws the energy out of that circuit into the aerial circuit, producing a high damping in the secondary circuit. This transference and re-transference of the energy from one circuit to the other continues for several cycles and the energy being rapidly damped out in both circuits, sharp tuning in either is impossible. If, however, the coupling is loosened as much as possible without appreciably weakening the signals, the energy will be transferred slowly from the aerial to the secondary and equally slowly will be returned to the aerial. Thus the oscillations will be only feebly damped in both circuits and sharp tuning will be possible in both.

Furthermore, when two circuits are coupled together, no matter how loosely, the system as a whole, if a receiver, responds to two wave-lengths, and if a transmitter, will radiate two wave-lengths. If the coupling is made sufficiently low, such as 3 per cent. to 5 per cent., the two waves will be so close together that they cannot easily be detected as two waves, but if the coupling is too close, that is of such value as 20 per cent. or greater, the two waves may be as much as several hundred meters apart. A transmitter coupled as closely as this, unless a quenched gap is used, will cause interference on either of these two wave-lengths and more or less interference on all wave-lengths between them or near them either above or below. In the case of a receiver the system will respond readily to any wave-length within these limits. Loosening the coupling of the transmitter to avoid double wave radiation is common practice, and in like manner if the receiver coupling is loosened, the two principal wave-lengths to which the system will respond will be brought closer together, so close in fact and without loss of signal strength, that the system will to all effects respond to but a single wave-length, that to which the system is tuned.

The Dead End Effects

Another cause of interference which exists to a considerable degree in nearly all amateur receivers lies in the so-called dead end effect. We hear much of late regarding dead end losses, but the losses are extremely small in effect as compared with what may be called dead end interference. It often happens that unusued portions of the primary and secondary inductances may in themselves or in conjunction with other portions of the circuit have a period of vibration which corresponds to some passing wave train. These coils will then be set in electrical vibration and the oscillations will be communicated to the detector and telephones and interference will result. In tables I and II are shown some figures taken on one type of amateur tuner. The test here disclosed the fact that there was no possible adjustment of the secondary with which one frequency only could be received.

Another cause of interference which was found to exist in many makes of amateur tuners tested by the writer was the fact that the shortest wave-length which they would respond to was in excess of 200 or even 300 or 400 meters. Any wave-lengths under these values which might be received would then be received as forced oscillations and the tuner would respond as easily to one wave-length as another.

Designing and Operating

In summing up the factors which should be observed in designing and operating a radio receiver, so as to be immune from interference, we may enumerate the following:

1. The resistance of both primary and secondary circuits should be as low as possible.
2. Both aerial and secondary circuits should be continuously variable so that an exact adjustment to the desired wave-length may be obtained.
3. A tuned secondary system should be used.
4. The coupling should be capable of very loose adjustment and should be worked as loose as possible with proper signal strength.
5. A maximum amount of inductance and minimum of capacity, for any wave-length should be used.

Some figures taken from a typical amateur tuner appear on the following page. Referring to Column 1 of Table I: Natural wave-length of secondary coil, measured by connecting detector unilaterally to end of winding and moving the switch lever across the secondary contact points. The switch lever was not connected with anything except the binding post. All readings of wave-lengths were well pronounced.

Column 2 of Table I: The detector and stopping condenser, in series, were connected across the secondary binding posts, forming a so-called untuned secondary circuit. Wave-lengths were measured with secondary switch on each point.

Column 3 of Table I: Direct current resistance in ohms measured between the secondary binding posts. The high frequency resistance would be considerably greater than the values given here.*

Secondary consisted of twelve sections or about forty turns, each wound on a cylindrical tube six inches long and about three and one-quarter inches in diameter. The winding space was five and one-half inches.

The primary was wound on a cylindrical tube slightly larger than the secondary so that the two tubes would telescope. In the primary there were 286 turns of No. 26 or 28 wire, arranged in the usual way with tens and units switches. There was also provided a small switch which, when open, cut off a portion of the primary coil.

Measuring Wave-Length

A loose coupling between the coils could not be obtained although the secondary was movable along the ordinary slide rods. The secondary could be moved out until it was just flush with the active end of the primary coil.

The secondary inductance was then shunted with a variable condenser and with this set at four different values of capacity, the wave-length was measured on different points of the secondary. It will be noticed from Table II that two wave-lengths at least could be received on any possible adjustment, one of which corresponded to the wave-lengths of the untuned secondary circuit as shown in Table I, and the other the resonant wave-length for the inductance in use in conjunction with the shunt capacity. It was found, furthermore, that the latter wave-length adjustment was very broad and after the contact switch had been moved past the fourth point no resonance point could be detected, the tuner responding to one wave-length as well

* Data on construction of the loose coupler known as "Navy Tuner."

as any other. The shunted variable condenser served only to reduce the loudness of the signals and was of no value in tuning.

Table I

Secondary Switch Point.	1 W. L.	2 W. L.	3 Ohms.
1	565	565	2.9
2	545	480	6.3
3	535	410	9.6
4	530	375	11.7
5	525	335	15.3
6	540	310	18.3
7	525	270	19.0
8	610	225	22.5
9	640	180	25.6
10	675	170	29.1
11	690	190	31.9
12	722	208	36.0

Table II

Secondary Switch Point	Shunt Capacity	Short Wave Length	Long Wave Length
1	0.00001 m.f.	310	575
	.00014	345	585
	.00025	405	600
	.00050	465	692
2	.00001	435	660
	.00014	455	760
	.00025	465	900
	.00050	470	1,183
3	.00001	415	805
	.00014	425	1,183
	.00025	425	1,265
	.00050	430	1,380
4	.00001	375	1,150
	.00014	380	1,270
	.00025	400	1,375
	.00050	405	1,850
8	.00001	225	No resonance point.
	.00014	205	
	.00025	220	
	.00050	220	

It is hoped that this article will be of value to amateurs and other operators in bringing out some of the important points in the design and manipulation of receiving apparatus that are related to the subject of interference.

* A long wave is always the loudest and the shortest wave the sharpest.

LONG DISTANCE WORK

I think the following will be of interest to readers of THE WIRELESS AGE. I find that long distance work is easy here in Wisconsin, especially in the evening. I have frequently copied 8AEZ and 8NH with the telephones ten feet away, by the use of a single vacuum valve detector, but the signals from these stations and all other stations at a distance fade considerably at times. Stations within my daylight range, such as 9IK, 9EV and 9EM of Chicago, come in equally well both day and night. I have often noticed that stations outside of the daylight range of my station come in much stronger after dark than stations located in the daylight range.

In regard to daylight transmission, I occasionally work 9IK, Chicago, a distance of about sixty miles, and another station located in Wauwatosa, Wis., a distance of about seventy miles, using a 3-inch spark coil set consuming twenty-four watts. I use an oil condenser having a capacity of .01 microfarad and usually employ a mechanical coupling of 6 inches between the primary and secondary circuits. My antenna is not designed for 200-meter work, as I have to use a series condenser to reduce my wave-length to 200 meters.

Station 9BF, of Racine, Wis., a distance of about thirty miles, reports that he can hear my signals about fifteen feet from the head telephones when using a single step vacuum valve amplifier.

My friend's station, 9MA, here in Wisconsin, has been heard at 8AEZ in Lima, O., a distance of approximately 250 miles, when using a 2-inch coil set consuming about fifteen watts.

In conclusion I might remark that this long distance working is certainly not freakish, unless you wish to consider everyday work freakish.

E. H. HARTNELL, *Wisconsin.*

Members of the John Paul Jones Post. United States Junior Naval Reserve, Sea Cliff, Long Island, are constructing a small portable set. They are ambitious to purchase a larger equipment, however, and in order to obtain the money to do so, several of the boys are engaged in selling newspapers.

From and For those who help themselves

Experimenters' Experiences.

The editor of this department will give preferential attention to contributions containing full constructional details, in addition to drawings.

FIRST PRIZE, TEN DOLLARS

Removing Induction Troubles and Making an Aerial Changeover Switch

A number of amateurs in my vicinity have installed vacuum valve receiving owner had the transmitter installed on the same table with the receiving apparatus and also had various lengths of antenna and ground leads strung about the operating room. I suggested that he remove the transmitter from the operating

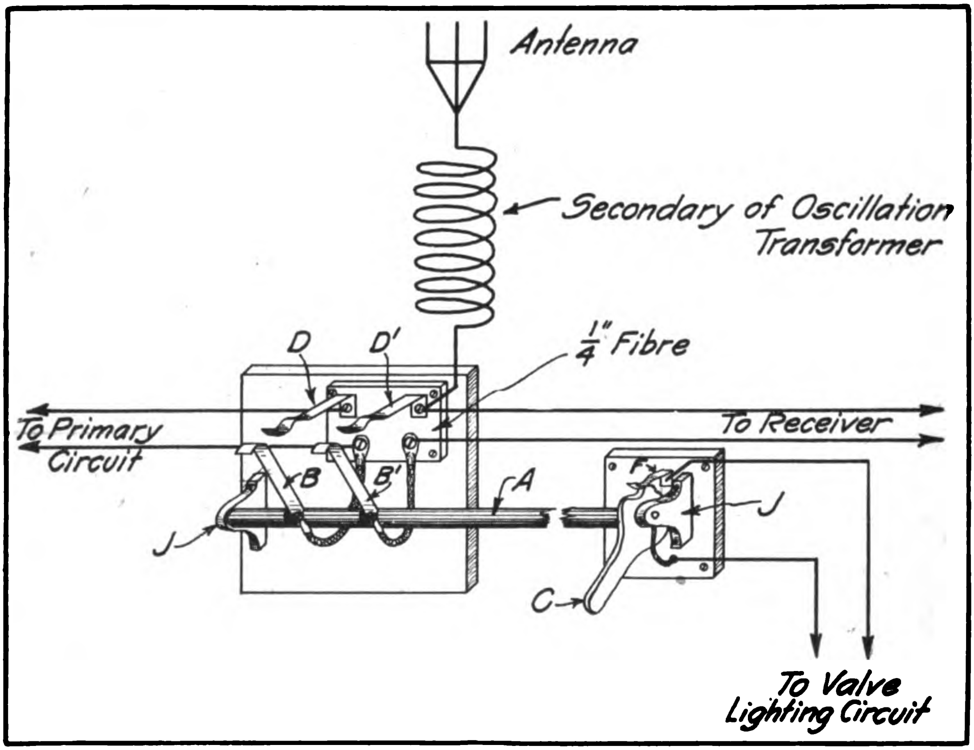


Figure 1, First Prize Article

outfits during the last year. Invariably they have found that the 110 lighting circuit strung about the operating room caused so much induction in the receiving phone that it was practically impossible to receive signals.

In each case which I investigated the table and mount it on a separate stand located as near as possible to the point where the antenna wire enters the room. I then suggested that he place his receiving apparatus at least six to eight feet from the transmitter, or to whatever distance conditions in the room would allow.

After these changes were made, the induction troubles were completely eliminated, being helped by the antenna switch as shown in the details of Figures 1 and 2. As a further precaution, the light was installed immediately over the operating table and the circuit leading to the telegraph key was wired up with No. 3 flexible conduit or "B. X." as it is popularly termed by supply houses. The outside iron casing was then connected to earth.

Referring to the construction of the lightning switch in Figure 1: The shaft, A, is a piece of hard wood of suitable length to reach from the transmitter to a position near the operator's left hand at the receiving table. The shaft may be round or square and should be supported by a pin driven into each end. The bearing brackets, J, are made of No. 3/8-inch sheet fibre.

At the end connected to the transmitting apparatus are two contactor arms, B and B-1, made of 1/16-inch sheet brass bent over at their free ends so as to present a smooth round surface for the springs, D and D-1, which are made of 1/32-inch sheet brass.

One pair of contactors, B and D, closes the primary and rotary spark gap circuits and the other pair, B-1 and D-1, completes the ground circuit of the transmitter and simultaneously short-circuits the primary winding of the receiving tuner as shown in Figure 1.

The handle, C, is shown in detail in Figure 2. It is cut from a piece of 3/8-inch sheet fibre and may be about 6 inches in length from the center of the shaft to the end of the handle.

The depressions, G and H, are so located that when the spring, F, rests on G, the switch is held in position for receiving. But when F rests in depression H, the switch is in a transmitting position.

A square hole is cut in the handle at I and the wooden shaft is shaped to fit it snugly. A piece of brass, which is connected by a flexible cable, K, is inserted in G. This is used as a switch to control the lighting circuit of the vacuum valve.

E. E. Sly, *Pennsylvania.*

SECOND PRIZE, FIVE DOLLARS
Regenerative Vacuum Valve Panel Set for Short Wave-Lengths

The regenerative vacuum valve panel set herewith described is designed for the reception of short wave-lengths only, the upper limit of adjustment being about 600 meters. A front view of the panel is shown in Figure 1, a side view showing the position of the variable condensers and variometer in Figure 2, and a complete circuit diagram of connections in Figure 3.

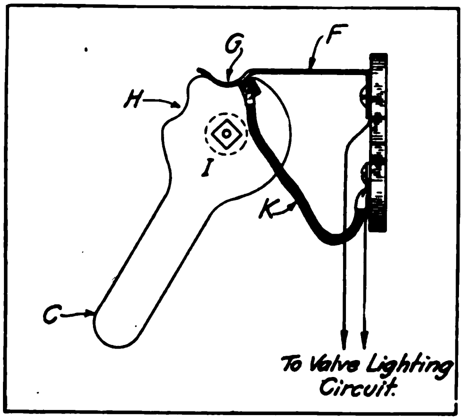


Figure 2, First Prize Article

The front of the cabinet should be made of some good insulating material, such as "Bakelite"; it may have the dimensions shown in Figures 1 and 2. It is recommended that the holes for the switch points be drilled first and the panel be polished with rotten stone and oil afterwards. The remainder of the case may be made of wood, properly stained and finished to suit the taste of the maker.

The variable condenser, C^1, shown in Figure 3 and also in Figure 2, should be of very small capacity, not more than .0005 microfarad. The variable condenser, C^3, should have maximum capacity of .001 microfarad. These condensers should be mounted on strips of wood at the back of the case and be connected with the knob and pointer on the front of the panel, as shown in the cross section of Figure 2.

The receiving transformer shown in the drawing should be made according to the dimensions given: The primary should be 3½ inches in diameter, 1¼ inches in length, wound with fifty turns of No. 26 S. S. C. wire, and the secondary winding 3 inches in diameter, 1¼ inches in length, wound with eighty turns

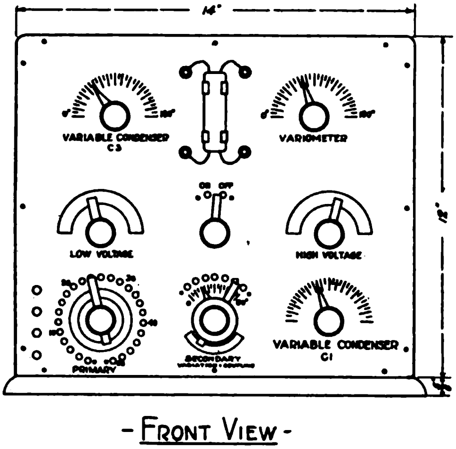


Figure 1, Second Prize Article

of No. 32 S. S. C. wire. It will be noted that the secondary is constructed to revolve within the primary on an axis which is controlled by a knob on the front of the panel.

The primary winding should be tapped every other turn and have leads extending therefrom to contact points on the primary switch. The turns of the secondary winding should be divided into six equal parts and leads connected therefrom to the taps of the secondary switch.

The completed secondary winding is mounted on an No. 8-32 threaded brass rod and locked into place by two nuts at each side as shown. The primary winding should be blocked up in a stationary position.

The variometer coupler should have tubes of the same dimensions as the loose coupler, but they should be wound with No. 32 S. S. C. wire. Care should be taken that the coils are wound in opposite directions or that the current circulates through them in opposite directions. The mounting of the variometer in the box and the connection to the knob and pointer may be similar to that employed at the loose coupler.

The grid condenser, C^2, should be made of two sheets of tinfoil, 2 inches in width by 4 inches in length, separated by a sheet of thin paraffine paper. The entire unit may be tightly rolled upon a short length of pencil. The grid condenser may be fastened in any convenient place within the case.

The low voltage rheostat may be either the carbon rod type or the ordinary battery resistance wire type. If it is the latter, it should be mounted on the inside of the case operated by a knob and pointer on the face of the panel. The variation of the secondary battery may be obtained by means of a high resistance carbon rheostat or by single cell variations through a multi-point switch. In the event that the latter method is used, the switch points therefore should be mounted on the panel, alternate points not being connected to prevent short-circuiting of adjacent cells, which would be the case if the switch blade rested on two adjoining contact points.

Proper binding posts for connection of the high and low voltage batteries, the aerial and earth connections, may be placed on the back or one end of the case, thus leaving the front free of all exposed wires except the phone cords. The four

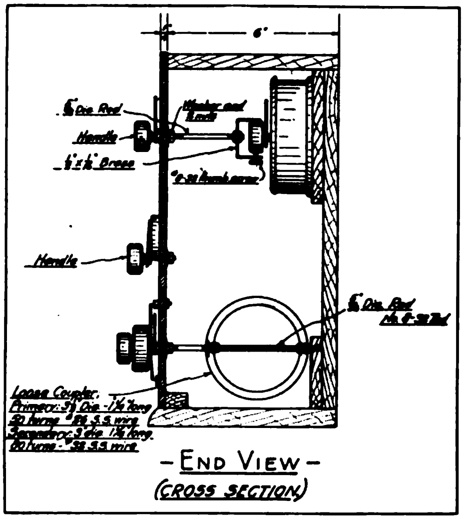


Figure 2, Second Prize Article

binding posts for the telephone connections are wired as shown in the diagram. These permit two pairs of receivers to be connected in series.

Either the round type of vacuum valve bulb or tubular type may be employed in connection with this cabinet, the type of course determining the method of mounting. The switch points, binding posts and knobs may be purchased at any supply house and are neater and as inexpensive as any that could be made.

The knife edge type of switch blade should be used wherever possible and may be made of spring German silver sheeting or phosphor bronze.

All interior wiring and connections should be made with rubber covered stranded "fixture' wire and the wiring diagram connection shown in Figure 3 should be closely duplicated. The back of the containing case should be made removable to permit examination of connections whenever necessary.

The writer has been using a set similar to the one described for the last few months and with an aerial but seventy feet in length, forty-five feet in height at one end and twenty feet in height at the other end, has heard amateur stations in twenty-five different states, including all amateur districts except the sixth and the seventh. This list includes 5 DU and 5 ZC of Dallas, Texas, at a distance of 1,100 miles, 5 AX of Shreveport, La., 1,000 miles and 5 BC of Little Rock, Arkansas, 800 miles, as well as numerous other stations at distances of 600 and 700 miles. All these stations are heard regularly and not only on "freak" nights as some readers might suppose. Certain stations within a distance of a few hundred miles have been read with the telephone on the table.

F. J. SCUPHOLM, *Michigan.*

THIRD PRIZE, THREE DOLLARS
Instructions for Making a Serviceable Transmitting Cabinet

In the design of the cabinet (Figures 1 and 2) I have endeavored to bring forth a compact and neat transmitting set which will give a high degree of efficiency. In designing these sets the fact that the average amateur uses a pancake oscillation transformer should be taken into account and the cabinet must be constructed to mount this instrument to the best advantage. I believe that I have succeeded in doing this without lengthening the connecting leads of the closed oscillation circuit. Contrary to the usual arrangement of such apparatus, the oscillation transformer in my set is not jammed up against the other parts of the apparatus, but is placed on the side where it is readily accessible.

All the woodwork of this set is of mahogany which should be given the following treatment: First give the wood one coat of stain, and when this is dried, apply a coat of filler. Allow it to set over night and in the morning give it a coat of white shellac. When this coat is dry, rub it down with steel wood, being sure not to

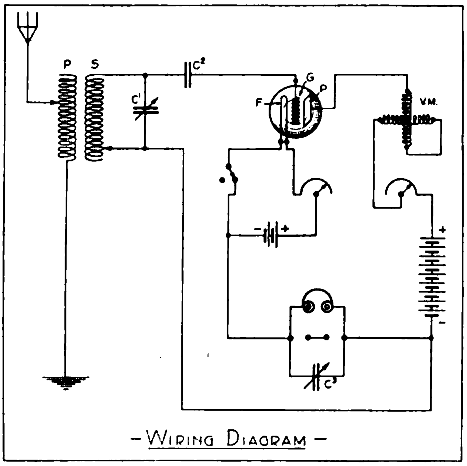


Figure 3, Second Prize Article

rub through the shellac as this would cause a scratch in the final finish. After the woodwork has been rubbed down, follow it by another coat of shellac and repeat this operation until the grain of the wood is completely filled up and no depressions can be seen. The wood should then be given a coating of very thin shellac and rubbed down with pumice stone and all. If a great number of coats of very thin shellac are applied instead of a few thick coats, a much finer finish will result.

The transformer should be mounted in the bottom of the cabinet with the condenser placed on a shelf immediately above it. This condenser should not have a capacity of over .01 microfarad as this is the limit permitted by the 200 meter-wave. A good value of capacity for 200 meters is .0086 microfarad and if the transformer has the correct secondary voltage, this is the value that should be employed. The rotary gap shown is some-

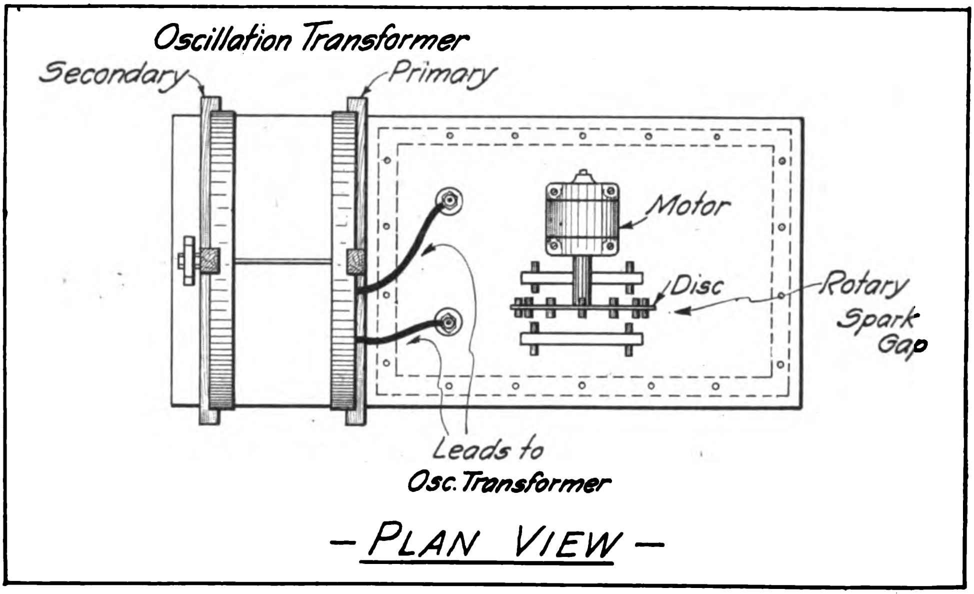


Figure 1, Third Prize Article

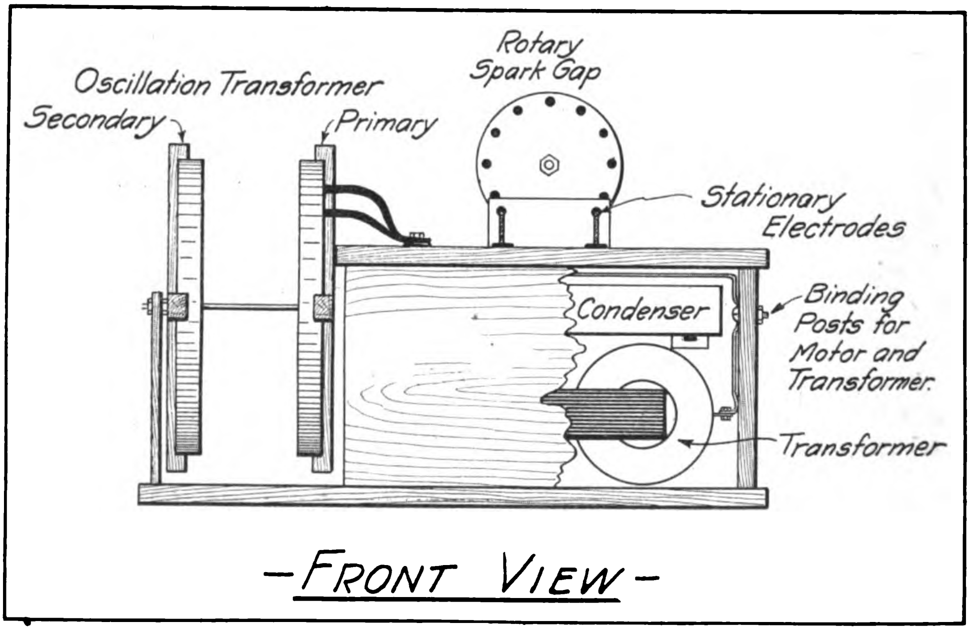


Figure 2, Third Prize Article

what different from the type used by the majority of amateurs, and for the benefit of those who would like to construct one of similar type I shall give the fundamental details.

The disc is of ⅛-inch Bakelite, 6 inches in diameter. It has twelve spark plugs which protrude on each side, their diameter being determined by the size of the transformer used. The stationary lugs, of which there are four, are supported by two pieces of ½-inch Bakelite, 2 inches in width and 4¾ inches in length. The lugs are connected so that the four sparking surfaces are in series. This will be clear from an inspection of Figure 1. The oscillation transformer is of the well known pancake type, and consequently, no description is required.

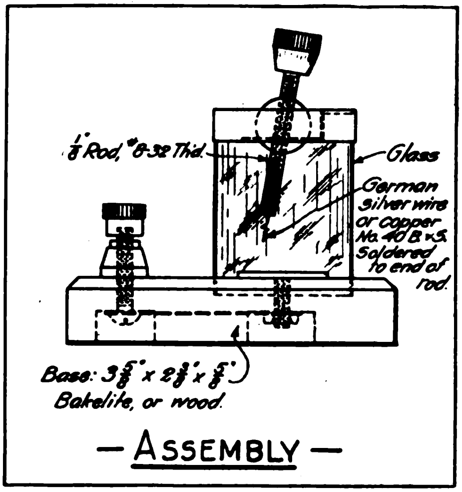


Figure 1, Fourth Prize Article

Although I have not employed this cabinet transmitting set during the winter months, I have been able to cover distances of 250 miles during the summer under very bad conditions of static at the receiving station. The power input during these tests was approximately 1 kw. Dimensions have not been given in my drawing as they must be changed according to the size and type of apparatus employed. The design was merely intended to show other workers how their transmitting cabinets may be assembled.

James M. Sommer, *Indianapolis.*

FOURTH PRIZE, SUBSCRIPTION TO THE WIRELESS AGE

A Dust Proof Detector That Is Easy of Adjustment

I find the dust proof detector shown in Figs. 1 and 2 to be very easy of adjustment and quite sensitive. It will be noted from an inspection of Figure 1 that the elements of the detector are mounted on an insulating base of "Bakelite" or wood. The dimensions of the base are 3⅝ inches by 2⅜ inches by ⅝ inch in thickness. At a point 1⅜ inch from the end and 1 5/16 inch from the side of the base a hole is drilled by means of an expansion bit to a diameter of 1-9/16 of an inch. This hole should be approximately 5/16 inch deep.

Another hole ⅛-inch in diameter is drilled at the center of this in order to pass a ⅛-inch binding post screw.

One half inch from the other end of the base, and approximately ½-inch away from each side, two additional ⅛-inch holes are drilled to take the binding posts. In order that the base may be perfectly smooth, the holes for the binding post are counter bored underneath with a ½-inch bit, to a depth of ¼ inch.

When the detector has been constructed thus far, the small hole in the center of the large hole should be plugged up and filled with sealing wax or tar which may be taken from the top of old dry cells. While this is hot, a piece of glass tubing 1½ inches in diameter and 1¾ inches in length is placed in the hole and left until the wax cools.

When the wax is cold, a ⅛-inch hole must be drilled through the center to take the binding post screw. Next, a round piece of brass is cut from 1/16ths of an inch or 3/32nds of an inch stock to a diameter of 1 inch and a hole is drilled in the center and tapped with an 8/32-inch thread; or the piece of brass may be soldered at the end of a binding post screw. This, as shown in Figure 1, is placed inside the glass tube for the support of the mineral cup.

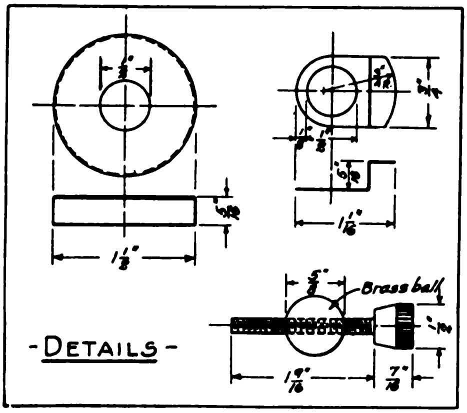


Figure 2, Fourth Prize Article

The complete dimensions for the cap to be placed on the top of the glass tube will be found in Figure 2.

A small wire for making connection with the cap and binding post can be run down the inside of the tube through the wax and base. Details of the adjusting rod for the detector are shown in the lower part of Figure 2.

Merle A. Cobb, *Wisconsin.*

HONORARY MENTION
A High Potential Transmitting Condenser of Goood Appearance

To amateurs who desire a high potential condenser with plates that can be easily removed without taking the entire unit apart, I suggest the design indicated in Figures 1, 2 and 3. If con structed as shown it will present an appearance on a par with the remaining apparatus in the complete set.

As shown in Figure 1, it consists mainly of a hard wood rack with slotted pieces, A, indicated in Figure 2. The slot is made of sufficient width to take the plate with an intervening distance between slots of ½ an inch. A small strip, D, is screwed to A to hold the plate in position at the base.

The plates are coated on both sides with tinfoil, as shown in Figure 4, and connections are made to them by the brass contact clip, B, indicated in Figure 3. These are in turn connected to the copper strip, C, with binding posts located at each end for connection to the transformer. To keep down the brush charge, the plates should be coated with a good grade of beeswax.

It is evident that the condenser is readily accessible and of more than passable appearance.

Robert Hall, *Minnesota.*

For anyone interested or enthusiastic over wireless—its fascination, construction or development, The Wireless Age, in my opinion stands out alone—a magazine that I will recommend as the best.—C. W. Patch, *Iowa.*

HONORARY MENTION
A Device for Preventing Flickering of House Lights

Amateurs who are troubled by the flickering of the house lights when sending at high power may be interested in the following device, which has proved successful.

The writer's transformer is of the open core type, operating on 220 volts, 60 cycle A. C., and is used in connection with a rotary spark gap. There are six different powers secured by means of a rheostat in series with the primary. The input varies from 50 to 830 watts, and the flickering of the lights was noticeable on all powers except the lowest, in spite of the fact that

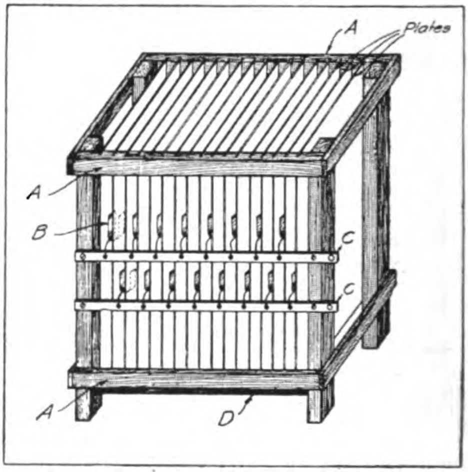


Figure 1, Honorary Mention Article, Robert Hall

the house lights are on the 110-volt circuit, while the transformer has a 220-volt connection direct from the main switchbox.

The principle employed was to make a rheostat of equal capacity to the primary of the transformer, placed in shunt with it in such a way that when sending, the key merely switched the current back and forth between the rheostat and the transformer. In this way a steady load was imposed upon the house mains during the time of sending, and the only noticeable effect upon the lights was a slight drop at the beginning, and a corresponding rise at the end of each message.

While this is simple in principle, a number of difficulties arose in practically carrying it out. An attempt to make an inductive rheostat composed of one or more choke coils failed on account of the large amount of heat developed. It could, of course, have been managed by using a very large wire, and making proper division for cooling.

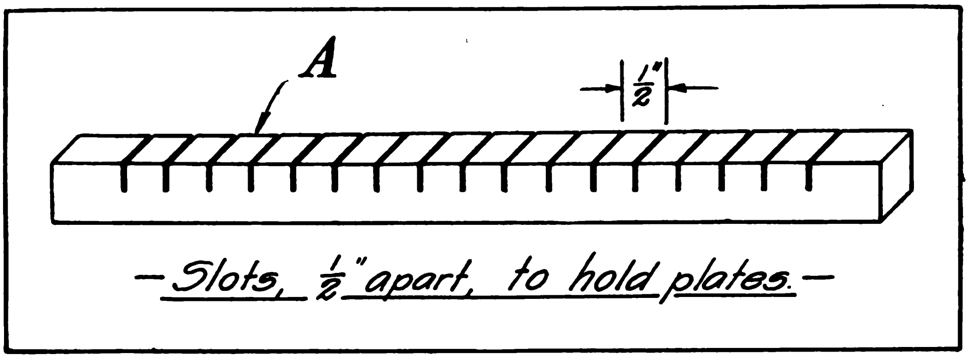


Figure 2, Honorary Mention Article, Robert Hall

The method finally adopted was to use a bank of incandescent lights. By selecting Tungsten lights of various sizes, eight independent units were made up, having the following capacities: One each of twenty, thirty, fifty, sixty and eighty watts; two of 120 and one of 400 watts. Wires were led from each of these units to separate switches on the operating table, and by use of one, two or more units, it was possible to balance any load imposed by the transformer, with an error of not more than ten watts. The heel of all these switches and one of the transformer leads was connected to one side of the A-C circuit. The other side of the circuit was connected with the armature lever of a sounder used as a relay.

The usual anvil on which the lever strikes was removed and a wooden frame, carrying upper and lower contact points, substituted. The lower point was connected to the transformer and the upper one to the return wire of the bank of lights forming the rheostat. The latter connection was interrupted by a circuit closer, so arranged in connection with the main aerial reversing switch that the rheostat lights would only be lit while sending.

Most houses are equipped with Tungsten lights. These lights respond very quickly to changes in load or voltage, and to prevent flickering the sounder lever must operate almost instantly in both directions. This is secured by placing the two contacts so close that the movement of the lever will be as small as possible, and by using a light lever, and sounder magnets of low inductance. A four ohm. sounder with an aluminum lever would be ideal for this purpose.

(Continued on page 530.)

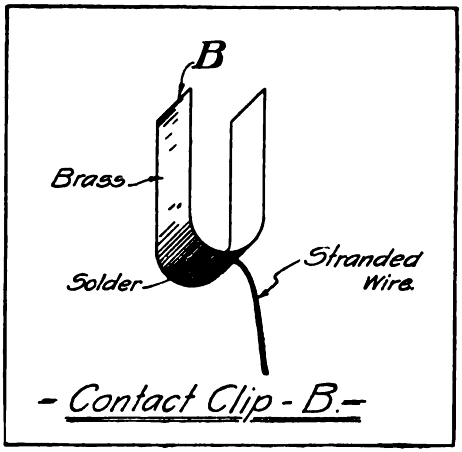


Figure 3, Honorary Mention Article, Robert Hall

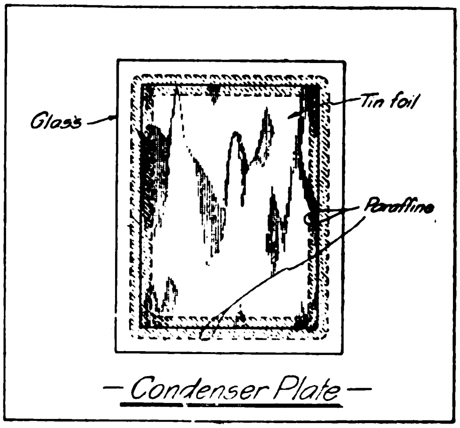


Figure 4, Honorary Mention Article, Robert Hall

General Advice for the Amateur Experimenter

By Elmer E. Bucher

CONTINUING the discussion of the problems of the amateur, pertinent advice will be given in regard to certain misconceptions held by some experimenters concerning the receiving station and associated apparatus.

We frequently receive an inquiry stating: "I have a 3,000-meter loading coil. What will be the wave-length of the aerial if I connect it to an aerial 120 feet in length?"

In this problem the electrical dimensions of the circuit in which the coil is to be employed are not known, nor are the dimensions of the tuning coil itself; in short, the information supplied concerning both the aerial and the coil is so incomplete that nothing can be calculated therefrom.

When a manufacturer offers to the amateur field a 2,000-meter or 5,000-meter loading inductance, the coil is only applicable to an antenna of stated capacity and inductance, and at all other values, the possible wave-length adjustment of the system will either be greater or less according to the dimensions of the aerial. To illustrate: Assume that an amateur aerial had capacity of .0005 microfarad (ignoring the inductance) and a loading coil of given dimensions raised the possible wave-length adjustment to 1,000 meters; if the same coil be connected to an aerial of double the capacity or .001 microfarad, the wave-length will be increased by $\sqrt{2}$ or to approximately, 1,450 meters. If the coil be connected to an aerial of .00025 microfarad capacity, the wave-length will be decreased by $\frac{1}{\sqrt{2}}$ or to approximately 710 meters. Thus we see that the affect of the coil depends upon the capacity of the aerial with which it is to be employed and unless something is known of the capacity of the aerial, the possible wave-length adjustment of the system cannot be foretold.

To be more explicit, in order to compute the affect of the loading coil on the total wave-length of an antenna system, we must not only know the capacity of the aerial but its total inductance as well. We must also add to this value the inductance of the primary winding of the receiving transformer, and with all these values before us, the frequency of the system can be readily obtained. We have shown the article of this series in the February issue how the inductance of the coil may be calculated by a simple formula, and on page 107 of the November, 1910, issue of THE WIRELESS AGE the inductance and capacity of four-wire T and inverted L aerials of various lengths are fully given. In determining the capacity of his aerial system, the amateur should select that value corresponding to an aerial nearest to the dimensions of his aerial.

When the individual values of inductance are obtained, the total wave-length is computed by adding the values of inductance together and multiplying the result by the capacity of the aerial. If the square root of this product is taken and the result multiplied by 59.6, the wave-length of the complete circuit is obtained.

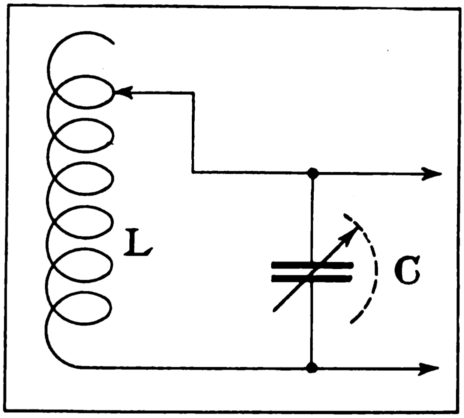
This may be written: Wave-length (of an aerial circuit) $= 59.6 \sqrt{\text{inductance}_{\text{cms}} \times \text{capacity}_{\text{mfds.}}}$ (1)

The amateur experimenter frequently requests us to compute the wave-length of receiving tuner, giving merely the dimensions of the primary and secondary windings together with the size of the wire. In a case of this kind we can do no more than conjecture the possible wave-length adjustment because we have no knowledge of the constants of the antenna circuit nor the capacity of the condenser to be connected in shunt to the secondary windings.

If the condenser is not to be connected across the secondary, we must assume a certain value of distributed capacity between turns. The value can be calculated, but the computation is somewhat difficult. In order to simplify the problem, we may assume a value of .0001 microfarad which is, of course, rather high for the average amateur coil. By calculating the inductance of the secondary winding from knowledge of its turns, diameter, length, etc., we can use the foregoing formula (1) for wave-length and thereby ascertain the maximum possible adjustment. If a variable condenser is employed, knowledge of its capacity enables us to determine the wave-length adjustment at any particular value of capacity.

In working out the possible wave-length adjustment of many amateur tuners we frequently find a set where the antenna circuit can be quite readily adjusted to waves of 6,000 meters length, but the maximum adjustment in the detector circuit is not more than 2,000 meters. On the other hand we have come across examples where the reverse condition obtains, and of course, in either case resonance cannot be secured throughout the range of wave-lengths. This means, in the first example cited, that when the primary and secondary windings are tuned to 2,000 meters, there will be a number of unused turns in the primary winding which are useless. It should now be self evident that in order to correctly estimate the wave-length of an amateur's tuner, we must know fully the inductance and capacity of his aerial and whether or not a condenser is connected across the secondary winding. Unless these data are given we can only conjecture the range of adjustment.

Many experimenters do not seem to understand the term wave-length as applied to the receiving apparatus. Some believe that in some incomprehensible manner the waves sent out by the transmitter pass through the apparatus and on to the earth, and that tuning consists in making mysterious adjustments in the circuits to pick up these waves. This is more or less true, but it is not directly the wave motion which passes through the tuner. The function of the receiving aerial is to extract a certain amount of the energy from the passing wave motion and to build up the oscillations induced thereby to amplitude by the phenomenon of resonance. The fact is, that in tuning a receiving aerial to a distant trans-

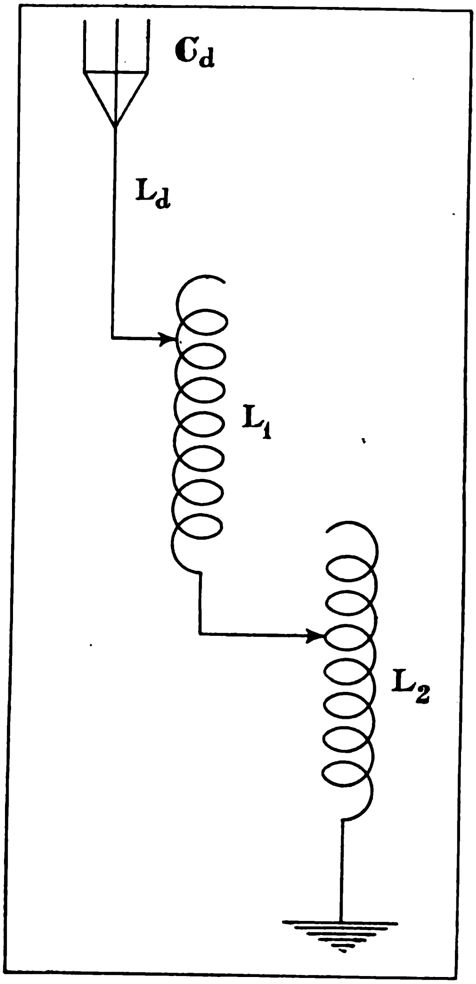


Secondary Circuit of Receiving Tuner.—The wave-length adjustment of this circuit = 59.6 × √L × C, if L is expressed in centimeters and C in microfarads. It is not advisable to design a tuner so that the values of C exceed .0003 microfarad in the case of the vacuum valve detector and .0005 microfarad in the case of the crystal detectors

mitting station, we adjust it so that if set into excitation it would radiate a wave of the same length as a distant transmitting station, although it would not necessarily have the same decrement. When the antenna is receiving a half wave of the transmitter must have set up a complete alternation of current in the receiving aerial before the next half wave acts upon it, otherwise the current set up in the receiving aerial by the first half will be opposed by that of the second half. Analogous to this is the case of the ordinary swing. If we wish to keep it in oscillation, we must be careful to push the swing exactly at the point where the energy of the movement in one direction has spent itself and another oscillation in the opposite direction is about to take place. If we apply a "push" at this particular moment the oscillation of the swing will not be interfered with, but, in fact, the applied force will tend to maintain the to and fro movement.

In designing receiving apparatus, the amateur should keep in mind:

1. That there is no need for constructing a spark tuner for waves in excess of 3,000 meters.
2. Practically all stations within range of United States amateurs employing wave-lengths in excess of 3,000 meters are fitted with undamped oscillation transmitters which require a special type of receiver.
3. The undamped receiver need not exceed the wave-length adjustment of 12,000 meters.
4. That for the reception of undamped waves either a tikker or a "beat" receiver is required.
5. That the most effective beat receiver is the vacuum valve oscillator employed in connection with special circuits which have appeared in previous issues of THE WIRELESS AGE.



Primary Circuit of a Receiving Tuner.—The wave-length to which this circuit will respond $= 59.6 \times \sqrt{(Ld + L_1 + L_2) \times Cd}$, *where Ld is the distributed inductance of the antenna in centimeters,* L_1 *the inductance of the loading coil, and* L_2 *the inductance of the primary winding. This formula is only strictly true when the aerial is loaded with very large values of inductance at the base. As shown in the October, 1916, issue of* THE WIRELESS AGE, *if small values of inductance are employed, a certain correction factor must be introduced, data for which appears in Figure 8, page 34, of that issue*

The amateur frequently inquires regarding the smallest possible dimensions for the coupler of the "beat" receiver. Experiment shows that a coupler which has sufficient values of self inductance to respond to the wave-length of 3,000 meters gives very good results, although a coupler of less mutual inductance will do. Also, it should be remembered that the dimensions given by the writer in previous issues for various types of beat receivers, need not necessarily be duplicated to the fraction of an inch, both in respect to the diameter and length of the windings. Should the experimenter use smaller tubes for the primary and secondary loading coils or for the coupler, he need only employ larger values of capacity in shunt to the secondary winding or in shunt to the primary winding. Care should be taken in the secondary winding, however, in the case of the vacuum valve not to exceed capacity of .0003 microfarad.

Many experimenters do not seem to

realize the labor involved in calculating the exact position for the dead end switch of a receiving tuner. It may also be remarked that a considerable number ask for these data without knowing the function of a dead end switch. A complete explanation appears in the book, "How to Conduct a Radio Club," and the subject has also been taken up several times in the Queries Answered department of THE WIRELESS AGE.

The experimenter will readily see that in order to give data for the position of the "breaks" in the primary winding, the inductance and capacity of the antenna must be definitely known and what would be the correct position for the switch in connection with one aerial would be entirely out of place for another aerial. On the other hand, the position of the dead end switch for the secondary winding can be quite readily determined when the capacity of the condenser in shunt is definitely known.

In the case of the 3,000-meter tuner, the first break in the primary and secondary windings should be located so that waves between 200 and 700 meters can be adjusted to. The next group of turns should permit adjustment to waves from 700 to 1,100 meters and the last group, waves from 1,100 to 3,000 meters. This will cover all the standard wave-lengths in use by spark stations, including the wave-length of the Arlington station when sending out the time signals.

In locating the position for the dead end switch in the secondary winding, the experimenter should decide definitely upon the value of capacity in shunt and if, for instance, this is to be .0002 microfarad, then the required inductance can be determined approximately by $L = \frac{700^2}{3552 \times .0002}$. After the required inductance has been obtained the dimensions for the winding can be calculated as shown on page 81 of the second revised edition of "How to Conduct a Radio Club."

(To be continued)

Receiving Without an Aerial

The man who spoke jokingly of a wireless message being received on an aerial composed of a tack sticking in the wall and a wire running from it to the receiving instruments, with a flower pot filled with earth for a ground, did not realize that he was predicting a near possibility. The idea of a flower pot for a ground, of course, is absurd; the tack aerial is not so contrary to the dictates of good judgment.

I have designed and built a receiving instrument with which, by using only one vacuum valve, I am able to read stations from a distance of 600 miles and more, without any aerial whatsoever; in fact, there is nothing connected to the aerial binding post, nor is there an aerial within a mile of my residence. All I use is a ground wire which is connected to a small piece of iron sticking in the earth.—T. M. DALY, *Tennessee.*

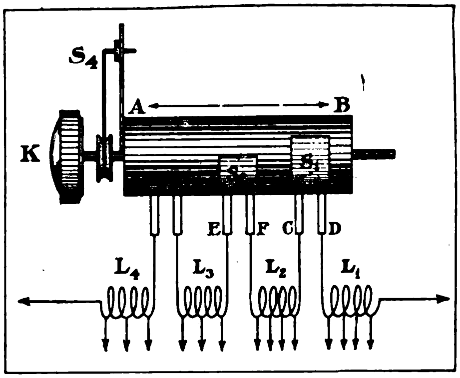


Diagram Showing the Use of a Dead-end Switch on the Receiving Set.—The taps of the single blade switch, S-4, are connected to the successive inductance groups, L-4, L-3, L-2 and L-1. When switch S-4 is turned counter clockwise and has progressed so far that all turns of L-1 are in use, segment S-1 makes contact with brushes C and D, connecting group L-2 in the circuit. In the same way, when all the turns of L-2 are in the circuit, brushes E, F make contact with segment S-2, thereby cutting in group L-3, and so on until all the turns of the winding are included

The members of the Sacramento, Cal., Radio Club

With The Amateurs

The Radio Club, of Marlboro, Mass., was notified at a recent meeting that it had been admitted to membership in the National Amateur Wireless Association. Robert Marshall was elected delegate to the national convention. Walter Weeks read a paper on "Charging of Storage Batteries."

The Fifth District Radio Club, at its annual meeting at the radio room in the Y. M. C. A. building, in New Orleans, La., re-elected Robert B. Godbolt president and Karl Freubing, secretary-treasurer.

Plans were discussed by members for the erection of a wireless station. Mr. Godbolt is taking active interest in the move to make the organization's library one of the best collections of wireless and electrical books in the South.

The Sacramento Radio Club, organized in Sacramento, Cal., a little more than a year ago, has now reached a membership of eighty. Meetings are held every Friday evening at eight o'clock. Social meetings are held every other Friday. The members of the Club recently held a banquet in their new quarters.

Plans are under way to install a 1-K.W. vacuum valve amplifier. With the aid of a mimeograph, bulletins, call lists, etc., are printed from time to time.

The dues at present are 25 cents a month. The initiation fee is 25 cents. All communications should be addressed to Ellis J. Griffin, secretary, 2216 Thirty-second street, Sacramento.

The Twin City Radio Club was formed at a meeting of wireless telegraph operators at the Lewiston (Me.) High School recently.

Officers elected were: Honorary president, Frederick Pierce; president, E. P. McShane; vice-president, A. Pasquale; secretary-treasurer, R. Anthony.

The following committees were named:

Library Committee: L. Hilton and C. Gagnon.

Electrical Board: A. Pasquale and L. Hunter.

Advisory Board: Messrs. Pierce, McShane, Pasquale, Anthony, Mansfield and Maliar.

Initiation Committee: A. Pasquale and L. Hunter.

More than sixty Colorado Springs, Colo., High School boys have enrolled for the wireless telegraphy class which has been formed at the school. A wireless outfit has been installed.

At a recent meeting of the Albany (N. Y.) Wireless Club, a resolution was passed offering the services of the members of the organization to the Government in case of war. The Club has eight commercial operators among its members. Copies of the resolution have been sent to Secretary of War Baker and Governor Whitman. The Club is installing a wireless station on the Central Y. M. C. A.

The wireless station of the Philadelphia Turngmeinde was closed recently by officials of the radio section of the organization. This action was taken to do away with any suspicion that the association's equipment was not being used in the best interests of the United States.

The alumni of St. Ignatius College, Cleveland, O., gave a smoker in the college gymnasium recently and presented to the college a wireless telegraph outfit.

A radio club has been organized at the Jackson (Mich.) High School under the name of the J. H. S. Radio Club.. The following officers were elected:

President, Lewis Holland; vice-president, Harold Knowles; secretary, Barry Frost; treasurer, Leon Watts. The Club has formed a class in wireless. Communications should be addressed to the secretary at 816 West Main street, Jackson, Mich.

The Plattsburgh (N. Y.) Wireless Club has been organized with the following officers:

President, C. W. Spaulding; vice-president; W. J. Vincent; secretary and treasurer, Norman P. Mason.

Meetings of the Club take place on the first and third Fridays of each month, due notice being published in newspapers. A course of lectures and experiments has been planned and the organization announces that it will welcome visitors who may be interested in wireless. The Club would like to hear from other wireless organizations on meeting nights.

The Radio Club, of Antigo (Wis.) has been formed. Its officers are as follows:

President, Paul Kavanagh; vice-president, Morgan Knott; secretary, Frank Manthey; treasurer, Herbert C. Fischer.

The Club has a home in the First National Bank Building.

Amateurs of Kansas City, Kans., have formed the Kaw Valley Radio Association. The officers follow:

President, Ralp Rehm; vice-president, Parker Wiggin; secretary, Harlow Eppert; treasurer, Joe Harlan. All communications should be sent to the secretary at 841 State Avenue, Kansas City, Kans.

The following message was sent by wireless on January 26, by the Rochester (N. Y.) Chamber of Commerce to the Chamber of Commerce, of Scranton, Pa.:

"To the Scranton Chamber of Commerce: The Rochester Chamber of Commerce sends greetings to the Scranton chamber and extends its best wishes for the ensuing year:

"Harper Sibley, president of Rochester chamber."

From his key in the parish house of St. Paul's Episcopal Church, the meeting place of the St. Paul Amateur Radio Association, Curtis Swanton started the message on its way. The members of the Association who arranged the feat were present to witness the sending.

Howard Alexander received the message at his station, SRL, No. 34 Asbury street, Rochester, and relayed it to the station at 435 Park Avenue, 8UC, owned by Willis Brockett and Abe Frankel. Cyril Staud, secretary of the Rochester Wireless Club received the message at his station, SOZ, in Rutgers street and sent it out of the city.

Laurens Taylor, of Geneva, was the first out-of-the-city operator to whom the message was sent. His call is 8AJE. Taylor sent the message in turn to Ithaca, where it was received by Perkins Coville, at station 8XU, and Robert Brown, at Cornell University. Dr. H. E. Fitch then received it at his station in Elmira and relayed it to L. Bush, secretary of the Binghamton Progressive Radio Association.

Bush sent the message direct to Roy C. Ehrhardt, 820 Monroe Avenue, Scranton, who delivered it to the Scranton Chamber of Commerce. Ehrhardt immediately replied through the same stations.

A book containing much useful information has been issued to the members of the Southern Tier Radio Association (of New York State). Included in the contents are a list of the stations of the members of the Association and the call letters; the power output of the sending stations and hours of listening in. The book also contains information about how the Arlington station transmits weather reports in code form.

More than 200 amateur wireless operators in the New Jersey counties immediately adjacent to Philadelphia are at the command of the Federal Government in the event of war. These stations are under the supervision of the South Jersey Radio Association, of which C. Waldo Batchelor, of Collingswood, is president. The Association was formed by a group of boys and young men last June. At that time there were only sixteen members all in Camden County. The Association has grown until it takes in all of Camden, Gloucester, Burlington, Ocean, Cumberland and Cape May counties and part of Salem County. The membership is more than 200.

Most of the operators are from sixteen to twenty years of age. They are carrying on a continuous round of lectures and research work to increase their proficiency.

Robert B. Godbold, was re-elected president of the Fifth District Radio Club at a meeting of the organization held in the class room of the Y. M. C. A. Radio School, 815 St. Charles Street, New Orleans, La., recently.

Mr. Godbold has done much for the promotion of experimental wireless work in the South and is now taking active interest in the Club's modern radio station. Plans for the wireless equipment of the Club's station was formulated at a meeting of the organization.

Karl Fruebing was installed in the office of secretary-treasurer. Members of the club are now working to make the organization's library one of the best collnctions of wireless and electrical books south of the Mason and Dixon line.

The Baltimore (Md.) Radio Association, which is composed of amateur wireless experimenters, has offered its services to the Government in case of need. The members of the Association met at their headquarters, 22 St. Paul Street, recently and passed a resolution which called upon Charles E. King, secretary of the Association, to offer their services to the Government. Mr. King sent the following telegram to President Wilson and Secretary of the Navy Daniels: "The Baltimore Radio Association, representing fifty amateur radio operators, offers its unqualified services to the Government in its hour of need."

Secretary King pointed out that the services of the operators in Baltimore could be put to excellent advantage during war, as many of the wireless stations in that city are high-powered.

The Boy of Promise Who Became a Knight of the Key

A Narrative with a Moral

By Robert Kennedy

ONCE upon a time. In a Small Town. And not so awful long ago. Was born a Boy of Much Promise. As a babe he could tell Soap from Candy at a glance. At two he could stick pins with deadly precision. In the Cat, his Father's Leg or Brother's Balloon. At five he was the terror of his family. He Inspired Disrespect. A dish-cloth in the soup. Molasses on the dog. Tacks on the chairs. Verily, he had much to his credit as a Budding Genius.

At ten Electricity gripped him. In its Power. Then, indeed, did the neighbors wax indignant. The Talented Youth Boy indulged his fancy. Shocking their pets, Animal and Human. Electrifying Gate Latches. Yeah, even did his Sister admit him clever. One day her Curling Iron. Developed a Kick like a mule. Thence on he was Fresh.

Thus toiled this Marvelous Youth. Borne down and Ridiculed on all sides. He Hit Back at them. Verily, he struggled thru their laughter. His woodshed laboratory became a Wondrous Place. All the powers of the Black Art had be chained. He knew when the Bell Rang. When the Gate Opened. He heard the soft, sweet nothings uttered in the parlor between Seven and Eleven—twice a week. Yeah, and all these he accomplished against Heavy Odds.

Verily, his wireless station was a Marvel. A Barbed wire aerial prevented the Escape of Messages. His lightning switch, a gigantic Gate Hinge. His transformer. Hand made. Had an efficiency of 23.7%, or so he Calculated.

Yeah, and well did the town know when he Sent. The Lights Winked in the whole community when he adjusted for a 2 K.W. to send one and one-half miles.

Then honor of honors. He met a Girl. He grew Sentimental about her. Wrote poetry. Tossed his long hair, while reading it to her on bended knee. Verily, he was Degenerating. Finally, the minx cast him aside for a Johnny with a Roll. Would he Despair? NO. He would rise to fame as a poet. And make her eyes Pop Out with envy and jealousy when he brought his Wife to town.

Sad, indeed! Long hair indicates not the Master Pen. Failure stared him in the face. Was he beaten? He must make her Look Up to him. But How? Ah, a thought! (Chain It! *Stage whisper.*) He would be a Hero. A Knight of the Key. Have his Photo in every paper in the country. Eureka! And Excelsior! He Had It.

Later he entereth the Radio School. His Trials were many. His code was Dilapidated and Threadbare. The Mystery Boxes (tuners) puzzled him not a little. Yet, true to his ideals, he Succeeded.

All honor to him. He is now Second Operator on the s.s. Snail. Flagship of the Peruvian Navy.

MORAL: When in doubt, be an Operator.

A Convenient Method of Calculating Inductance of Coils

By Hugh A. Brown, Instructor of Engineering, University of Arkansas

THE busy experimenter and radio Engineer must view with dismay some of the intricate precision formulas for calculating the inductance of air cored coils. It is the purpose of this article first to give a method, which is not only short, but also will give results accurate within 3.5 or 4 per cent., and second, to show how to obtain a coil having the maximum inductance within the minimum length of wire.

Figure 1 shows longitudinal sections of various coil shapes, the constant for each shape being calculated from the universal formula derived by Professor Morgan Brooks, which is accurate within 3 per cent. for any shape of coil, long or short, thick or thin, wide or narrow, assuming that the spacing between the wires is small, i. e., spacing for D. C. C. wires, or even thin rubber for the larger sizes. Professor Brooks points out that it is almost impossible to duplicate a coil already constructed and have it check within less than 3 per cent. in inductance. The method of this article is as follows: To find the inductance of a coil of given proportions, it is only necessary to select the diagram in Figures 1, 2 or 3, whose proportions are nearest that of the coil in question, and using the constant K given with the diagram, substitute in the formula,

$$L = \frac{K d^2 N^2}{10^8\, l} \text{ henries or } \frac{K d^2 N^2}{10^5\, l} \text{ milli-henries}$$

where d is the radius of the coil in inches, N is the number of turns and l is the axial length of the coil in inches. Take as an example the following coil: axial length l is 2 inches, inside diameter d is 6.8 inches and it contains 2,000 turns of a certain size wire. This coil corresponds in proportions to the first diagram in Figure 1, for which K = .97. Substituting in the formula,

$$L = \frac{.97 \times (6.8)^2 \times (2000)^2}{10^8 \times 2} = .896 \text{ henries}$$

It makes no difference whether the

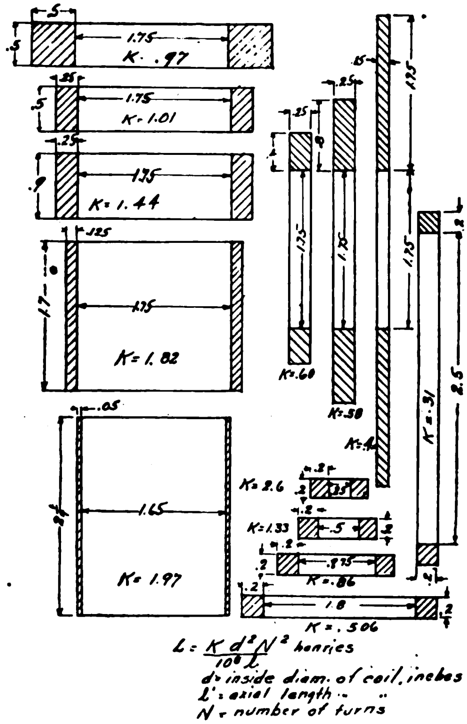


Figure 1

coil to be calculated is much larger or much smaller than that shown in the figure; as long as the proportions are the same the constant can be used. Figure 2 shows coils of the average variometer, loose coupler and theoretical long solenoid, and the constant for each. In the heterodyne receiving circuits large variable inductances are required for the long wave-lengths, and there is a certain shape of coil which will give the maximum inductance with the minimum length of wire, as can be seen by examining the figures. Professor Brooks has deduced the maximum shape to be that of Figure 3. Take a coil having the dimensions of that in Figure 3, which are

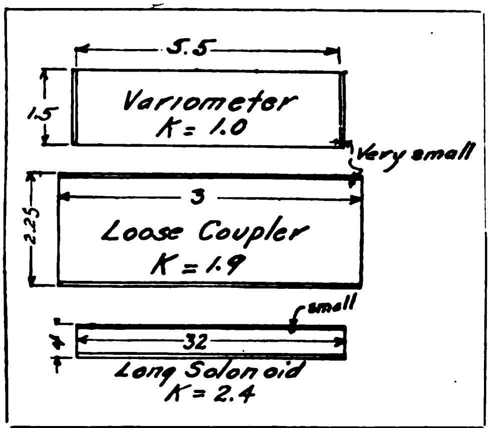


Fig. 2

in inches. If this size and shape coil were wound with No. 24 D. C. C. wire, it would have an inductance of from 65 to 135 milli-henries, depending on how closely and evenly it were wound. Taking an average value of 1,000 turns per square inch gives 1 x 1.2 x 1,000 = 1,200 turns and using the formula and

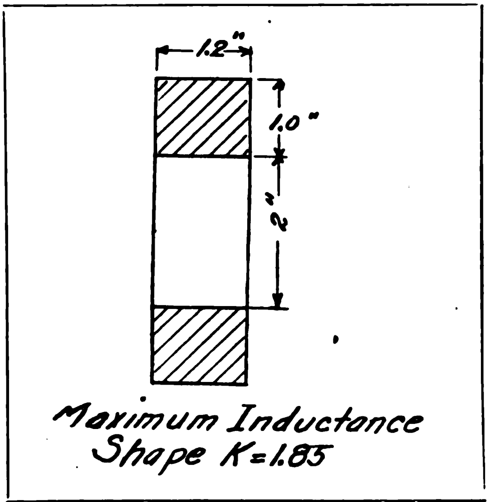


Fig. 3

K as given for this shape, L = 89 milli-henries. The inductance varies with the number of layers, counting from the inside outward as shown in Figure 4; and if it is desired to use a twelve-point switch, so as to vary the inductance in twelve equal steps, the first tap (connecting to the first switch point), should be made after 30 per cent. of the total number of layers are put on. This corresponds to 1/12 or 8 1/3 per cent. of the total inductance as read from the curve.

In winding this coil it is well to leave a radial slit ⅛ inch wide in one of the sides of the spool or form to facilitate counting the number of layers and making the tap connections. After winding

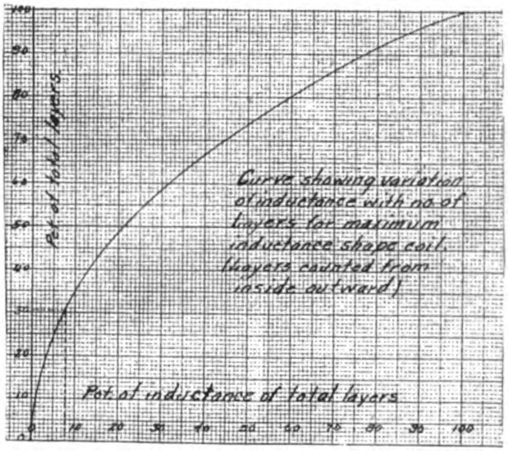


Fig. 4

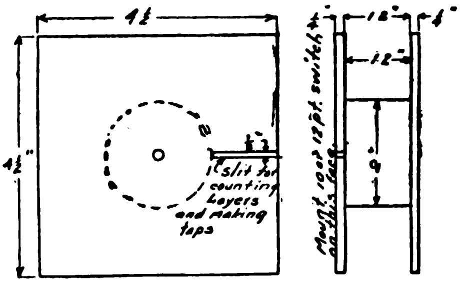
on wire to give about ¼ inch thickness, one can easily estimate the total number of turns he will have by counting the number of layers and turns per layer. The location of the remaining eleven taps can be found in the same way as for the first. This is an excellent loading coil to put in series with the antenna, as the total resistance will be only twenty-five or thirty ohms. The author has found that for the best results, pieces of 1/32" cardboard should be used to divide the coil into four parts. Each part will be ¼ of an inch thick, and the outside diameter of the coil will be 4¼' inches. This will not change the calculated results very much. If silk covered wire is used, more turns can be gotten on this size and the inductance will be considerably larger. Thus, we have a 12,000 to 17,000 meter loading coil that is only 1.2 inches long, and 4 inches in diameter.

For the inductance coils in the grid and plate circuits of the heterodyne receiver, much smaller wire may be used with little reduction in efficiency. Taking No. 30 D. S. C. wire and a coil of the proportions of Figure 3 whose diameter is 1.16 inches, outside diameter 2.32 inches and axial length .7 inch, the total inductance will be 115 milli-henries with 800 feet of wire or ¼ pound. The location of the taps may also be found from Figure 4.

In order to show how economical this shape of coil is: If 1,500 turns (about 1,200 feet) of No. 22 D. C. C. wire can be wound on the coil of Figure 3, the inductance will be 133 milli-henries, and if this same length of wire be wound in the form of the long solenoid of Figure 2, the inductance will be only 16 milli-henries.

Another loading coil that is easier to wind than the above is of the shape shown in Figure 1, for which K = is 1.82. If the inside diameter is 3.75 inches, the axial length is 3.64 inches, and wound with ten layers of No. 24 D. S. C. wire, the inductance will be 140 milli-henries. A tap is made after each layer is completed, making ten taps. One layer of cardboard should be wrapped around the coil after five layers have been wound on to divide the coil into two parts. The next shape in Figure 1, for which K is 1.97, is a good one to use if the wire is small, and the inside diameter should be about four inches.

Although the constants do not hold for coils of large spacing between wires, such as in the spiral or helices in the radio transmitter, the comparative merits of the helix (coil for K = 1.82), and flat spiral (coil for K = .42, but smaller inside diameter), can be worked out. The author made some calculations and found that for the same length and size of wire, the inductance of the spiral is about 10 per cent. lower than for the helical form, the outside diameter of the spiral is twice that of the helix, and the axial length of the helix is about 10 times that of the spiral. Therefore, for stations of small capacity and short wave-length, the "pancake" oscillation transformer is probably the better, while for the station of long wave-length the helical form is better. The coil sheaves and constants for the cylindrical or helix types ought to aid the radio engineer in calculating the large loading coils used in the transmitters of the arc stations, as the voltages are not high and the wire



Wood spool for 12000 meter loading coil #24 DCC wire

Fig. 5

may be covered and closely wound.

Mutual inductance is a maximum when two flat coils placed together form the shape of Figure 3, or, if the coils are concentric, when both together form a short thick tube whose thickness is one-half its length. These are the most effective shapes for the primary and secondary of a transformer.

For those who may be interested in Professor Brooks' universal formula, it is as follows

$$L = \frac{.366 \times \left(\frac{\text{ft.}}{1{,}000}\right)^2 \times F' \times F''}{b + c + R}$$

$$F' = \frac{10b + 12c + 2R}{10b + 10c + 1.4R}$$

$$F'' = .5 \log_{10} \left(100 + \frac{14R}{2b + 3c}\right)$$

L is inductance in henries, ft. is number of feet of wire in the coil, b is axial length of the coil in inches, c is the radial thickness of the coil in inches, and R is the outside radius of the coil in inches.

The radio station at the State University of Iowa will send QST on Tuesday, Thursday and Saturday nights at ten minutes after eight o'clock (Central time). On Tuesdays and Thursdays the message will consist of a short radio lesson, while on Saturday it will be composed of university news.

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.

E. O. S., Dorchester, Mass., inquires:

Ques.—(1) What changes in the size of the coils described on page 92 of the book, "How to Conduct a Radio Club," would have to be made in order that this receiving set may have a range of 25,000 meters?

Ans.—(1) If the inductance of these circuits is increased by four, the possible wave-length adjustment will be increased by $\sqrt{4}$ or 2, that is to say, the receiving coils would respond to wave-lengths of 20,000 meters if the coils are made four times their present dimensions. Please keep in mind, however, that after you have constructed a receiver of this range of adjustment, it would be of no use whatsoever as there are no stations in the world with which we are familiar that operate at wave-length near the value of 25,000 meters.

Ques.—(2) If the coils of the beat receiver referred to in the book, "How to Conduct a Radio Club," were fitted with dead end switches, would it be possible to receive 4,000 meter waves?

Ans.—(2) If the loading coils of the primary and secondary circuits were cut out, the tuner would easily respond to 4,000 meters.

Ques.—(3) How should taps be taken off these coils?

Ans.—(3) The more taps, the finer the adjustment; consequently, it is up to the builder to decide how many taps he would like to have.

* * *

J. G., Invercargill, New Zealand:

The diagram of connections attached to your query is a type of regenerative vacuum valve circuit. Although recommended for its simplicity, the circuit will not give the results of the more complicated Armstrong type of circuit. An explanation of the Armstrong Regenerative circuits appear in the September, 1915, issue of the proceedings of the Institute of Radio Engineers.

* * *

B. M. J., St. Raymond:

A complete description of the Goldschmitt tone wheel appears in the December, 1916, isue of the MONTHLY SERVICE BULLETIN of the National Amateur Wireless Association. The tikker is a circuit interrupter which takes the place in the ordinary receiving circuit of the crystal detector. The tikker may be some form of commutator interrupter which will interrupt the receiving circuit at rates varying from 300 to 600 times per second. A popular form of tikker is the so-called slipping contact detector which consists of a polished wheel with a groove in which rests a light contact wire. This wheel is rotated approximately 1,800 revolutions per minute and will give a hissing note in the telephone when receiving from undamped wave stations.

* * *

A. B. R., Kansas City, Mo., inquires:

Ques.—(1) What is meant by a regenerative vacuum valve detector circuit?

Ans.—(1) A regenerative receiver is one where either the current of radio frequency or audio frequency of the local telephone circuit is repeated back to the grid circuit and again amplified. It has been shown by Armstrong and others that the vacuum valve detector will repeat the oscillations of radio frequency into the local telephone circuit under suitable conditions. These oscillations, in turn, may be coupled back to the grid circuit and reinforced, by the well known relaying action of the valve.

* * *

V. C. M. C. I., Tampa, Fla., inquires:

Ques.—(1) How can I make the transformer described on page 220 of the December, 1916, issue of THE WIRELESS AGE give a secondary voltage of 5,000 volts for use with a rotary quenched gap?

Ans.—(1) Use six secondary sections of the size mentioned instead of ten.

Ques.—(2) Please publish a diagram of connections for a tuner and receiving set, using an anchor spark gap instead of an aerial change-over switch.

Ans.—(2) A diagram of connections is not necessary. The anchor gap should be exceedingly short and should be connected in series with the earth lead of the transmitter. Two leads should be extended from either side of the gap to the terminals of a primary winding of a receiving transformer. The circuit to the primary winding may be broken by a small two-blade switch, or, if the gap is kept very short, the primary need not be disconnected.

Ques.—(3) Where can I secure a diagram of a regenerative circuit for waves up to 600 meters, giving the size of the coils, the wire, etc.?

Ans.—(3) This diagram appeared in the December, 1916, issue of the Monthly Service Bulletin of the National Amateur Wireless Association.

A complete course in radio engineering is given at the College of the City of New York. Further particulars can be obtained from Dr. Alfred N. Goldsmith, Ph. D. director in charge, or from the dean of the College, Carleton D. Brownson.

* * *

L. L., Bay City, Mich., inquires:

Ques.—(1) How far apart should the wires be placed on an aerial which has a mean height of 70 feet and a flat top length of 60 feet? The lead-in is to be taken from the center of the flat top.

Ans.—(1) No advantage is derived from spacing the wires more than 2½ or 3 feet.

Ques.—(2) Approximately, what would be the wave-length of this aerial if the lead-in were 80 feet in length?

Ans.—(2) Approximately 125 meters.

Ques.—(3) Please give the dimensions for the loading coils of an 18,000-meter tuner used in connection with a coupler which ordinarily tunes to wave-lengths of 600 meters.

Ans.—(3) Generally speaking, a 600-meter coupler has insufficient values of mutual inductance for efficiency with the longer waves. Before you begin the construction of a coupler of this type, you should take into consideration that there are no stations that operate at wave-lengths of 18,000 meters. A tuner having a range above 12,000 meters is useless.

The receiving set described in the second revised edition of "How to Conduct a Radio Club" will be adjustable to 10,000 meters and if the length of all coils is doubled, the tuner will respond to about 15,000 meters.

* * *

C. A. S., Salem, Mass.:

It is not advisable to wind the loading coil in the antenna system with No. 28 wire. No. 24 wire is preferrable. Regarding the long distance receiving apparatus for response to waves of 6,000 meters upwards; you should construct apparatus like that described in the second revised edition of "How to Conduct a Radio Club." The tuning coil you mention, which is 11 inches in length, 2½ inches in diameter, wound with No. 24 wire, will respond to waves up to 2,000 meters. You should have no difficulty in hearing WCC with this apparatus.

* * *

C. C. H., Pennsylvania:

The third revised edition of the book, "How to Conduct a Radio Club," which is now on the press, will contain a number of circuit diagrams suitable for your long distance receiving set. The second revised edition of this publication contains a diagram for a "beat" receiver which you would do well to duplicate.

C. L. W., Colima, Mich.:

If your apparatus will respond to the time signals of Arlington during the daylight hours, you should have no difficulty in receiving them at night. Perhaps you have listened in at the wrong time. The night signals are sent out at ten o'clock at night. Eastern Standard Time. The apparatus you describe is well designed and cannot be improved upon.

* * *

H. O. H., Detroit, Mich:

You are quite right in believing that the capacity of the condenser in the closed oscillation circuit of a transmitter must vary somewhat with the speed of the rotary gap. No definite rule, however, can be laid down for the design of the rotary disc as it will depend a great deal upon the operating characteristic of the transformer. When a condenser is charged by a 60 cycle alternating current, there is generally no advantage in constructing a rotary spark gap to give more than 300 or 400 sparks a second. By special design, these gaps and transformers can be constructed to give 1,000 sparks a second, but this does not apply to the usual amateur outfit. It makes no difference whether the disc is run at a high speed with a few number of points or at low speed with a great number of points. In either case the interruptions per second will be the same. Furthermore, the spacing of the electrodes on the disc is immaterial provided they are not so close as to permit the spark to discharge to two electrodes at one time.

With the average amateur set, the correct value of condenser capacity and the speed of the disc are best found by experiment. In any event, a capacity of less than .01 microfarad must be employed. The adjustment for maximum should be gone about in the following manner: The open and closed oscillation circuits should be carefully tuned with a wavemeter or hot wire ammeter and the speed of the rotary disc adjusted until the maximum value of antenna current is obtained, taking care that the pitch of the spark note is not sacrificed thereby. Experiment reveals that the average amateur non-synchronous rotary spark gap will give better signals at the distant receiving station when revolved at such speed as to give 200 to 240 breaks a second.

Regarding the sounds issuing from your aerial: These are undoubtedly brush discharge and are due, of course, to excessive voltages. The remedy is to employ a looser coupling at the oscillation transformer.

* * *

A. W., Sylvan Grove, Kas., inquires:

Ques.—(1) Would a lightning rod or telephone or electric light wires interfere with the reception of wireless waves on an indoor aerial?

Ans.—(1) These conductors would absorb part of the energy from the passing wave, but they will not wholly prevent the reception of signals. In fact in certain cases a certain amount of energy picked up by the telephone or nearby wires may be re-radiated into your receiving aerial, resulting in increased strength of signals.

* * *

H. N. M., Covington, Tenn., inquires:

Ques.—(1) In what edition of the book, "How to Conduct a Radio Club," does the formula for the calculation of inductance mentioned in a recent article in THE WIRELESS AGE, appear?

Ans.—(1) In the second revised edition, also in the third edition which is now on the press.

Ques.—(2) I have heard that a wireless telephone set can be made from an ordinary ½ K. W. transmitting set. How is this accomplished?

Ans.—(2) The spark gap is connected directly to the secondary winding of the transformer and the terminals of the gap connected in series with the antenna. A microphone transmitter is connected in series with the earth lead. When the spark discharges across the gap, owing to the small capacity of the antenna, an arc will result, that is to say, the antenna will discharge at an extremely high spark frequency, at a rate sufficient to permit the modulations of the human voice to be transmitted. The amplitude of the oscillations in the antenna circuit is varied by speaking into the microphone and corresponding variation of the received current takes place at the receiver.

* * *

G. C. H., Fort Stockton, Tex., inquires:

Ques.—(1) Referring to your reply to the query of R. A. Danville, Pa., appearing on page 366 of the February, 1917, issue of THE THE WIRELESS AGE: Is there any method of eliminating this sort of interference at the receiving station such as by the connection of a fixed condenser in series with the power wires to the ground? Is shunting the "leak" in the power circuit the only way to get rid of this interference?

Ans.—(1) The only method that we know of is to stop the leak in the power circuit.

* * *

W. M., Springdale, Ark.:

There is no better way to determine the range of your receiving apparatus than by learning the Continental Telegraph Code and listening to stations which are in operation. After you have obtained the call letters of the station, refer to the Government Call List and then measure the distance off on a map and you will have the range of your apparatus.

* * *

A. S. R., Wisconsin:

We know of no method by which you can eliminate the interference caused by the sparking of the trolley wires. The fluctuation of the current in the trolley wires either acts upon your aerial, by ordinary induction or the spark at the trolley wheel sets up a highly damped wave which will set your receiving aerial into excitation regardless of the wave-length to which it is adjusted.

In the second revised edition of the book, "How to Conduct a Radio Club," a balancing out aerial which may assist in eliminating this interference is described. In some cases this apparatus has proven satisfactory while in other cases it has been only partly effective.

* * *

F. A. T., Fort Stanton, New Mexico, inquires:

Ques.—(1) Will you be kind enough to state the probable wave-length of an aerial, the flat top portion of which is 250 feet in length with an average height of 75 feet and the lead-in 90 feet in length.

Ans.—(1) The fundamental wave-length of this aerial is approximately 500 meters.

Ques.—(2) Could a series condenser be used for the reception of 200-meter waves, and if so what should be the capacity?

Ans.—(2) The aerial is by far too large for the reception of 200-meter signals even with a series condenser. The flat top portion should be reduced to a wave-length of approximately 100 to 110 feet for the reception of 200-meter signals.

* * *

H. V. H., Kansas City, Mo., inquires:

Ques.—(1) Please state the wave-length, inductance and capacity of a T aerial, 42 feet in length, with an average height of 52½ feet. It consists of four No. 14 copper wires, spaced 2 feet apart.

Ans.—(1) The natural wave-length of this aerial is about 112 meters, the capacity approximately .0002 microfarad, and the inductance about 15,000 centimeters.

Ques.—(2) Would you advise changing this to an inverted L aerial for transmitting?

Ans.—(2) The L aerial would require less inductance to radiate the wave of 200 meters and the resistance of the antenna circuit would thereby be reduced.

Ques.—(3) What is the possible wave-length adjustment of a receiving coupler the primary of which is 7½ inches in length, 5 inches in diameter, wound for 7 inches with No. 26 silk covered wire? The secondary winding is 7½ inches in length, 4½ inches in diameter, wound for 7 inches with No. 32 silk covered wire.

Ans.—(3) This tuner will respond to waves 4,000 meters in length provided the correct values of capacity are employed across the secondary winding.

Ques.—(4) Is this coupler large enough to receive signals from Nauen, Germany, if the proper loading coils are supplied, together with an audiotron detector?

Ans.—(4) This coupler is quite large enough for transferring the oscillations from the antenna to the closed circuit.

Ques.—(5) Kindly give dimensions for the necessary loading coils?

Ans.—(5) Correct dimensions for these loading coils appear in the second revised edition of the book, "How to Conduct a Radio Club."

N. R. B., Tacoma, Wash., inquires:

Ques.—(1) Please give me the dimensions of an inductively-coupled receiving tuner that will respond to 600 meters.

Ans.—(1) The secondary winding for this tuner should be 2½ inches in diameter, wound for 2 inches with 200 turns of No. 32 S. S. C. wire. The primary winding should be about 3 inches in diameter, 4 inches in length, wound with 220 turns of No. 26 S. S. C. wire. This coupler will respond to waves slightly in excess of 600 meters.

* * *

R. T., Poughkeepsie, N. Y.:

The book, "How to Conduct a Radio Club," contains innumerable circuit diagrams of the vacuum valve detector and full instructions for the connection of a variometer.

The variometer inductance is preferably connected in series with the antenna circuit, although one may be used in the secondary circuit if desired.

* * *

H. S. H., Orrville, Cal.:

Any of the vacuum tube bulbs obtainable in the amateur market, can be used as an amplifier. By connecting an iron core transformer around the fixed stopping condenser of your detector circuit and extending the terminals of the secondary winding to a second bulb, the signals received on a crystal detector can be amplified. A complete circuit of this type is given in the book, "How to Conduct a Radio Club."

* * *

M. B., Corpus Christi, Tex., inquires:

Ques.—(1) I have a T aerial, 65 feet in length, 70 feet in height, comprising four wires spaced about 2 feet apart. Please state the natural wave-length of this aerial.

Ans.—(1) The fundamental wave-length of this aerial is approximately 150 meters.

Ques.—(2) To what wave-length can this aerial be loaded for receiving purposes?

Ans.—(2) If a supersensitive vacuum valve receiver circuit is employed, this aerial could be loaded for wave-lengths up to 7,000 or 8,000 meters. In fact it would be possible to receive signals at the wave-length of 10,000 meters, but with not quite the strength of signal that could be obtained with a larger aerial.

Ques.—(3) What is the call of the Government wireless station at San Diego, California?

Ans.—(3) NPL.

* * *

S. W. P., Hagerstown, Md., inquires:

Ques.—(1) What is the natural wave-length of my aerial which is 132 feet in length consisting of 4 wires spaced two feet apart? It is 40 feet in height.

Ans.—(1) The natural wave-length of this is approximately 240 meters, and when the secondary winding of the oscillation transformer is connected in series, the emitted wave will be increased in length, depending upon the amount of inductance in use.

H. L., Brooklyn, N. Y., inquires:

Ques.—(1) I note that the table of natural wave-lengths of aerials given on page 26 of "How to Conduct a Radio Club" differs widely from the tables given by A. S. Blatterman on page 108 of the November number of The Wireless Age. Can you explain the difference?

Ans.—(1) The data in the table of "How to Conduct a Radio Club," were computed from the formula given by Dr. Cohen in February, 1913. Mathematical investigation revealed later that in oscillation circuits where the values of inductance and capacity were distributed rather than concentrated, as in the case of the closed circuit oscillator, a certain correction factor must be introduced into the usual equation for calculating the frequency of the oscillations in the closed circuit. The data given by Mr. Blatterman were calculated in accordance with Dr. Cohen's latest exposition of the facts. Hence the difference between the two tables.

In your question No. 2 you inquire concerning the natural wave-length of an aerial. It is evident from your first query that you possess a copy of the November, 1916, issue of The Wireless Age, and you should refer to the data given in that issue for determining the fundamental wave of an aerial from its dimensions. The Cape Cod station transmits at fifteen minutes after ten o'clock at night, Eastern Standard time.

Regarding your rotary spark gap: The best way to determine the correct speed of the disc is to set it into rotation and note the readings of the aerial ammeter. The disc should be run at a speed that will give the maximum flow of current in the antenna circuit, provided the pitch of the spark note is not sacrificed thereby. Generally the best results will be obtained if the disc is revolved to give about 200 or 250 sparks per second.

* * *

A. J. B., New Orleans, La.:

The November, 1916, issue of The Wireless Age gives full data for the calculation of a fundamental wave of an aerial from its dimensions. The second revised edition of the book, "How to Conduct a Radio Club," shows fully how the inductance of the secondary winding or the primary winding of a receiving tuner can be computed. The third revised edition of this volume, now on the press, gives more detailed information regarding the method of calculating the possible wave-length adjustment of a receiving set.

The tuner you describe will respond in the secondary winding to waves 4,500 meters in length.

* * *

H. H. L., London, England:

Unless you state specifically the particular type of Murdock tuner to which reference is made, we cannot compute the dimensions of the loading coils for obtaining a definite wave-length adjustment. We are not familiar with the windings of all makes of am-

ateur tuners. You could easily ascertain for yourself the exact dimensions of a loading coil if you would calculate the inductance from the formula given in the book, "How to Conduct a Radio Club." If you will count the number of turns in the secondary and primary windings of your receiving tuner and substitute the necessary dimensions in this simple formula, the inductance of the winding will be readily obtained. To compute the possible secondary wave-length adjustment, you must assume a certain value of capacity in shunt to the secondary winding. Similarly, you must know the capacity and inductance of your aerial to compute the possible wave-length adjustment in the primary circuit.

In the November, 1916, issue of The Wireless Age, the capacity of various sized aerials (inverted L and T types) is given, and by the use of these data you can easily calculate the size of the inductance required to obtain a definite range of wave-lengths by the following formula:

$$L = \frac{(\text{wave-length})^2}{3552 \times \text{capacity}}$$

Regarding the secondary condenser: One of .0004 microfarad, as you suggest, will do. Generally there is no advantage in using a capacity in excess of this across the secondary winding.

The use of multi-layers loading coils is not advised except in the case of long wave tuners. There is also no necessity for coupling between the aerial loading coil and the secondary loading coil provided the tuner has the proper amount of mutual inductance. If it does not possess the required value, then a certain amount of coupling between these two coils will be of advantage.

Any electrical supply house in Greater New York, such as the Manhattan Electrical Supply Company, or others, will be able to give you the cost of various insulating materials, like bakelite, asbestos wood, etc.

* * *

A. B. L., St. Louis, Mo., inquires:

Ques.—(1) Can you tell me of any publication which shows in detail how to assemble and construct a closed core transformer? I want a full set of drawings and detailed instructions.

Ans.—(1) "Wireless Telegraph Construction for Amateurs," by A. P. Morgan, and "Experimental Wireless Stations," by Philip Edelmann, tell of the construction of closed core transformers in detail.

An excellent article on amateur transformer design was published in the December, 1915, issue of The Wireless Age. This article was entitled "Designing Your Own Transformer" and was written by R. H. Chadwick.

* * *

N. L. D., Findlay, Ohio, inquires:

Ques.—(1) Will the inductively-coupled receiving tuner described in the Third Prize Article of the February, 1917, issue tune to waves of 3,000 meters? If not, will you kindly furnish dimensions of a tuner of this type, which will tune to this wave-length?

Ans.—(1) The tuner described will respond to 3,000 meters provided a small variable condenser is connected in shunt to the secondary winding. If you should place a reversing switch between the two coils comprising the primary and the two coils comprising the secondary, you could change the connections so that when the two coils in either winding are concentric, the inductance can either be zero or at a maximum value, depending upon which way the current circulates through each. To be more explicit, when the movable coil of the primary is directly over the stationary (primary) coil, and the current circulates in both coils in opposite directions, the inductance will be practically zero. However, if you reverse connections (while in this position) so that current circulates through both windings in the same direction, a large value of inductance will be obtained, which will not only be the result of the self-inductance of the two coils, but also of their mutual inductance.

Ques.—(2) Should as good results be obtained with this type of tuner as with the conventional type?

Ans.—(2) This type of tuner will not be quite as efficient on the shorter range of wave-lengths because when small values of inductance are employed, the current in both the primary and secondary winding is required to circulate through a number of turns of wire which are really of no use. Hence the damping of the oscillations will be increased and a slight decrease in efficiency result thereby.

Ques.—(3) Is it true that a variable shunt condenser is not necessary for close tuning of the secondary circuit?

Ans.—(3) A variable secondary condenser is not necessary with any type of tuner, but better results are obtained by the use of slight values of capacity across this winding. To say the least, this condenser permits a closeness of adjustment of the inductance of the secondary which the usual multi-point switch does not afford.

Ques.—(4) Where can I obtain a copy of "List of Radio Stations of the U. S."

Ans.—(4) The list is on sale by the Wireless Press, Inc., 42 Broad street, New York. The Government Call Book can be obtained from the Government Printing Office, Washington, D. C.

* * *

S. T., Ottawa, Ill., inquires:

Ques.—(1) Will a quenched spark gap increase the pitch or the tone of the spark generated by a spark coil?

Ans.—(1) It may have an effect of smoothing out the tone, but it will not increase the pitch.

Ques.—(2) Approximately, how much will a quenched gap cost?

Ans.—(2) It depends entirely upon its construction. Generally they are found to be

rather expensive because the sparking surfaces must be milled to the thousandth of an inch in a milling machine.

If, as you state in your last question, the noise of the plain spark gap is objectionable, why not enclose it in a muffling box?

* * *

T. C. R., Vancouver, British Columbia, inquires:

Ques.—(1) How can one tell if the high-voltage condensers are broken down?

Ans.—((1) A breakdown of the condensers will be immediately manifested by no sparking at the spark gap. Generally the discharge of the broken plate is directly visible and in this manner it can be located.

* * *

J. C., Brooklyn, N. Y.:

Ans.—(1) We cannot undertake to calibrate a wave-meter for you and publish the results in this department. If you will refer to the second edition of the book, "How to Conduct a Radio Club," you will find a calibration for a small wave-meter made up of Mesco variable condenser and a coil of wire of fixed dimensions. A complete table of wave-lengths is supplied.

Ans.—(2) Your apparatus is properly connected and should give good results. The difficulty of arcing at the key is probably caused by too much current flowing through the primary winding of your induction coil. Some adjustment of the flow of current should be obtained by variation of the exposed surface of the fine wire electrode of the electrolytic interruptor.

If we should reply in detail to your third query, we should be required to publish a list of all wireless stations on the Atlantic and Gulf coasts. Full information concerning the call letters of these stations appears in the Government Call Book, a copy of which can be purchased from the Government Printing Office, Washington, D. C.

* * *

W. K. S., Jr., Clifton Forge, Va.:

Your 750-foot aerial has a fundamental wave-length of 1,150 meters. The receiving tuner you have described will permit adjustments in the secondary winding to waves of 4,000 meters. The wave-length of the antenna circuit with the primary winding connected in series will be approximately 4,500 meters.

* * *

W. H. Y., Sacramento, Cal., sends us a wiring diagram of a proposed break-in system. In this diagram two aerial wires lie parallel and are only separated by ten feet. One is connected to the transmitting apparatus and the other to the receiving apparatus. A small electromagnetic switch disconnects the receiving apparatus on the receiving aerial just previous to pressing the transmitting key. He desires our opinion of the working qualities of the arrangement.

The device is not practical because the receiving aerial will pick up a great amount of energy from the transmitting aerial. In fact, oscillations of such strength will be induced in the receiving apparatus that the oscillations will jump the gap at the magnetic switch.

In his second question he desires to know the dielectric constant of the glass used in ordinary photographic plates. The value can only be found out by actual test, but with this grade of glass it averages about 4.5.

The same inquirer seems to have difficulty with the three-element vacuum valve. He finds that the degree of vacuum apparently changes and that different values of voltage are required from time to time.

This difficulty is encountered in all types of valves in which there is a considerable amount of gas present and it can be compensated for by gradually increasing the voltage of the battery in the local telephone circuit.

* * *

O. R., Strand, London, England:

Ans.—(1) The regenerative vacuum detector circuits are without doubt the most sensitive of all types of receiving apparatus. You are, of course, aware that the vacuum valve can be used as a combined amplifier and beat receiver, all functions being performed by the single bulb.

Ans.—(2) It makes little difference whether the tuning of the antenna circuit is accomplished at the primary winding or at the aerial tuning inductance. All the inductance of the antenna circuit can be combined in the primary winding, but in many cases, it is more convenient to mount the aerial tuning inductance separate from the remainder of the apparatus.

Ans.—(3) A three-step amplifier can be readily employed to step-up the signals of a "beat" receiver. An audio frequenty transformer must be placed in the local circuit of the valve which produces the best current.

* * *

W. B., Fort Dover, Ont.:

You and others are advised to purchase a copy of the book, "How to Conduct a Radio Club," and calculate for yourself the inductance of the windings of your receiving tuner. Knowing the capacity of the antenna with which it is to be employed and also the capacity of the secondary condenser, you will have no difficulty in calculating the possible wave-length. adjustment of your apparatus. The inductance of the loading coils for the tuner you have suggested can also be easily reckoned in this manner. We would not advise you to construct receiving apparatus for wave-lengths in excess of 10,000 meters, as high-power stations do not normally operate at waves in excess of this value.

The 5¼-inch tubing you have on hand can be used quite as readily as the 6-inch tubing mentioned in the book, "How to Conduct a Radio Club." It makes little difference if the dimensions given in that volume are not exactly duplicated. For example, if the coils are slightly larger or slightly smaller than the dimensions given, the lack of inductance can be compensated for by a condenser in shunt to the primary winding and by the use

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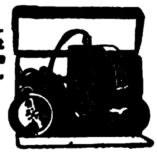

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* * *

F. J. B., Chicago, Ill.:

A previous issue of The Wireless Age described fully the construction of a dead end switch. This switch merely disconnects some portion of the primary and secondary winding of a receiving transformer which is not in use at a particular wave-length adjustment. It is customary to divide the primary and secondary windings into groups convenient for operation on standard wave-lengths. For example, enough inductance should be included in the primary winding to permit a wave-length adjustment of 600 meters. At this point the winding should be interrupted and two leads extended out to a switch. Then all unused turns of the primary winding will be metallically disconnected from the used turns and the energy losses usually resulting therefrom be reduced to a minimum.

* * *

A. S., Albany, N. Y.:

A commercial operator is required when at sea to be six hours on duty and six hours off until the ship makes the next port. He is not required to be on duty in port, but he must keep in close touch with the officers of the ship and the local office of the wireless company. In the event of the ship docking in New York Harbor, the operator is required to report to the head office of the company daily.

* * *

L. R., Dayton, Ohio:

Complete plans for the construction of ½ k.w. closed core transformer appear in the book, "Wireless Telegraph Construction for Amateurs," by Alfred P. Morgan. The December, 1916, issue of The Wireless Age contained an article by R. Chadwick which gave very important information concerning the design of an amateur transformer.

* * *

A. T. B., Decatur, Ill.:

The porcelain base battery rheostat of the type used in the vacuum valve detector set can be purchased from almost any electrical supply house. The Manhattan Electrical Supply Company, New York City, will be able to furnish you with one of this type.

* * *

T. R., Newport, R. I.:

In the usual experiments, a two-wire receiving aerial will generally do as well as a four or six-wire aerial. It may be of advantage, in case the length of the flat top is limited, to use more than two wires, but in ordinary circumstances this number will do.

* * *

W. F. B., Sandwood, N. J., inquires:

Ques.—(1) What will be the spark frequency of my transmitting set which consists of a ½ K. W. 60-cycle alternating current transformer, high potential condenser and a rotary spark gap which has eight stationary electrodes and revolves 3,400 revolutions a minute.

Ans.—(1) The spark frequency will be approximately 488 sparks a second.

* * *

L. J., Des Moines, Iowa:

Therlo resistance wire can be purchased from the Manhattan Electrical Supply Company and also from G. H. Bunnell Company, New York City.

* * *

A. C., Paris, France:

Dead end switches are of great value to a receiving tuner which has large values of inductance but which sometimes is operated at short wave-lengths. In such cases the cutting off of the unused turns of the winding, gives increased strength of signals.

Complete circuit diagrams of vacuum valve amplifiers and detectors of all types appear in the third revised edition of the book, "How to Conduct a Radio Club," which is now on the press.

The receiving apparatus shown in the diagram of connections accompanying your query would not function satisfactorily on the shorter waves, such as 600 meters because the natural wave-length of the antenna-circuit will be close to 2,000 meters. An aerial of this length can not possibly be reduced to 600 meters by condensers. When the aerial tuning inductance (which you have marked as coil No. 1) is connected in series with the antenna circuit, it will respond to waves up to approximately 5,500 meters.

* * *

R. A. B., Buffalo, N. Y.:

It makes no difference whether the secondary pancakes of a transformer are wound in the same or opposite directions, provided they are properly connected so that the current flows in the same general direction throughout the entire set of windings.

The vibrator of an interruptor may be made of phosphor bronze or spring brass The contact points are, of course, made of platinum.

* * *

J. H., Jr., New York City:

Full information concerning amateur licensed certificates can be obtained from the chief radio inspector, Custom House, New York City.

* * *

V. V. V., Lodi, Cal.:

The 20,000-volt transformer mentioned in your query is recommended. A transformer with a 40,000-volt secondary places great strain on the condenser jars and on the insulation of the apparatus throughout.

A complete diagram for the amplification of signals by two-vacuum valve bulb, appears in the third revised edition of the book, "How to Conduct a Radio Club."

Two loose couplers can be quite readily connected in series both in the primary and secondary windings for the reception of longer waves provided the secondary windings do not oppose. The proper connection can

be readily obtained by trial; if signals are not obtained in one way, the secondary connections can be reversed.

* * *

W. R. M., Bangor, Me.:

We cannot publish in the columns of this magazine the complete operating schedules of various radio stations throughout the United States. The hours of service of most stations appear in the Government Call List, a copy of which can be purchased from the Government Printing Office, Washington, D. C.

The black line opposite the coil L-5, on page 218 of the December, 1916, issue of THE WIRELESS AGE means nothing. The variable contact, T, is fully explained in that issue.

Your aerial, 30 feet in height, 51 feet in length, has a fundamental wave-length of about 98 meters.

* * *

S. H. L., Greensboro, North Carolina, inquires:

Ques.—(1) Would a No. 16 tin wire make a good earth wire?

Ans.—(1) It might do for receiving earth wire, but it is not large enough for the transmitting earth connection. Several copper wires should be used in this case.

Ques.—(2) How many wires should a receiving aerial have?

Ans.—(2) Two wires will do in most cases.

Ques.—(3) Should the lead-in wire be the same kind as the aerial wire?

Ans.—(3) The lead-in should have the same number of wires as there are in the flat top.

Ques.—(4) What is the approximate wave-length of an aerial 100 feet in length, 50 feet in height comprising two wires spaced 2½ feet apart?

Ans.—(4) Approximately 175 meters.

Ques.—(5) I often hear the term "dead end" employed. Will you kindly explain it?

Ans.—(5) The dead end turns of a receiving tuner are those turns which are not actively connected in either the open or closed circuit at any particular wave-length adjustment.

* * *

A. J. H., Windsor Locks, Conn.:

In any event you cannot use a condenser the capacity of which exceeds .01 microfarad, for the 200-meter value, and since the Leyden jars constructed by the Marconi Company each have a capacity of .002 microfarad, you would require four (connected in parallel) for use with your transformer.

* * *

C. W. S., Modesto, Cal.:

From our calculations the natural wave-length of your upper aerial must be about 190 meters and when the secondary winding of the transmitting oscillation transformer is connected in series, the emitted wave will exceed 200 meters. We suggest that you remove the lower aerial entirely, but make no change in the upper aerial. In fact, according to our calculations, the upper aerial already requires a short wave condenser.

F. E. Van A., Gilmore City, Iowa:

The 22,000-volt alternating current power line, which is near to your aerial, will undoubtedly set up inductive noises during the reception of signals, and the only remedy we know for this is the balancing out aerial described in the second revised edition of "How to Conduct a Radio Club."

* * *

A. B. L., Chicago, Ill., inquires:

Ques.—(1) Please give me a formula for calculating the capacity of the rotary variable condenser.

Ans.—(1) The following formula applies:

$$C = \frac{2{,}248 \times \left(\frac{3{,}1416\ A^2\ N}{2}\right) \times K}{D \times 10^9}$$

Where N = the total number of air spaces between the moving and stationary plates.

D = the thickness of air space between a moving plate and a fixed plate.

A = the radius of the movable plates in inches.

In the case of the air condenser, the value for K is 1; for paraffine paper it is about 2 and for hard rubber approximately 5.

* * *

J. B. L., New York City, inquires:

Ques.—(1) Please give me a formula for determining the capacity of condensers for transformers of various power ratings.

Ans.—(1) The following formula is applicable:

$$C = \frac{D \times 10^{12}}{E^2 \times N}$$

Where C = the capacity of the condenser in microfarads

KW = the kilowatt rating of the transformer secondary

E = the secondary voltage (effective).

N = the frequency of the primary current in cycles per second.

This formula is based upon the assumption of synchronous discharges, or two sparks for each cycle of the charging current.

* * *

D. V. B., Charleston, South Carolina, inquires:

Ques.—(1) Approximately, what is the specific inductivity of ordinary or common grades of glass such as the amateur may procure from a photographic supply house?

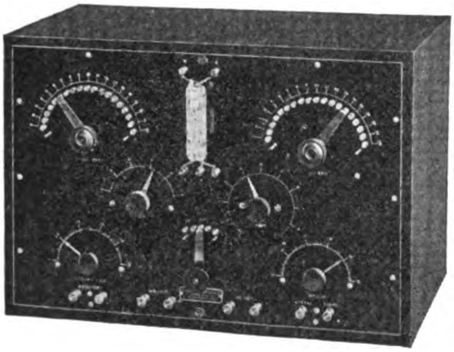
Ans.—(1) The inductivity of this grade of glass is rather low, generally no more than 4.5.

Ques.—(2) Is it of advantage to employ oil insulations in high voltage condensers?

Ans.—(2) Oil insulation is preferred, particularly when an extraordinary high potentials are employed.

Ques.—(3) How can I eliminate brush discharges?

GERMANY—ON AN 80 FOOT AERIAL



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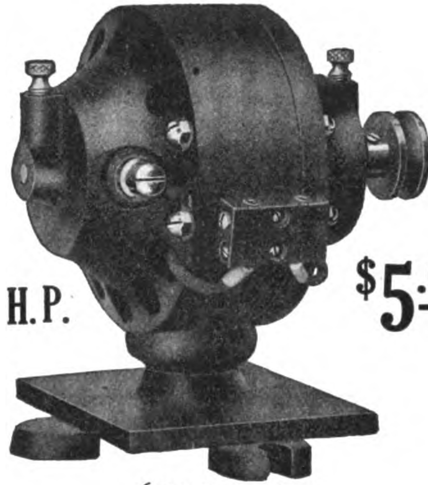

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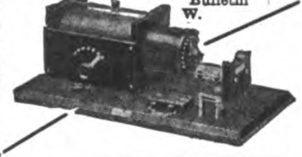

Send for Bulletin W.

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Ans.—(3) All corners of the tinfoil on the glass plate should be rounded off and the plates immersed in a god grade of Transil oil.

Ques.—(4) Which types of condensers secure preference in commercial work, the oil plate glass condenser, or the Leyden jar type?

Ans.—(4) The Leyden jar type is used in the majority of installations in the United States, principally because it is more convenient to install and handle and is not so difficult to repair in case of break down.

D. R. S., Chicago, Ill., writes:

* * *

A. B. K., Chicago, Ill., inquires:

Ques.—(1) Should the lower end of the ribs of an umbrella aerial be connected together?

Ans.—(1) They are usually so connected, but we have no data at hand to show that this is absolutely necessary.

Ques.—(1) Will you please explain the "Lepel" arc transmitter?

Ans.—(1) The Lepel arc transmitter uses a very short form of discharge gap which can be operated from either alternating or direct current. The arc gaps consist of two circular discs of copper with convex and concave surfaces having a thin sheet of paper between them. The discharge occurs between the discs through the paper. A small perforation is made near the center of the paper to afford a suitable starting place for the discharge. As this continues, the paper gradually burned away from the center outward. Since this burning takes place in an atmosphere practically devoid of oxygen, it requires several hours of use before the paper is completely burned up.

A groove is cut near the outside edge of the adjacent spaces of the copper plate to prevent the arc from getting to the outer edge of the disc and thereby being exposed to the air.

When this arc is connected to a condenser and oscillation transformer in the usual manner, a series of groups of oscillations are obtained, the frequency of which mav be exceedingly high. The effect is much similar to that obtained from the singing spark system of Thomson. But in addition to the arc effect, a certain quenching is obtained which is highly desirable.

To make the oscillations of the antenna circuit audible, a tikker, or chopper, is required at the receiver.

The oscillations of the antenna circuit (at the transmitter) may be varied periodically by shunting the condenser with a large condenser and inductance, the circuit including a telegraph key. When the key is closed, energy is withdrawn from the closed circuit at a rate corresponding to an audio frequency and accordingly the oscillations in the aerial will be damped and can be heard at the receiver with ordinary detectors.

FROM AND FOR THOSE WHO HELP THEMSELVES

(*Continued from page 505.*)

The writer's sounder was a twenty ohm. one with a brass lever, and was too slow in its movements in its original condition. The inductance was cut in half by breaking the wire connecting the two magnet spools, and operating the two spools in parallel instead of in series. The mass of the lever, however, was too great for the spring to return it with sufficient quickness, so a wooden lever was substituted. For the electrical connection a thin brass strip was led along the top of the lever, over the end, and back for about an inch on the under side. This strip was securely fastened to the lever, and silver contacts were soldered on the top and bottom to correspond with similar ones on the fixed contacts. The sounder is, of course, operated by a key and battery circuit in the usual manner.

The adjustment of the relay can be readily tested, as follows: Disconnect the transformer lead, and connect the lower relay contact to the rheostat circuit as well as the upper. Close one or more of the switches controlling the lights in the rheostat, and operate the key. The lights will, of course, be lit, whether the sounder lever is up or down, but there will be more or less flickering as it passes from one position to the other. By properly adjusting the spring and using a suitable lever and magnet winding, this can be made almost, or even quite, imperceptible. When this condition is reached the house lights will not be materially affected in sending, if proper rheostat values are used to balance the transformer. These values can be readily determined by experiment if the power consumption of the transformer is not known. When once the proper light switches are closed, it will not be necessary to make any change until a different power is used, as the main switch will put out all the lights when it is moved from the sending position. If only the power is to be balanced, this will be the only switch required.

E. C. Reynolds, *District of Columbia.*

James A. Norris, secretary of the Radio Experimental Club of New Orleans, died on February 28.