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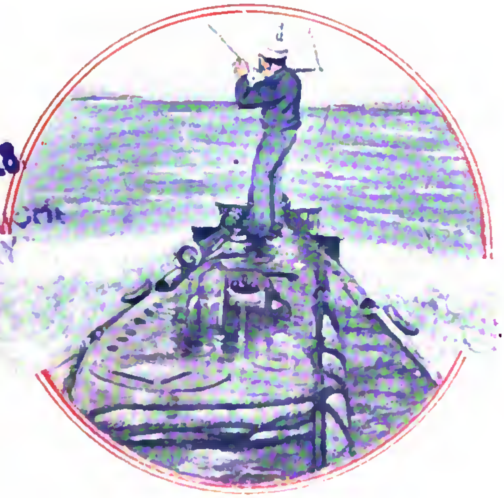

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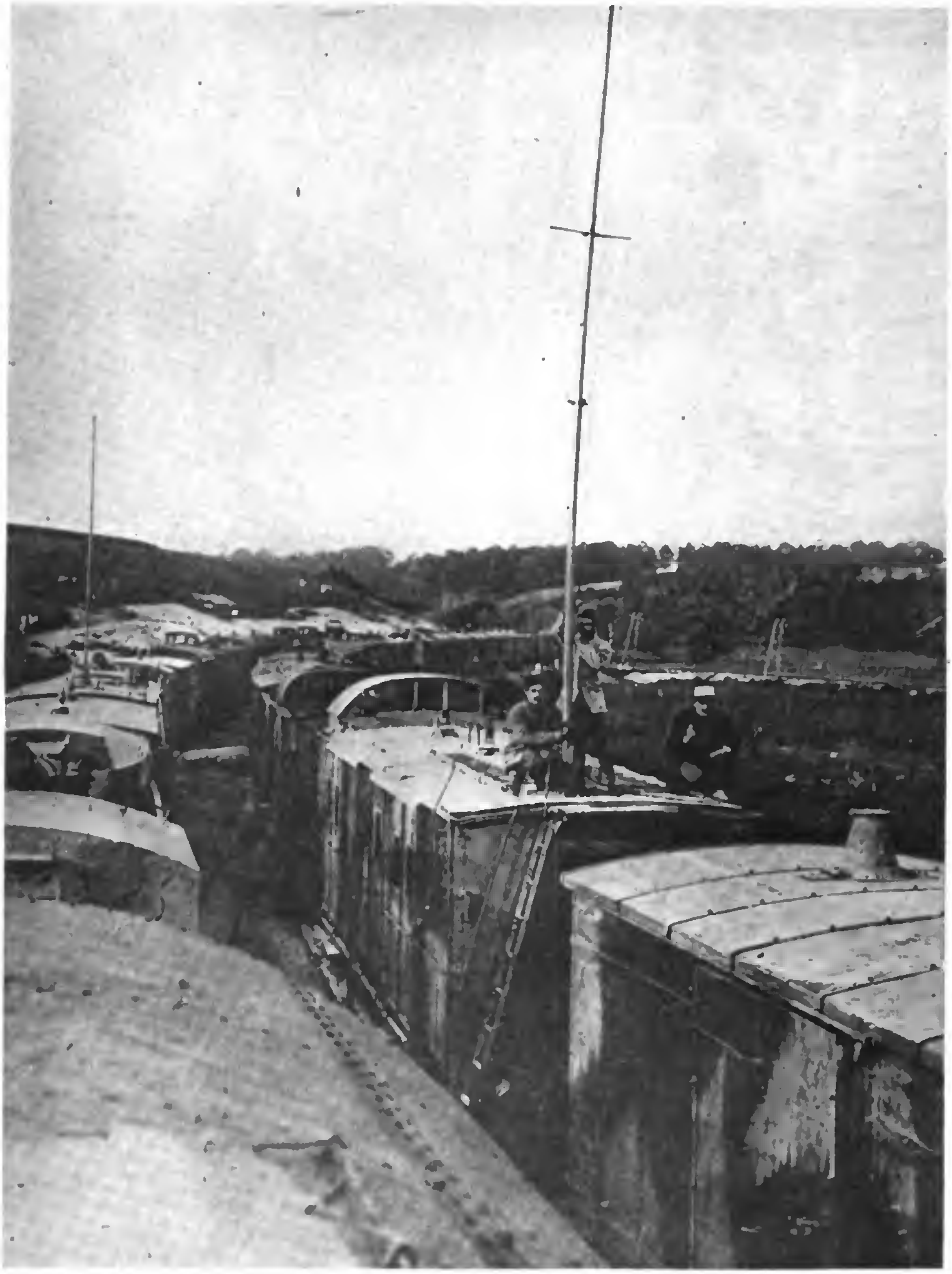


The lessons learned in peace times through the equipment of passenger railroad trains with a wireless dispatching system, are given practical application to war problems. The photo shows French soldiers at work erecting a wireless outfit on the top of a camouflaged train in the Marne district

VOLUME 5, No. 4 JANUARY, 1918

THE WIRELESS AGE

WORLD WIDE WIRELESS

German Station in South America No Myth

THE new disclosures made public by Secretary Lansing concerning Prussian trickery and intrigue in Argentina will not surprise anyone. Prussian methods could not be made blacker than they have already been proved to be. The new information merely constitutes additional evidence of the gigantic German conspiracy against the rest of the world. The total is complete and damning.

A little note in the Luxburg correspondence indicates that the German agent in Buenos Aires, in pursuance of orders from Berlin, actually erected a wireless station with a view to communicating directly with the wireless operators at Nauen, on German soil.

Buenos Aires is 7,000 miles from Nauen. It would be highly interesting to know whether such communication ever was established, and if so to what degree it was efficient.

Under date of July 20 Luxburg wired to Berlin:

"Receiving plant erected according to instructions. When does Nauen send at greatest strength, and which is the wave length?"

This means that a German radio plant had been erected in Argentina and that Luxburg wanted to know when the great German sending radio plant at Nauen sent and what were the wave lengths the Nauen station was using, so that the messages might be picked up in Argentina.

In the same message Luxburg shows that he had plenty of money for German propagandist and other operations at his command. He makes the statement to his home Government that his legation had 856,000 pesos in bank at Buenos Aires. Less than a month later there appears to have arisen some question regarding the radio concession and the transocean wireless service, for on August 16, in reply to a message from Berlin, Luxburg sent this significant message:

"Readjustment probable, not certain. Objections of Government regarding concessions have to be overcome. What amount is to be reimbursed to Transocean? What is desired is that the German Government as sleeping partner should share expenses up to date, half and half, with Siemens Schuckert, and also in future the working expenses of the company."

The Siemens Schuckert companies evidently are alluded to in this message. The Trading With the Enemy list issued by the United States Government on December 5, giving the names of enemy firms in South America with which Americans are forbidden to trade, included the "Siemens Schuckert Companies, Buenos Aires."

The word "Siemens" in the above Luxburg telegram was a sufficient cue to the American Government when it came into possession of this message. Officials recalled the connection of the Siemens interests with the German radio station at Sayville. It was the Atlantic Communication Company that asked for the license for the operation of the Sayville radio station. The license was refused, partly because the Atlantic Communication Company was owned by the Telefunken Company of Germany which is itself owned by the Siemens & Halske Company and the Allegemeine Electricirate Gesellschaft of Germany.

Marconi to Be High Commissioner to United States

ALTHOUGH no information is available either from Italian official sources or the State Department regarding the appointment of Mr. Marconi as Italian High Commissioner to the United States, it is assumed that he will come to this country in the same capacity as other High Commissioners named since the war to co-ordinate all of the war activities of his Government in the United States and arrange a closer co-operation with the American Government. His duties here will probably be similar to those of Lord Northcliffe for the British Government.

Senatore Guglielmo Marconi, who has been appointed head of the Italian Permanent Mission in America, made the following remarks in addressing the Senate on Italo-American relations:—

"The Italian mission to the United States again realized during its journey the great friendship and sympathy existing there for us and the great assistance the United States is ready to give us.

"The friendly feeling and concrete measures adopted by the American people in favor of Italy deserve our entire gratitude. We must consider the spontaneous American intervention in the war with special satisfaction."

Senatore Marconi was a member of the Italian mission which came to the United States last spring. After his return he served on the staff of General Piaz, the Italian commander in chief, with the rank of commander, giving special attention to the wireless system at the front.

Historical Brant Rock Station Demolished

A FIRM of contractors has bought the 420-foot wireless tower at Brant Rock, Mass., a familiar sight to Worcester summer visitors, and converted it into junk. The only signal tower like it in the world is on the north coast of Scotland.

The station cost the International Signal Company $1,000,000 to build, it being the first erected on the Atlantic coast, at which early experiments on the 500-cycle transmission apparatus were made, in the United States.

The tower was cylindrical in shape and supported by wire cable stays. The plant made 60 tons of scrap iron and steel, including the cylindrical standard and the wire cables.

President's Master Message Speeded by Wireless

THE record of two extraordinary circumstances will go down to posterity with President Wilson's masterly message giving the aims and basis for world peace. The first circumstance is the manner in which it was distributed throughout the reading world; second, the remarkably short time—one hour and forty-five minutes—it took to spread it broadcast.

A full half hour before the President's message was flashed to all the ends of the earth—to every point in Europe, Asia, Africa, Australasia, South and North America, every island in the Atlantic, Pacific and Indian Oceans, possessing a telegraph or wireless instruments, newspaper or courier service—word had gone out to "clear the way for an important address by President Wilson."

The mighty naval radio stations at the Brooklyn, San Diego and Darien were primed to play their part. Shortly after Darien, which is on the Isthmus of Panama flashed the word to the Pacific, Atlantic and Indian Ocean islands that something big was coming and to lend an ear, the operator at Heligoland, it is believed by naval officials, became immediately attentive. There was extraordinary power and punch in the Darien operator's key, and it is fair to assume the Prussian operators at the Hamburg, Kiel, Berlin, Karlsruhe, Frankfort, Prague, Vienna, Constantinople and Philoppopolis radio stations were brought to a sharp state of wakefulness.

Promptly at 12:30 o'clock, New York time, the director of the Division of the Foreign Press Service of the Committee of Public Information, signaled the cable companies and the naval radio station at Brooklyn to begin sending the President's message.

Until the message was fully transmitted seven men in the room were kept under lock and key. Advance word on the message would have been of tremendous importance in Wall Street.

The message from Washington came over the Government's private wire. After it was received it was read back to Washington by telephone to make sure that every word was correct.

The seven men in the room were the Director, his assistant, two naval officers, two operators and a stenographer. When the message was verified by Washington it was split into "cable takes" of about 100 words each, and the operators started their work. The message contained about 2,700 words.

American Marconi Company's Profitable Year

GROSS earnings of the Marconi Wireless Telegraph of America have nearly doubled during the period of the war, while expenses, including taxes, were less last year than in 1914. The company's net income for 1917 was $609,430, and undivided profits and reserves on December 31, last, amounted to $2,150,000. The capital stock is $10,000,000.

A comparative summary of receipts and expenses follows:

	1914	1915	1916	1917
Gross earnings	$756,572.75	$748,238.03	$862,501.55	$1,328,525.94
Deduct: Total expenses including estimated taxes	634,958.25	564,176.34	624,568.94	576,038.30
Net earnings from operations	$121,614.50	$184,061.69	$237,932.61	$752,487.64
Income from investment of surplus funds	150,274.21	104,932.97	98,107.98	97,442.86
	$271,888.71	$288,994.66	$336,040.59	$849,930.50
Deduct: Reserves for depreciation	122,011.24	111,678.15	76,151.79	240,500.00
Net income for year after charging reserves	$149,877.47	$177,316.51	$259,888.80	$609,430.50

Capital stock	$10,000,000.00
Undivided profits and reserves, December 31, 1917	2,150,000.00

These figures have been published by authority of the Directors as a statement preliminary to that to be issued prior to the Annual Meeting which will be held April 15, 1918.

Description of "Zep" Apparatus Given by Crew

SOME of the aerial secrets of the Kaiser's Zeppelins revealed by the capture intact of the L-49 at Bourbonne les Bains in France have now reached this country. The French censor did not permit detailed or technical descriptions of the giant raider to reach the press, but British and American expert observers were invited by M. Dumesnil, French under secretary for aviation, to examine the German craft, and through English sources some of the secrets of construction which they learned are now reaching the ears of American experts.

Perhaps the most interesting fact about the L-49 is the extent of its wireless equipment. The wireless installation is extremely highly developed. It is of the Telefunken type, capable of sending wave lengths of from 1,000 to more than 5,000 meters. The antenna, 400 feet long, is suspended from the craft.

Announcement has been made of what is known as the scheme of Zeppelin guidance from Germany. Before the war, as is known, Germany was literally dotted with high powered wireless stations. By a suitable reciprocal arrangement of the wireless apparatus of the L-49 and that of the other German raiders and of the chief of the high powered wireless stations in Germany, it is possible for the latter, according to the crew of the L-49, to tell within a very small margin of error the exact direction from which a Zep-sent message is received. A message from the L-49, for instance, would be simultaneously received by two widely separated high powered stations in Germany. These latter stations would then get in wireless communication themselves, and, by a simple computing of distance by angles, determine almost the precise location of the signaling Zep. This position, in terms of latitude and longitude, one of the stations then would wireless back to the operator on the L-49, who could thus direct a course regardless of fog or height or any uncertainty from breakage of instruments or weather obscurity.

In all probability, this so-called description of wireless guidance, given by the crew, is a distortion of the more probable use of the radio goniometer, or direction finder, which incidentally, appears to be playing an important role in the war.

Germany's Attempt to Establish a Station in Mexico

AGENTS of the German government attempted to establish a wireless telegraph station on the west coast of Mexico in 1914, according to testimony given in San Francisco on January 4th, at the trial of thirty-one persons charged with conspiracy in connection with a proposed revolution against British rule in India.

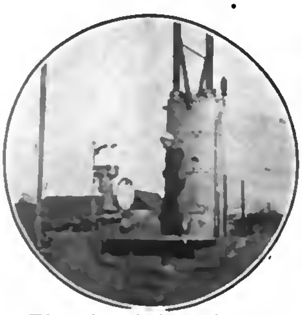
Gustave Koeppel, a shipping broker of San Diego, Cal., on the stand in the United States District Court, said he had arranged several details in the wireless matter for Baron E. von Schack, former Vice-Consul General for Germany in San Francisco. The plan failed, Koeppel said, when several persons engaged in the enterprise had been arrested by Mexican authorities, and the expedition returned to the United States.

A Cantonment With a Wireless Fire Alarm

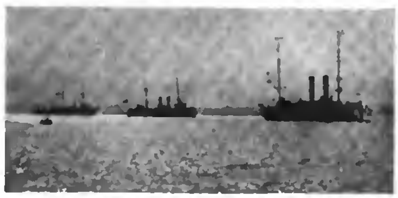
A WIRELESS fire alarm system has been installed at Camp Dix, Wrightstown, N. J., to protect the ten great storehouses where provisions and equipment for the entire cantonment are kept. It brings to the highest state of efficiency the system perfected by Lieut. John J. Sweeney, chief of the camp fire department, for the protection of the 2,200 buildings of the camp against damage by flames.

The system bids defiance to sleet and wind storms that destroy telephone lines and other means of communication. Thermostats in different parts of each building connect with a wireless sending outfit, which will automatically flash a fire signal to the headquarters of the 303d Signal Battalion. The operator on duty day and night can tell at a glance the building from which the signal comes. He will immediately relay the alarm and definite information as to the location of the blaze to fire headquarters.

Under the Sea in a Submarine



The dreaded periscope



Down the river in the cold gray of the morning

Speeding on the surface

By P. B. COLLISON

THE WIRELESS AGE has previously chronicled many hair-raising tales of encounters with submarines. In these accounts the "sub" was given the villain's role and little mention was made of the marvelous devices which make its capture so difficult. I recently spent two months aboard a fleet of six of these "mechanical fish," during which I went on several trial trips. In this article I have described the "sub's" working parts.

A trip under the surface of the water is an event to be long remembered. We started down the river in the cold gray of the morning with a fast patrol boat just ahead of us to keep our course clear when we were running submerged. Out past the forts into the open sea we sped, the boat throwing up a large bow wave, the spray of which blew back and whipped across our faces like an icy lash. Soon the order was given to prepare to "dive," and I entered the conning tower with the Captain. First, all railings, the wireless masts and aerials came down, the latter being stored in the forward hatch. The crew then went below and made the hatch fast and watertight. In a similar manner all other openings were quickly closed, and after a rapid inspection by the Captain we were ready to enter the domain of the fish. Sufficient water was then taken into our ballast tanks to neutralize the buoyancy of the hull.

To look out through the tiny glass ports of the conning tower and see the ocean rise and cover your decks is no pastime for a man with a weak heart. Gradually the water rises over the ports and you are in a world of green. You can see only a few feet ahead, really not more than ten. Unless in very clear water you can never see your own bow, contrary to various published statements; neither do the fish come up and smile at you through the glass. When one of these underwater craft enters their world the fish swim away. The ballast tanks were divided into enough compartments to allow the balancing of the boat because, if not exactly balanced, the craft would stand on end and sink down into

The particular boats which I surveyed are nearly two hundred feet long, blunt nosed, with a long tapering tail. From a birdseye view they resemble huge fish

the mud. We submerged to about fifteen feet below the surface and then set our periscope to look dead ahead. Off to one side we could see the patrol with her men peering at us with glasses. Dead ahead was the open sea. On the other side was a tug towing in a string of heavily laden barges. Overhead a gradually brightening sky smiled down on us, and about us was the peaceful calm of the depths.

Given the order to proceed ahead, we continued on our course. The electric motors gave little if any vibration to the hull. We slipped along through an unchanging green for quite a while and then the Captain asked me if I had looked up yet. Having been trying to pierce a solid wall of water with little success I wondered what I could see by looking up rather than ahead. Such a sight! The under-surface of the water appeared as a stormy sky across which were scurrying flashing patches of brightness. These phenomena were caused by the reflection of the sun on the waves at the surface and our own speed.

Looking through the periscope we saw a flock of wild ducks, frightened by those queer glass eyes rushing at them, jump from the surface of the water, and far ahead another pair of periscopes coming towards us almost hidden in a smother of foam. I then went below and using the "oscillator" tried to find out something about the approaching craft, but without success. However, in the course of a few minutes I learned that there was an "old Marconi Op" at the key.

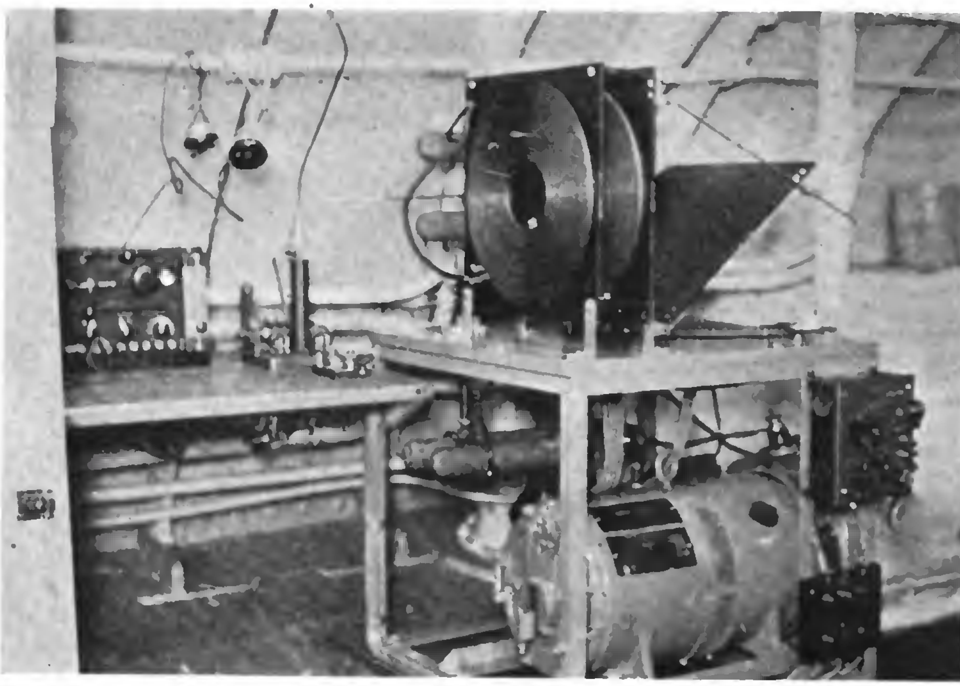
We altered our course to clear the other boat and then dove deep down. The Captain told me to keep a sharp lookout ahead as we were going to "porpoise" —whatever that might be. Next I realized that we were rushing to the surface at an angle of about thirty-five degrees from the horizontal. Looking ahead I saw the sea change to a lighter green and, as our tower started to emerge from the sea, a rushing of water was heard. Suddenly the green became white and then the sun broke into view. Immediately afterward we beheld our own bow rising up out of the water and we were again able to look around over a sparkling blue sea; but only for an instant. The bow again sank into a creamy foam and we observed a white crested wave rushing back at us. Instinctively we recoiled, believing that we were about to get wet, but of course the glass kept the water out. There came another rush and roar of water, the scene changed to the white foam of the water and then back to a beautiful pale green, and the silence of the depths was about us once more. We again proceeded quietly and shortly afterward came to the surface once more to show the patrol where we were and to shift our course into deeper water. Our ballast tanks still being full we did not open any of the hatches.

Ordinarily, when a submersible wishes to come to the surface the water is driven from the tanks by powerful pumps. This takes a few minutes. However, the Captain on this trip desired to make a test of the emergency depth gauge. The hull is only made to withstand certain pressures and since the pressure rapidly increases as you sink deeper it is necessary to have some method of quickly bringing the boat to the surface, should the horizontal rudders refuse to bring the craft up. They therefore carry several air flasks filled with air under terrific pressure to blow the water from the tanks. This causes the vessel to rise at once. These valves can be set to open at any depth. Our valves were set for a trifle less than 100 feet and we dove down past the danger point. With a rush and a roar the water was forced from the tanks and we were literally blown out of the water in a smother of foam and spray.

After opening the hatches we started the Diesel engines and proceeded on the surface back to the base. All hands made a rush for the open air as it was getting thick inside. But it was necessary to exercise caution, for the fresh air acts as an intoxicant and one is liable to become violently seasick or dizzy or both. The decks being still wet and very slippery, there is danger of falling into the water, which might result in being ground to pieces by the propellers.

The wireless mast and deck insulator are just at the point of the shears

All railings, the wireless masts and aerials came down before we submerged



The compartment which contains the wireless apparatus, also holds the underwater signaling diaphragms; the wireless operator is in charge of both

Because of the publicity given to its piratical activities, the outside of a submarine is familiar enough to all. I will therefore dwell lightly on these features. The particular boats which I surveyed are nearly two hundred feet long, blunt nosed, with a long tapering tail. From a birdseye view they resemble huge fish. Along the backbone is placed a light, flat superstructure or deck containing four small circular hatches which are surrounded by a light bronze cable supported by detachable stanchions. There is also a long slanting hatchway through which the torpedoes are lowered into the hull. A collapsible crane is provided to swing these long, slender, miniature submarines aboard, for they weigh close to a ton and sometimes more.

The next point of interest is the conning tower, from which protrude the antenna-like periscopes. The latter are protected and supported for a part of their height by curved, flat plates called shears. These shears are made in a streamlike form to lessen head resistance when the boat is running submerged. The conning tower with its tiny glass ports is placed just forward of the periscopes and likewise is protected by shears. A small "bridge" encircles the top of the tower and on this are mounted an engine room telegraph, electric steering gear control, and gyro-compass repeater. These are placed in a small watertight case supported on a pillar much like an ordinary compass stand except that it is made entirely of metal. When the boat is operating beneath the surface a watertight lid is screwed down over these controls. All movements of the boat on the surface are controlled from this point.

The wireless mast and deck insulator are located just at the point of the shears for the radio equipment. A very heavy electrose insulator set on the top of a heavy brass pipe with another electrose insulator placed at the bottom brings the lead-in wires to the apparatus. The wireless masts (of which there are two) are hinged at the deck and are lowered and "lashed fast" when the order is given to prepare for a "dive." The rear portion of the hull superstructure contains the engine room hatch and then the hull tapers off to the tail which supports two screw propellers and the vertical and horizontal rudders.

So much for the general appearance externally. We will now enter the hull through the hatchway nearest the bow. This hatchway is only eighteen inches in diameter. Upon entering the hull you must keep your head down and your eyes wide open. The deck space being rather limited all machinery possible is hung from the shell overhead, leaving scant headroom. I can truthfully state that "my first impression upon entering a submarine" was a dent caused by unexpected contact with an anchor windlass motor. This was fastened on a level with my face just back of the entrance ladder. One lesson was enough; on every occasion afterward when I came down that ladder I "ducked."

The first to meet the eye upon entrance are the "stingers" or torpedo tubes of which this boat was equipped with four, two above and two below. Water is prevented from entering the hull, when the breech plates are opened to place a torpedo in the tube, by an outside swinging bow cap. The procedure is to close the bow cap, then drain the tube, and by means of a small traveling crane place the torpedo in the tube. The bow cap is then turned and air, at a pressure of 2,800 pounds to the square inch, is admitted behind the torpedo. This drives the torpedo out with a rush and as it leaves the tube a small trigger is forced back which sets its tiny compressed air turbines into motion.

The torpedo will go forward until the air pressure no longer will drive the turbines. If it has missed its mark its sea-cocks are set so it will sink. Otherwise it would float about on the surface, a menace to friend and foe alike. Each of these vessels were supplied with eight torpedoes, four in the tubes and four on racks inside the hull. The space underneath the floor of this forward compartment is taken up by ballast tanks, fuel tanks, room for several air flasks, and a storage battery well. The fuel tanks hold more than 5,000 gallons of oil and the forward battery compartment holds sixty 3,500 ampere-hour storage cells. The sides of the shell give space for the lockers which contain the bedding and personal effects of the crew. The men sleep on cots when the weather is good, but in bad weather they sleep in hammocks swung from the shell overhead.

This compartment also contains the wireless apparatus and the underwater signaling apparatus. The latter device consists of two large, thick diaphragms set one on each side of the bow. The diaphragms are set into oscillation by solenoids through which pass a 500-cycle alternating current of about five kilowatts. The sound waves sent through the water travel up to forty miles or more, depending on the depth and density of the water through which they travel. The deeper the boat is submerged, the farther it can signal. A regular telegraph key is used and by means of the Continental Morse or any other code communication is carried on in a manner similar to radio. The wireless operator is in charge of the underwater system as well as the radio apparatus.

Through a watertight bulkhead, we next enter the "brains" of the boat. This part of the interior, known as the central operating compartment, contains a staggering number of air and water gauges and valves which control the buoyancy of the hull. One of the largest dials shows the depth at which you are operating. It runs up to 200 feet. There are also large brass wheels controlling the horizontal or diving rudders and the vertical rudder. Another gyro-compass repeater is fastened on the bulkhead in front of the helmsman. A small ladder leads up into the conning tower which is separated from the main hull by a small watertight hatch. This can be closed from beneath in case the conning tower is damaged by shell fire. Up here we see more gauges and appliances, also one of the periscopes. We look into an eyepiece much similar to a telescope and by means of large control handles the barrel can be swung around so as to view any portion of the horizon. Objects appear exactly as they do when viewed through a telescope.

The helmsman stands directly under the conning tower and steers under direction from the Captain, who, when the vessel is submerged, is always stationed at the periscope. Another larger periscope with an eyepiece in the operating chamber is used also to take observations because the upper one is usually pointed dead ahead, although it can be swung around to any angle. Besides the helmsman, men are stationed at the diving rudders and "Kingston" valves which open from the ballast tanks into the sea. Other men operate the pumps. In fact, every individual in the boat has a definite task and is highly trained to do just this and nothing else.

The electrical compartment contains the master Gyro-compass. The "master" compass is carefully installed in a safe place and being non-magnetic can be placed without regard to outside disturbing forces. Electrically operated relay "repeaters" are distributed throughout the vessel. These repeaters operate in any position and are connected to the master by a flexible armored cable which permits their being moved about if necessary. Here, also, is the electric stove with its grills and ovens. Food lockers and a sink fill one corner. At the rear of the compartment are the switchboards, controlling the charge and discharge of the main storage battery. Underneath the floor is a second set of sixty storage cells.

Two immense Diesel oil engines and the two generators are in the engine room. The oil engines propel the vessel when operating on the surface and at the same time drive the two electric generators which charge the battery. When operating under the surface the engines are stopped and the dynamos, connected as motors, drive the vessel at a slightly reduced speed. For slow speed the storage battery banks are connected in parallel giving a potential of about 120 volts; for full speed the banks are connected in series giving 240 volts. The battery is thus discharged evenly.

The battery is ventilated when charging on the surface by means of motor driven blowers which drive the gases out into the air. When under water the battery gases are blown into the hull to prevent a dangerous explosive accumulation in one compartment. After a few hours' run under water the air becomes quite warm and the gases, which are rich in sulphuric acid, condense on the cold inner walls of the hull and start to drip. It is therefore necessary for the crew to wear both water and acid proof garments.

The wireless sets on these boats give remarkable satisfaction when the handicap of a very low and short aerial is considered. Reception of signals over several hundred miles is common. Transmission is dependent on the length and height of the aerial.

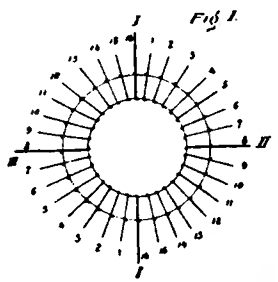
What camouflage does to a "sub"—Can you find it?

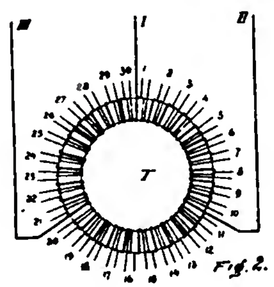
Radio Science

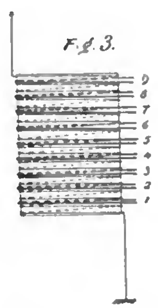
The Production of Continuous Waves by Spark Discharges

A SYSTEM for generating high frequency alternating currents, which is somewhat out of the ordinary, has been developed by Riccardo Arno, an Italian. By means of the arrangements shown in principle in figures 1, 2 and 3, and more in detail in figure 4, the inventor states that he is able to secure more than 30,000 spark discharges per second, resulting in a practically continuous flow of high frequency currents in a wireless aerial.

The system consists of the combination of a polyphase generator, a static phase transformer, designed to increase considerably the number of phases and







Figures 1, 2—Arno's special static transformer
Figure 3—Polyphase jigger

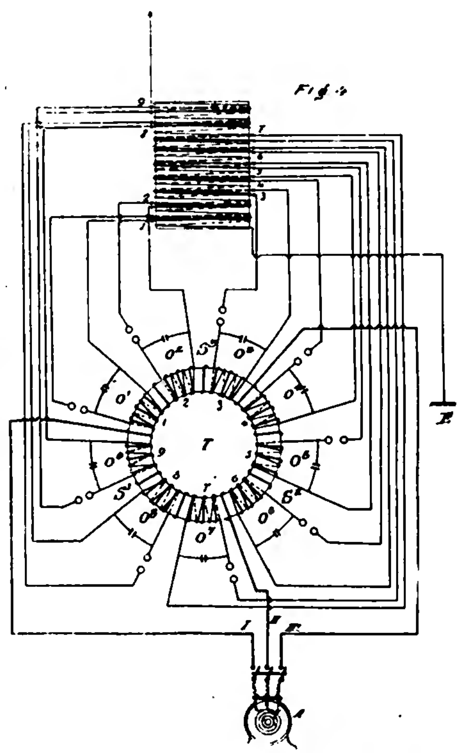


Figure 4—A spark discharger producing continuous waves

eventually to raise the tension of the current, and a series of spark oscillators actuated by these phases. The primary circuits of the spark oscillators are coupled to a single aerial.

Signor Arno observes that by the special static transformer shown in figures 1 and 2, he is enabled to obtain 32,000 sparks per second, provided the transformer is excited by 1,000 cycle alternating current and is constructed to give 16 phases of current.

The construction of the transformer is as follows: A torus of magnetic material carries a continuous winding. At equidistant points it is fed by a polyphase current. In the figure the feeding current is biphase. The phase of the difference of potential between two diametrically opposed convolutions, varies with the angles formed by this diameter with the diameters I, I and II, II. In the case of the figure, for example, the phase of the difference of potential between the points 4, 4, differs by one-eighth of a period from the feeding phases of the difference of potential I, I and II, II. By taking a sufficient number of points on the winding any desired number of phases may be obtained. In figure 1, for example, is shown an arrangement whereby a biphase system may be changed to a 16-phase system.

Suppose n to be the frequency of the polyphase current and N, K, the total number of phases drawn from the phase transformer; the total number of sparks which can be obtained will obviously be $2n$ N K.

It is entirely possible to construct machines of 1,000 frequency. Consequently, in order to obtain 32,000 sparks per second, the phase transformer need only furnish 16 phases, and if it is desired to employ a current of the frequency ordinarily employed in the industries, 60 cycles for example, then 32,000 sparks per second could be obtained provided the phase transformer supplied 320 phases.

In practice, the phase transformer consists of several bobbins, convolutions, or windings, regularly distributed over the whole circumference. The number of these bobbins is a multiple of 4 or 3, according as the current of the polyphase system of feeding is biphase or triphase. In the first case the bobbins are placed in pairs diametrically opposed, and consequently the number of phases is equal to half the number of the bobbins.

In event that the secondary voltage must reach a certain value and the E. M. F. of the alternator is not sufficient, two courses may be followed.

First, the difference of potential of the feeding phases may be raised by means of a transformer before sending it into the phase transformer.

Second, the phase transformer may be constructed with two coils, one for the feeding phases, and the other for the secondary phases. In this case, the phase transformer operates as a transformer of potential and can serve either as a system of connected phases or a system of disconnected phases (see for example, the triphase primary arrangement I, II, III and 30-phase secondary in figure 2).

Referring to the case in which the phase transformer consists of two distinct coils, the number of phases in the secondary system may be odd or even, and it will be readily seen how, inasmuch as the generation of electromagnetic oscillations is involved, it is more advantageous to adopt an odd number of phases of the secondary system. In fact, it is clear that in the case of an even number of phases, there would be the inconvenience of having the phases in pairs corresponding to an angular value of 180°.

To utilize a large number of phases a single aerial wire can be employed as represented in figure 3, which is a polyphase jigger.

The complete arrangement is shown in figure 4, in which a triphase alternator A, of 1,000 cycles, for example, is employed; by means of three connected phases I, II and III, this alternator directly feeds the triphase primary of the phase transformer. The 9-phase secondary furnishes the 9-single phase and disconnected high tension currents to the 9 corresponding oscillating circuits connected to a single jigger 1, which is represented separately in figure 3.

The Arno apparatus is not limited to the high frequency alternator mentioned; any type of generators or oscillators heretofore employed in connection with the wireless art can be connected up in a similar circuit.

Open Circuit Oscillators as Receivers

IT is well known that because of the relatively high resistance of the three-electrode vacuum valve it requires to be connected in a receiving circuit which will impress the maximum possible voltage for a given group of incoming oscillations. Such a secondary circuit will give the maximum strength of signals.

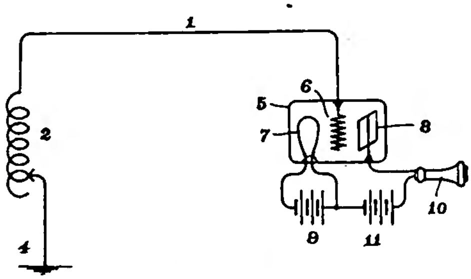


Figure 5—Bucher's valve detector circuit

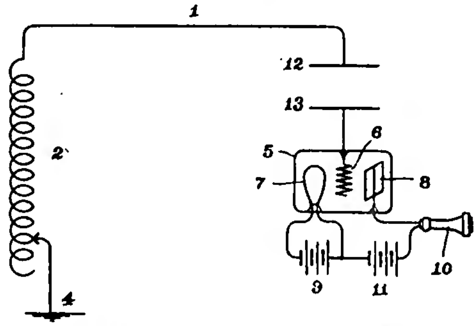


Figure 6—Circuit with alternative arrangement

An unusual detector circuit, shown diagrammatically in figures 5 and 6, is credited to Elmer E. Bucher. In both diagrams the three-electrode vacuum valve detector is connected to the free end of the wireless telegraph aerial, and at the opposite, or earth end, a tuning coil is inserted to tune the aerial circuit to resonance or impress the maximum potential on the grid of the vacuum valve for a given group of incoming oscillations. An alternative arrangement is shown in figure 6, where the grid of the valve is electrostatically coupled to the free end of the wireless telegraph aerial.

As in the usual wireless telegraph receiving circuits, the aerials of figures 5 and 6 may be tuned to resonance by variable condensers as well as by radio-frequency inductances.

Electron-Discharge Apparatus

STUDENTS of radio engineering who have followed the development of the pure electron-discharge apparatus will be interested in the perfection of a new vacuum tube by Dr. Irving Langmuir.

The filament of his new tube consists in part of thorium, which at a given temperature has a much greater electron emission per unit surface than the emission of a refractory metal such as tungsten. In the preparation of these tubes, great care must be exercised to remove the last traces of oxygenous gases, particularly water vapor, and the precaution must be observed not to evolve water vapor from the bulb walls during the operation of the device.

The tube shown in the drawing, figure 7, may be employed to rectify alternating current. It comprises an envelop 1, consisting of a glass not chemically attacked by alkali metal, provided with a cathode 2, consisting for example of thoriated tungsten, and a cylindrical or cup-shaped anode 3, also consisting of a highly refractory metal, such for example, as tungsten.

The cathode 2 is prepared by adding a thoria compound, such as nitrate of thorium to the oxide of tungsten before reduction of the metal, or by adding either thorium nitrate or thoria to the metal powder after reduction.

The preliminary evacuation of the envelop is carried out by the usual methods of producing a non-striking high vacuum, which includes baking out the envelop to remove water vapor. The final stage of the evacuation is preferably, but not necessarily, carried out by a Gaede molecular pump to the highest possible vacuum obtainable by this means, that is, to about .001 micron. While the apparatus is still on the pump the cathode 2 is heated to a temperature of about

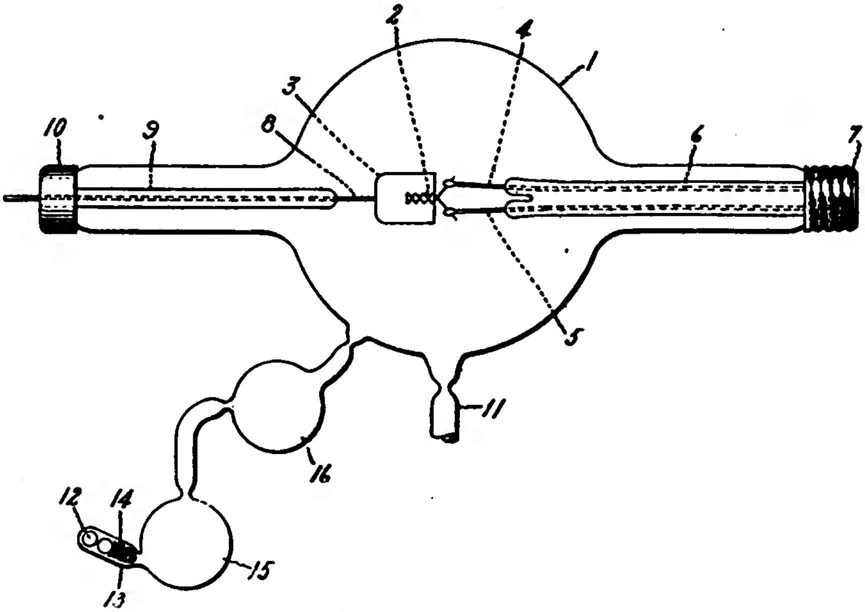


Figure 7—Langmuir's vacuum tube for electron-discharge

2900° K. (2727°C.) for a short time and the envelop 1 is baked out in an oven at a temperature of about 360 to 450°C.

The substance to be distilled into the envelop, for example, potassium, is indicated at 12 in a small side chamber 13, a small quantity of glass particles, or glass wool, 14, being preferably placed in front of the reducing material. As already indicated all glasses (including the glass wool) used in the apparatus should be unattacked by alkali metal. When the envelop is baked out care should be exercised not to heat the chamber 13 to too high a temperature. The potassium, or other material, is transferred by melting into a communicating chamber 15, after which the chamber 13 may be sealed off. Thereupon, the material is distilled into a second communicating chamber 16 and finally a very small amount is introduced into the main envelop 1, both the chambers 15, 16, being successively sealed off. The redistillation of the reducing material serves to purify it. Although alkali metals are preferable, other reducing materials may be used, for example, hydrocarbon compounds. The bulb is finally sealed from the vacuum system at the contraction 11.

The thoriated cathode 2 is now heated to about 2900° K. for about one minute. The treatment of the filament at this temperature appears to be desirable for purifying the surface of the cathode. The cathode is then incandesced within the range of about 2000° to 2400° K, and by this temperature treatment some change is produced in the cathode which enormously increases its electron-emitting property under the condition described. The greatest activity is obtained between about 2200° to 2300° K. and the treatment at this temperature is usually continued for about one minute. Apparently a concentration of metallic thorium or of some other oxidizable thorium material takes place on the surface of the filament. The filament 2 may now be used as a cathode at or below this forming temperature.

Under carefully controlled conditions the benefit of the increased electron emission of a thorium-containing cathode may be secured in a device filled with an inert gas, such, for example, as argon or other monatomic gases, at pressures ranging from a few millimeters of mercury pressure upward, in the presence of potassium or equivalent material for preventing the oxidation of thorium. Care must be exercised to have the cathode at a high enough temperature with reference to the current transmitted so that the vicinity of the cathode is surrounded by free electrons. In other words, the electron emission should be greater than necessary to convey the current thereby preventing a removal of the active thorium material on the surface of the cathode by a bombardment of positive ions.

With the filament thus prepared Dr. Langmuir has obtained at a temperature of about 1300° to 1380° K. substantially the same electron emission per square centimeter as with a pure tungsten filament of about 2000° K., that is, about 3 miliamperes per square centimeter. A thoriated cathode may be operated around 1700° to 1800° K. at which temperatures its life is long, and thermionic current may be obtained many thousands of times greater than obtainable with pure tungsten at the same temperature.

A Recent Development in Wireless Telephony

THE vacuum tube lends itself to a variety of uses in the art of wireless telephony. It may, for example, be employed as a generator of radio frequency current, as an amplifier of the output of a radiofrequency alternator, or as a modulator of radiofrequency current in accordance with the fluctuations of the human voice.

In the majority of wireless telephone systems heretofore described, the apparatus has been of the type in which a portion of the high frequency current was constantly radiated by the wireless telegraph aerial and this current was modulated by a superposed current of mean speech frequency. John R. Carson has recently designed a wireless telephone transmitter, the important feature of which is that the wireless aerial radiates no energy until the microphone transmitter is spoken into.

Carson's circuits are shown in the accompanying drawings, figures 8 and 9. In figure 9, telephonic signal waves are generated by the variations of a transmitter 1, in a circuit 2, containing a source of direct current 3, and a winding 4 of a repeat coil 5. A second winding 6 of the repeat coil, is connected to the input side of an amplifier 7, the output circuit of which, 8, contains a second winding 9 of the repeat coil 10. A second winding 11 of repeat coil 10 is a part of circuit 12, which includes also a condenser 13 and the field winding 14 of a high frequency alternating current generator 15.

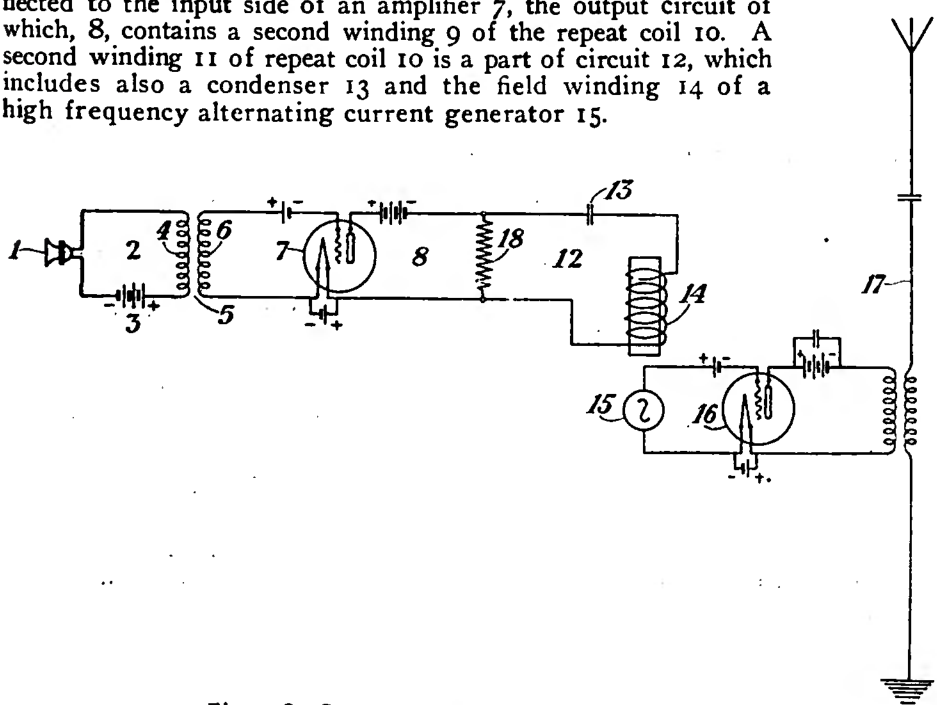


Figure 8—Carson's circuit for wireless telephony

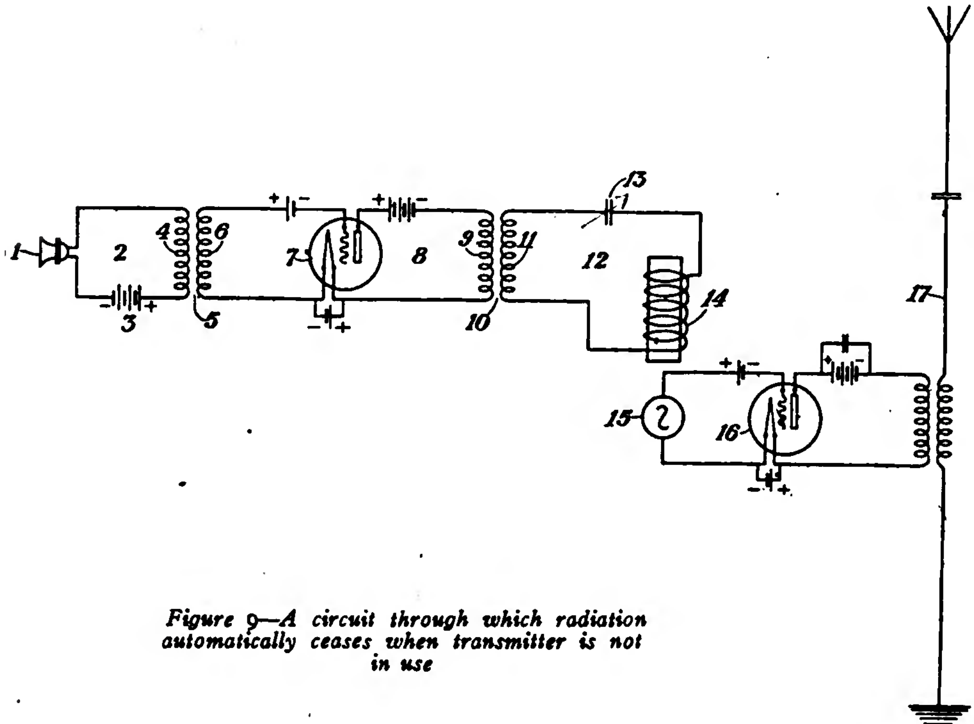


Figure 9—A circuit through which radiation automatically ceases when transmitter is not in use

Coupled to the armature of the high frequency generator is a high frequency vacuum tube amplifier 16, the output circuit of which is coupled to a wireless telegraph aerial. Several amplifiers may be connected in parallel at this point if desired.

Because the circuit 12, including the field winding 14, is inductively coupled through amplifier 7 to a transmitter 1, it will be self-evident that alternating current alone flows in the field windings of the generator; that is, there is no direct current component in the field winding 14, which is an important development.

Because alternating current flows in the field winding of the generator only when the transmitter 1 is spoken into, it will be seen that the high frequency currents which set the antenna circuit into oscillation are generated only when the transmitter is actuated.

When the transmitter 1 is in operation, telephonic current flows in circuit 2, and by means of a repeat coil 6 an alternating voltage of signaling or telephonic frequency is impressed upon the amplifier 7. A current, the reproduction of the signaling current, therefore flows in the circuits 8 and 12. By means of a condenser 13, circuit 12 may be tuned to offer a low impedance to the signaling frequency.

As a consequence, a high frequency wave is radiated from the antenna 17, the amplitude of which is directly proportional to the low frequency signal wave.

The important advantages gained by this system will be readily appreciated by those who understand the problems of wireless telephony. In ordinary radiophone systems, there is a continuous radiation of energy in the form of an unmodulated carrier wave, even when the transmitter is not spoken into. The transmission of this unmodulated wave, besides involving a waste of energy, constitutes a serious bar against the operation of duplex systems. But with the arrangements just described, energy transmission or radiation automatically ceases when the transmitter is not in use.

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By CAPTAIN FRITZ E. UTTMARK

ARTICLE IV

CHAPTER III (Continued)

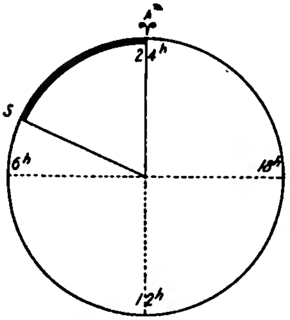


Figure 24

Right Ascension

THE right ascension of a celestial body is the angle at the pole between the hour circle of the body and that of the first point of Aries. It is measured from the first point of Aries eastward, extending up to 360° or twenty-four hours.

P is the pole.

A is the first point of Aries.

A S is the right ascension of S. (Figure 24.)

Sidereal Time

Sidereal time is the hour angle of the first point of Aries. This point, which is identical with the vernal equinox, is the origin of all co-ordinates and does not, like the sun, moon and planets, have actual or apparent motion therein. It shares in this respect the properties of the fixed stars. We may therefore say that intervals of sidereal time are measured by the stars.

The Apparent Sun

The apparent sun is the real visible sun. Its apparent movement in the ecliptic is irregular, rendering days of unequal length.

The Mean Sun

An imaginary sun is supposed to move in the equinoctial with a uniform velocity equal to the mean velocity of the true Sun in the ecliptic. This mean sun is supposed to coincide with the true sun at the vernal Equinox or the first point of Aries.

Apparent Time

Apparent time or solar time is the hour angle of the center of the sun. An apparent or solar day is the interval of two successive transits of the sun. It is apparent noon when the sun's hour-circle coincides with the celestial meridian, or in other words, when the bearing of the sun is true north or true south. This is the most natural and direct measure of time, and the unit of time adopted by the navigator is the apparent solar day.

Mean Time

Mean time is the hour angle of the mean sun. A mean day is the interval between two successive transits of the mean sun over the meridian. Mean noon is the instant when the mean sun's hour angle coincides with the meridian. Mean time lapses uniformly. At certain times it agrees with the apparent time, while at times it is behind and at other times in advance of the apparent time. Ordinary clocks and chronometers for use in navigation are regulated to this time.

Equation of Time

Equation of time is the difference between mean and apparent time. The amount and application may be found in the Nautical Almanac for any given day.

Civil Time

Civil time is the time used in ordinary everyday life. It begins at midnight and ends the following midnight, reckoning two periods, A. M. (ante meridiem) and P. M. (post meridiem) of twelve hours each.

Astronomical Time

Astronomical time is a continuous period of twenty-four hours, beginning at noon and ending at noon the following day.

The Celestial Poles

The extension of the poles of the earth into space, or the poles of the celestial sphere are called celestial poles.

The Elevated Poles

The pole which is above the horizon of the observer, or the pole of the earth of the same latitude as the observer, projected into the heavens is called the elevated pole.

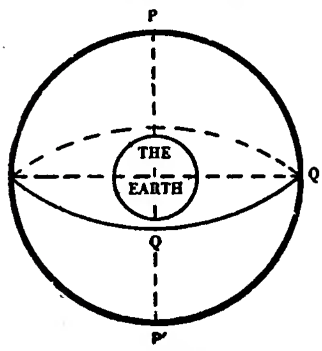


Figure 25

The Equinoctial

The equinoctial or celestial equator is the great circle formed by extending the equator of the earth until it intersects the celestial sphere.

E Q E is the equinoctial.

The Ecliptic

The ecliptic is the great circle representing the path in which the sun appears to move in the celestial sphere. The plane of the ecliptic is inclined to that of the equinoctial at an angle of 23° 27½′. This inclination is called the obliquity of the ecliptic.

C C′ represents the ecliptic.

The Solstitial Points

The solstitial points or solstices are points on the ecliptic 90° from equinoxes at which the sun reaches its highest declination in each hemisphere. They are called summer or winter solstices, according to the time of the year.

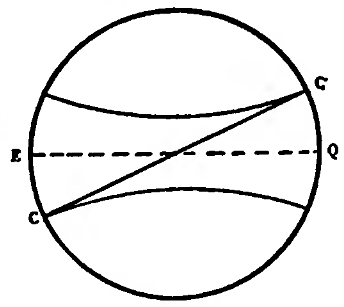


Figure 26

Celestial Latitude

Celestial latitude of any point in the heavens is its distance north or south from the ecliptic measure on a great circle at right angles thereto.

Celestial Longitude

Celestial longitude of any point in the heavens is its distance from the first point of Aries measured on the ecliptic eastward up to 360°.

Co-ordinates

A system of lines, angles or planes, or a combination of these used in determining the position of a point from some fixed plane or line adopted as a primary.

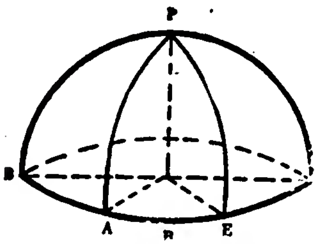


Figure 27

Hour Circles

Hour circles, declination circles, or celestial meridians are great circles of the celestial sphere passing through the poles. They are therefore at right angles to the equinoctial and may be considered formed by extension of the terrestrial meridians until they intersect the celestial sphere.

P A, P B, and P E are Hour Circles.

The Visible Horizon

The visible horizon is a small circle limiting the observer's view at sea or the intersection of sea and sky.

O is the point of observation.

H H′ H″ is the visible horizon of O.

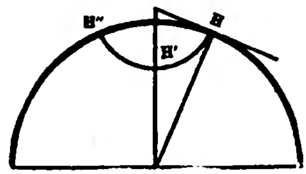


Figure 28

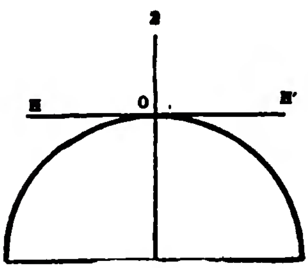


Figure 29

The Sensible Horizon

The sensible horizon is a plane at right angles to the plumb-line at the point of observation in Fig. 29. H H′ is the Sensible Horizon.

The Celestial or Rational Horizon

The celestial horizon is the great circle formed by a plane passing through the center of the earth at right angles to the zenith of the observer and extended until it intersects the celestial sphere.

H H′ in Figure 30 represents the Celestial Horizon.

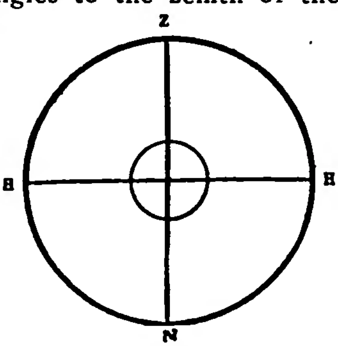


Figure 30

The Artificial Horizon

Any liquid in a state of rest forming a reflective surface is an artificial horizon, mercury being generally used for this purpose.

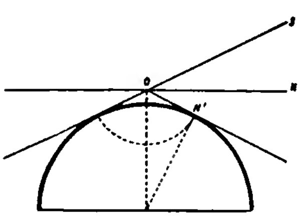


Figure 31

Dip of the Horizon

The dip of the sea horizon is the angle of depression at the point of observation due to the elevation of the observer's eye above the level of the sea.

In Figure 31, the angle, H O H′, is the dip of the horizon as seen from the point of observation at O.

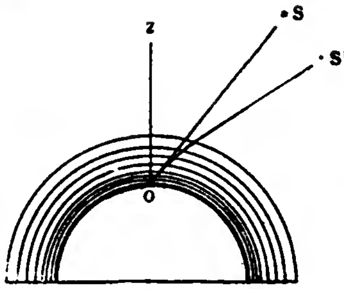


Figure 32

Refraction

Refraction is the bending of a ray of light when passing through the atmosphere. It renders the observed altitude to appear greater than its real value.

The Angle S O S′ is refraction.

Parallax

Parallax is the angle of the earth's radius at the position of the observer as seen from the center of a celestial body.

O is the position of the observer.
O C is the radius of the earth.
S is the center of the celestial body.
The angle O S C is the Parallax.

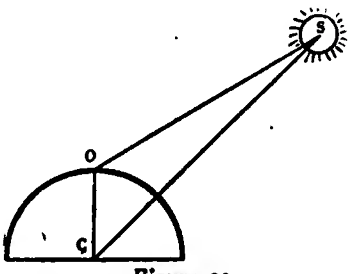


Figure 33

Semi-Diameter

Semi-diameter or half diameter is the angular measurement of the radius of a celestial object as seen from the observer's position.

The angles S O L and S O L′ are the semi-diameters of S.

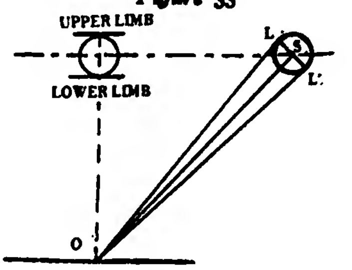


Figure 34

Augmentation of the Moon's Semi-diameter

The augmentation of the moon's semi-diameter is the apparent increase due to the decrease in distance from the observer as the moon rises above the horizon.

Observed Altitude

The observed altitude is the angular height above the horizon as measured by the sextant and expressed in degrees, minutes and seconds of arc.

The angle S O H is the observed altitude of S

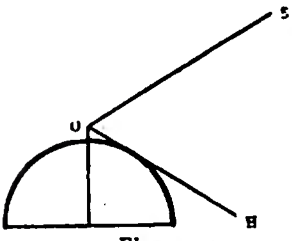


Figure 35

True Altitude

True altitude is the angular height of a point or the center of a celestial body above the rational horizon, as measured from the center of the earth.

In Figure 36, S O H is the true altitude of S.

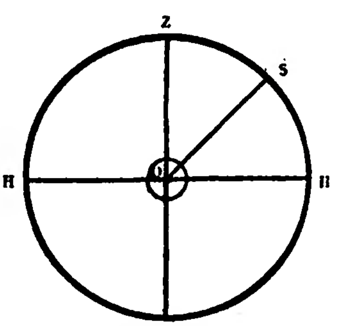


Figure 36

Zenith Distance

Zenith distance is the arc of a vertical circle between the objects and the zenith of the observer, or its true altitude subtracted from ninety degrees (90°—Alt.)

Z S or the angle Z O S is the zenith distance of S.

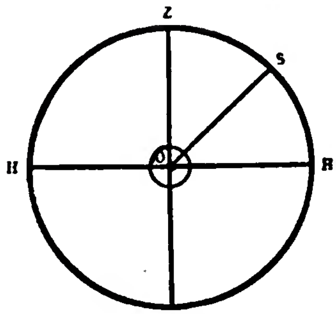


Figure 37

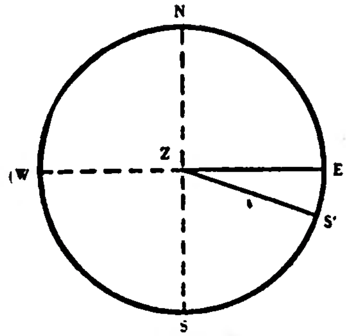


Figure 38

Amplitude

Amplitude is the angle at zenith between the prime vertical and the vertical circle passing through the center of the celestial body at the horizon while rising or setting. It is reckoned from east while rising and from west while setting toward north or south, according to the declination of the observed celestial body.

Z is the zenith.

S′ is a heavenly body.

The angle E Z S′ is the Amplitude of S′.

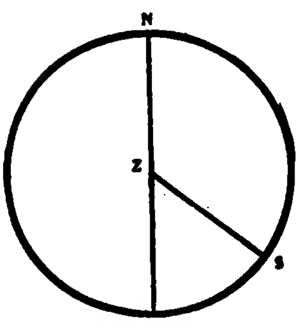


Figure 39

Azimuth

Azimuth is the angle at zenith between the meridian of the observer and the vertical circle passing through the center of the celestial body. It is generally reckoned from north in north latitude and from south in south latitude up to 180°, east or west according to whether the body is east or west of the meridian.

In Figure 39, N. S. or the angle N Z S, is the Azimuth of S.

Diurnal Motions

The movements of the celestial bodies during the 24 hours are called Diurnal or Daily Motions.

CHAPTER IV

The Compass Errors

Variation. The earth being considered as a huge spherical magnet with two poles, one is situated in about 70° north latitude and in about 97° west of Greenwich. This is called the north magnetic pole; the south magnetic pole is in latitude and longitude east of Greenwich. Thus we see that the north magnetic pole is about 1,200 miles away from the geographical or true pole. Now, a magnetic needle when suspended and allowed to swing freely in the horizontal plane, if unaffected by iron in the vicinity, will come to rest. With one end pointing to the north magnetic pole, or the direction of the needle, it will fall in with the magnetic meridian. Thus we see there will be an angular difference between the true and the magnetic meridians. This difference or error is called *variation*. It differs in amount from 0 to 180° and in name, easterly or westerly, in the different parts of the globe. We call this variation westerly if the north end of the magnetic needle is drawn or deflected to the left hand side of the true meridian, or easterly if the same end of the needle is drawn or deflected to the right hand side of the true meridian.

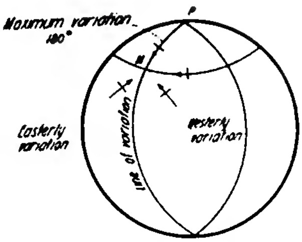


Figure 40

In Figure 40 P represents the geographical north pole and M the magnetic north pole. The arrow heads, indicating the north end of the magnetic needle, point to the magnetic pole and show the variation in different places on the globe. When correcting a magnetic course or bearing, apply westerly variation to the left hand side, or easterly variation to the right hand side in order to obtain the true course or bearing.

(Note.—Always assume that we stand in the center of the compass looking towards the circumference; otherwise right or left has no meaning in reference to variation.)

Deviation

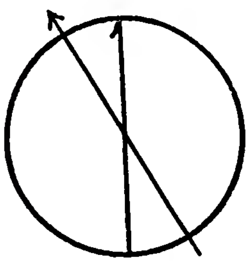


Figure 41

This is caused by the disturbing influences of iron in the construction of the ship or in her cargo. It differs in amount and name according to the direction of the ship's head or the course she is steering. When the north end of the compass needle is deflected to the left hand side of the magnetic meridian (Figure 41) the deviation is called westerly, and when the same end of the needle is deflected to the right hand side of the magnetic meridian (Figure 42) the deviation is called easterly.

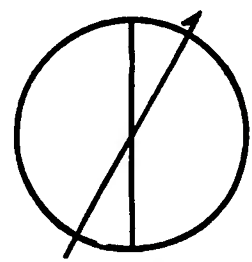


Figure 42

Rule. When correcting a compass course for deviation, apply *westerly* to the *left* and *easterly* to the *right* hand side in order to obtain the magnetic course or bearing.

(Note.—Always assume that we stand in the center of the compass looking towards the circumference, same as for Variation.)

Local Attraction

This error is caused by disturbances, such as when in shallow water, the ship passes over ground rich in iron ore. It is local and temporary in its effects, and differs constantly in its amount. It is not ordinarily taken in consideration when correcting courses.

Leeway

Leeway is caused by wind and waves pressing the ship to leeward and may be defined as the angular difference between the ship's course by compass and the actual track through the water.

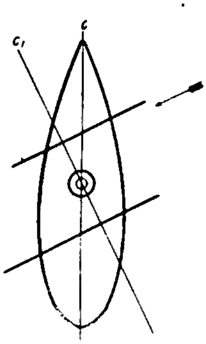


Figure 43

Figure 43 illustrates leeway. The amount differs according to strength of wind and roughness of the sea. It is best estimated when standing in the after part of the vessel and looking at the wake of the ship. The angular difference between this and an imaginary line pointing straight aft is the leeway, or in other words, the difference between the lubber line and ship's compass course.

In correcting a course for leeway, apply this when the ship is on *starboard tack* to the left or when the ship is on *port tack* to the right hand side, assuming as before that we stand in the center of the compass looking towards the circumference.

(*To be continued*)

Signal Officers' Training Course*

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

EIGHTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

Radio Apparatus of the Signal Corps—Part Two

Field Radio Pack Sets

The smaller size of portable sets, known as a field radio pack set, has been made in several models designated by the number of the year in which they were made. Owing to the rapid improvement in design and construction, the 1912 model has become practically obsolete.

1913 Model

Radio pack set, model 1913, consists of the following *units*:

1 operating chest.
1 hand generator.
1 mast.
1 pack frames, set (3 frames).
1 tent.

Each *unit* contains *component parts* as follows:

Operating chest:
 1 chest.
 1 resonance transformer.

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

1 condenser.
1 oscillation transformer.
1 sending key.
1 spark gap.
1 hot-wire ammeter.
1 switch.
1 receiving set.
1 connecting cord for generator (4-conductor with plugs).
1 connecting cord, with plug, for antenna.
1 double-head receiver.
1 test buzzer.
1 tool kit.
1 extra section for transformer secondary.
1 extra set crystals.
1 canvas case for receiver.
1 connector, 4-wire (lower half), generator.
2 connectors, 2-wire (lower half), antenna and counterpoise.

Hand generator:

1 generator.
2 cranks.
1 stand.
1 speedometer (carried in operating chest).
1 cap for speedometer opening.
1 canvas hood.

Mast, type F. (Type D mast has 1 top, 1 bottom, 5 intermediate, and 3 extra sections):

1 top section.
1 bottom section.
8 intermediate sections.
4 intermediate sections, extra (3 for tent).
1 antenna.
1 counterpoise.
9 carriers, wire.
4 pins, antenna.
2 hammers.
1 set adapters for tent (4 pieces).
1 bag, antenna and counterpoise.
1 bag, accessories.

Pack frames, set:

3 frames (1 set). Each frame is complete with cincha, 2 cincha straps with rings and snap hooks, and 2 straps with snap hooks at each end.

Tent:

1 tent.
14 pins.
2 guy ropes.
1 insulating device.

Complete sets should be designated as *"radio pack sets, complete,"* giving *year* and *serial number,* and should be so carried on property returns, invoices, and shipping manifests.

Operating the hand driven generator

Type F sectional mast with pack mule

Incomplete sets should not be so designated, but *units* in them which are complete should be designated as under the *unit* heading above and *units* that are not complete should be designated as under the *component part* heading. When *units* or *component parts* are used to complete sets they should be expended.

Operating chests and hand generators should always be designated by the *year* and *serial number,* and masts by the *type letters.*

Sectional Mast

The new type F sectional mast with short sections is superseding the type D with long sections as the stock of the latter becomes exhausted, as it has been found by experience that a mast with short sections can be raised more easily from the ground than one with long sections. The type F mast equipment consists of 14 sections, each 4 feet 2 inches long or 5 feet 2 inches over all, including the coupling tube. The 10 sections are used for the mast itself, 3 sections for the shelter tent when erected, and 1 extra section for use in case one of the others becomes unserviceable.

When starting to erect the mast, the four antenna wires and guys should be laid out on the ground at right angles to each other and the umbrella insulator put on the upper end of the section that is not provided with a coupling tube. This section should then be raised and eight more sections with coupling tubes added, section by section, the tenth and last section being the one provided with the insulator fixed at the bottom end. During the erection the mast should be kept as nearly vertical as possible by the men holding the distant ends of the antenna guy ropes. Owing to the liability of the mast to buckle, no attempt should be made to erect the entire mast at one time; that is, by coupling all sections together and raising by means of the guys.

Antenna and Counterpoise

The standard antenna is of the umbrella type with four radiating wires, each 85 feet long, suitably insulated at the open ends and held as nearly horizontal as possible by guy rope extensions, each 85 feet long, the outer ends of which are made fast to ground pins. The standard counterpoise has four radiating insulated wires, each 100 feet long, laid out on the ground under the antenna wires. Both antenna and counterpoise wires are carried on hand reels for convenience in packing and quick reeling and unreeling in setting up and taking down the mast.

Generator

The generator is a hand-driven, 18-pole, alternating-current machine having an intermittent output of 250 watts at 110 volts and 500 cycles at a speed of 3333 R. P. M. It is self-excited, the exciting current for the fields being generated by a small shunt-wound direct-current machine, the armature of which is mounted on the same shaft as the alternator armature. The exciter has two poles and delivers the direct current at about 110 to 150 volts. The whole machine is driven by two handles, which should be turned at the rate of 33 R. P. M. to give the necessary armature speed of 3333 R. P. M., the combination gear having a ratio of about 100 to 1. The direction of rotation of the handles must be as shown by the arrow on the top of the gear case, as otherwise the machine will not deliver any current. The whole is inclosed in a dust-proof aluminum case. To obtain access to the commutator, remove the flywheel, taking care not to lose the key on the flywheel shaft; then remove the large brass nut and the aluminum disk held in place by the latter, after which it will be found that the commutator is readily accessible. To remove the armature from the machine, proceed as above; then take off the casing covering the spur gears at the opposite end of the shaft, and the gears themselves; before removing the armature take the brushes out of the holders to avoid injuring or breaking them.

The tension on both sets of the generator brushes should be kept as light as possible consistent with good commutation. A small increase in the friction of these brushes will require considerable additional power to drive the machine. Both sets of brushes can be removed when necessary through openings in the lower part of the case, the D. C. exciter brushes being at the flywheel end and the A. C. brushes at the opposite end.

A canvas cover is provided for the generator, which should be kept on at all times when the generator is not in use.

Speed Indicator

A speed indicator is mounted on the upper part of the gear case in sight of the men driving the machine so as to show if it is being driven at the proper speed, at which time the red line on the moving vane coincides with the black index or arrow at the window. The vane is divided diagonally into black and white parts, the white showing if the speed is too low and the black if too high.

In putting the speed indicator in place it may be necessary to turn handles slightly so as to permit the gears to engage.

In case the vane of the speed indicator comes on the underside when the indicator is screwed into place, it can be turned into proper position after loosening the depressed set screw on the threaded part fitting into the case and then tightening the set screw again.

In making the set ready for transportation, the speed indicator should be removed and packed in its proper place in the operating chest and the opening closed with the brass plug provided.

Gearing

The gearing is a combination planetary worm-and-spur type of high efficiency when in proper alignment. The high-speed shafts have ball bearings and the gears run in grease or oil so as to reduce the friction as much as possible. The gears should never be taken apart unless absolutely necessary to replace worn or broken parts, and then only by an experienced person. If not properly reassembled, or if the driving gear does not run perfectly true with the worm, undue friction and wear will result, the machine will be harder to turn than before, and the gears will be speedily destroyed.

The gears and ball-bearings can be lubricated by either a nonfluid oil or a light, thin oil, such as Medium Monogram, but both must be free from acid and water to prevent rusting. If oil is used it should be supplied through a small cap on the opposite side of the case from the speed indicator. The level should be kept not more than one-eighth inch above the *lower edge* of the glass window at the flywheel end of the gear case; if kept above this, the oil will overflow to the lower part of the case and cause trouble and sparking at the commutator and collector rings. The same kind of oil should be used on the flywheel shaft through the small hole on the upper side of the bearing.

If nonfluid oil is used it should be supplied through the opening where the speedometer is screwed into place. Not less than a pint nor more than a quart should be used in the main gear case, but only a small amount in the spur gear case at the end opposite the flywheel, as otherwise the machine will turn hard on account of choking the gears with too much nonfluid oil in the narrow gear case.

With the exception of an occasional addition of oil, the machine should run for months without attention. If the oil becomes thick or dirty, the gearing should be washed out with gasoline and refilled with clean oil *without dismantling.*

Care must be taken *not* to *start* or *stop* the machine *suddenly,* as this may strain or break the gears. The machine must *not* be stopped by means of the handles, but *only* by *friction on the flywheel.*

Connections

The leads from the armature of the A. C. generator are directly connected to the transformer primary by means of the heavy pair of leads, the larger plug of which being put into the socket at the left-hand end of the operating chest marked "Gen." and the smaller plug into the socket on the underside of the gear case, also marked "Gen." The sending key is in the circuit of the alternator fields and the exciter armature, and is so connected by means of the light pair of leads, the larger plug of which being put into the socket at the left end of the chest marked "Fld." and the smaller plug into the socket on the underside of the case, also marked "Fld." By the use of these circuits, the electrical load on the machine is limited to the small one of the exciter field, except when the key is closed in sending. Experiments have shown that twice the output of the former machines can thus be obtained with practically no more tiring effects on the men than before.

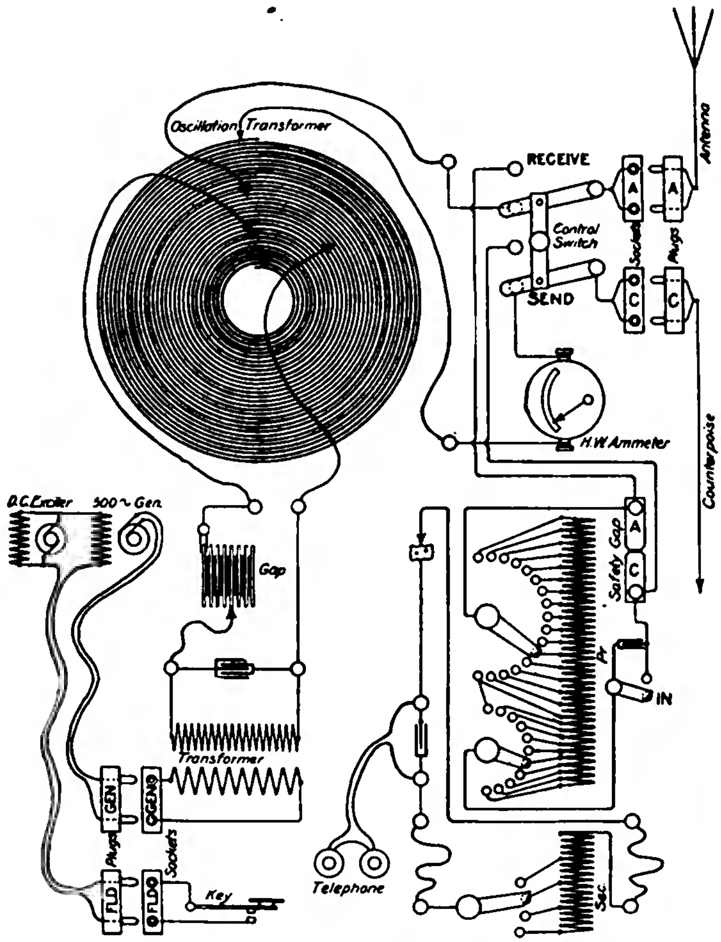


Figure 1—Field Radio Pack Set, model 1913

Operating Chest

In this chest is mounted the transmitting and receiving apparatus, the diagram of which is shown in Figure 1. To put the chest in condition for sending, connect the double contact plugs of the leads from the hand generator, field, antenna, and counterpoise to the receptacles marked "Gen.," "Fld.," "A," and "C," respectively, and the four variable contact clips on the leads from the condenser, spark gap, antenna, and hot-wire ammeter, to the four points on the flat spiral, as indicated on the diagram, making sure that the counterpoise clip is at the end of the outside turn. Set the control switch at the "sending" or lower position. Release the indicating needle of the ammeter by turning the small knurled screw at the left-hand side of the upper binding post. When the needle is free, adjust to zero position on the scale by means of the small knurled screw at the right side of the upper binding post. Set the variable spark-gap contact on the fifth plate, counted from the left end, so as to put *four gaps* in circuit. Start the generator, and when the proper speed is obtained the set is ready for sending.

Quenched-Spark Gap

The spark gap used in this set is made up of several copper disks separated by mica washers about 0.01 inch thick. Its action is to allow all of the energy of the closed oscillating circuit to be transferred to the open or radiating circuit in a few oscillations, after which the spark is quenched and the circuit is, in effect, open. The activity in the closed circuit having ceased, the open or radiating circuit continues to oscillate at its own period, radiating waves of its own wave length without any retransfer of energy to the closed oscillating circuit, which continues to remain open until a spark breaks down the gap again at the peak of the next alternation.

In order to work at maximum efficiency, the quenched-spark gap should be kept cool. It is for this reason that the plates are provided with thin cooling flanges having a large surface exposed to the air, and are blackened, a black body cooling more rapidly than one highly polished. If the gaps have become too hot, as by keeping the key closed for a long time, the antenna current will gradually decrease, the loss at times being as much as 40 per cent, so that it is always best to allow the gap to cool before using again.

The gap should not be taken apart to clean its sparking surfaces like an ordinary type of open gap. In general the more frequently such a gap is opened the more unsatisfactory may be its operation. The explanation is that the repeated opening of the gaps introduces air each time, and that with free exposure to air the sparking surfaces are corroded or pitted, but that when kept air-tight they are worn smooth and clean by the sparking action. Sometimes, if there is a flaw in one of the plates or if air leaks into the gap, there will be a noticeable drop in the antenna current, and the note will become poor. When it is believed that the trouble is confined to one or two gaps it is possible to continue sending without dismounting the whole gap by short-circuiting the bad gaps by means of clips provided for the purpose, in which case as many new gaps must be put into circuit by adjusting the movable clip to the right as were cut out by the short-circuiting clips.

The gap should be dismounted *only* when the trouble has been located in the gap and it has been found impossible to remedy it by short-circuiting the different gaps in use. The gap should be dismounted only by an experienced man, who should clean the surfaces by rubbing them face down on fine emery cloth or paper on a *flat surface*. It is absolutely necessary that both the bearing surface and the sparking surface be kept true and plane, as shown by a straightedge.

Great care should be exercised in reassembling the gap to set the mica washers accurately on the annular surfaces of the disk and to put on enough tension with the clamping screws to render all of the gap spaces air-tight.

Tuning of Sending Set

The tuning of the closed and open circuits to resonance, and the determination of the correct coupling between them are the two most important adjustments in a quenched spark transmitter. In the present type of directly coupled set with a flat spiral as the oscillation transformer, these adjustments can be made either with or without the help of a wave meter. If made without the meter the adjustments are more difficult and must be found by trial, but they should satisfy the following tests: (1) The number of turns in the closed circuit should be chosen so as to give the desired wave length; (2) the antenna hot-wire ammeter should show the maximum reading that can be obtained by adjusting the number of turns in the open circuit according to the table given later; and (3) the note as heard in the telephones of the receiving set should be clear and characteristic of 500 cycles. These adjustments are, in general, dependent on each other, an incorrect change in one seriously affecting all the others; but when obtained the circuits will be in resonance at the desired wave length, they will be correctly coupled, and the closed-circuit condenser will be charged and discharged regularly once per alternation.

The adjustments should be made as follows: Set the closed and open circuit clips on the turns corresponding to the desired wave length. These turns are approximately correct with the standard antenna and should be used in beginning to make the adjustments. If the antenna ammeter reads between 2.2 and 3.0 amperes and the note is clear and of 500 cycles, then the adjustments are correct and the circuits properly tuned. If the ammeter reading is low and the note low and clear or low and ragged, possibly the circuits are correctly tuned, but there are too many gaps in circuit, and the condenser is being charged and discharged either regularly or irregularly only every second or third alternation. Reduce the number and see if this change gives a clear 500-cycle note, etc. Similarly if the note is high and hissing, the condenser is being charged and discharged more than once per alternation. Increase the number of gaps and see if this change gives a clear 500-cycle note, etc. If none of these changes gives the correct adjustments, then the circuits are not in resonance, or the coupling is wrong. Move one of the *open-circuit* clips to see if the correct adjustments can be obtained; it is impossible to state which clip should be moved or in which direction. If the change of one clip is not sufficient, move both *open-circuit* clips until, by repeated trials, the correct adjustments have been found. If possible, leave the counterpoise clip on or near the outside turn, so that it will be at ground potential. It will be found that the character of the note will be changed as these various changes in coupling and tuning are made, but the clearest 500-cycle note will be obtained when all adjustments are correct and the circuits properly tuned. After the adjustments have been completed at this wave length, tabulate the results as shown and repeat at other wave lengths within the range of the spiral.

Although there is no direct test that can be applied, except with a wave meter, to determine if a single wave length is being radiated, yet in general this will be the case if the adjustments satisfy the tests.

If a wave meter is available the adjustments are much easier to make, and they should satisfy the following tests: (1) A single sharply defined wave should be radiated of the desired wave length, (2) the antenna ammeter and the signals in the telephones of the meter should show the maximum reading and signals obtainable under the first condition, and (3) the note should be clear and of 500 cycles.

It will probably be best to use the wave meter with a detector or helium tube, because it will be impossible to turn the hand generator at a sufficiently constant speed to obtain steady readings on the wattmeter and hence difficult to determine the resonance point and wave length.

The adjustments for tuning should be made as follows: Disconnect the open-circuit clips and set the closed-circuit clips on the turns corresponding to the desired wave length. Measure the wave length according to the instructions just given to make certain that it is correct. Set the open-circuit clips on the turns given in the table, and, with the wave meter near the antenna or counterpoise wires, but near the spiral, see whether there is one wave length or two in the meter. If there is a single sharply defined wave length, and the antenna ammeter reading can not be increased by slight changes of either or both of the *open-circuit* clips and the note is clear and of 500 cycles, then the adjustments are correct and the circuits properly tuned. If there is only one wave length, but the antenna ammeter reading is low and can not be increased by slight changes in the open-circuit clips, then the coupling is too loose and must be tightened. Move the *open-circuit* turns in use inward as a whole, by moving both clips inward and slightly increasing the number of turns in circuit to allow for the decrease in their diameter, until with a single sharply defined wave length the antenna ammeter reading is a maximum, etc., as before, in which case the circuits are properly tuned. If the note is low, decrease the number of gaps; if high and hissing, increase the number as previously described. If, however, there are two wave lengths, move one or both of the *open-circuit* clips, but it is impossible as in the previous case to state which clip or in which direction, until by repeated trials it has been found that there is a single sharply defined wave length, a maximum antenna ammeter reading, etc., as before, in which case the circuits are properly tuned.

After the adjustments have been completed at this wave length repeat at other wave lengths as before and tabulate the results.

If the one-eighth or one-fourth kilowatt motor-generator or the engine-driven one-fourth kilowatt generator supplied by the Signal Corps, is available, it should be used as the source of the 500-cycle current because its voltage will be much steadier than that of the hand generator. When the motor-generator set is used, the A. C. armature and the D. C. motor should be protected from "kickbacks" due to the use of the sending key in the alternator fields by two high-resistance carbon rods mounted on suitable bases to be connected as follows: The end terminals of one rod to the two A. C. leads close to the machine; the end terminals of the other rod to the two main line D. C. leads close to the machine, and the middle points of both rods to be connected together and this common point grounded on the frame of the machine.

The constant speed of the motor-generator makes it possible to get steady readings on the wattmeter of the wavemeter, and hence easy to find the resonance point and wave length. It may also be more convenient than a detector because it is often difficult to keep a detector point in sensitive adjustment on account of the nearness of the spark gap and to determine the resonance point on account of the continuous note in the telephone. However, the detector and helium tube can be used if desired; the circuits will be correctly tuned no matter what means are used for determining resonance. The circuits should be adjusted to resonance, etc., as described in previous paragraphs.

In some cases it may be convenient to use the following slight modification of the method described. Disconnect the transformer secondary from the closed circuit and connect it to the two terminals of a small zinc or brass spark gap, one of which is connected to the counterpoise and the other to the standard antenna. Measure this wave length, which will be the fundamental wave length. Next insert, say, two turns of the spiral, Nos. 28 to 30, counting the turns from the inside turn outward, in series with the antenna, and measure this wave length. Continue in this manner until all wave lengths are measured within the range of the spiral and tabulate. Next make the standard connections, setting the open-circuit clips on the turns corresponding to the desired wave length, as just obtained. Set the closed-circuit clips on the turns given in the table which follows—"Short Waves," "Long Waves"—and make the necessary adjustments by moving these clips until it has been found by trial with the wavemeter that there is a single sharply defined wave length, maximum current in the antenna, etc., as before. Tabulate these results and repeat for wave lengths within the range of spiral. In this case the *closed circuit* is tuned to the open circuit, whereas in the previous case the open circuit was tuned to the closed circuit, but the same tuning points will be found for the same wave length, whichever method of tuning is used.

It is impossible to use exactly the same method as in this table, in which the number of turns for a given wave length is determined for both the primary and secondary circuits, after which the principal adjustment is one of coupling, because the number of turns in the primary circuit of the spiral at any wave length will depend on the part of the spiral which is included in the circuit, and hence it will vary with every combination of turns. It is for this reason that the primary tuning and coupling must both be found by trial.

Open-Circuit and Closed-Circuit Tuning

Wave length.	Antenna.	Counterpoise.
Meters.	*Turn No.*	*Turn No.*
300	26 7/8	30
325	24 7/8	30
350	22 3/4	30
375	20 3/4	30
400	18 5/8	30
425	16 5/8	30

Turns to be counted from the inside turn outward.

Wave Length.	Closed-circuit clips.	Open-circuit clips.
Meters.	*Turns.*	*Turns.*
300	8 and 12 1/2	26 7/8 and 30
325	8 and 13 1/8	24 7/8 and 30
350	8 and 13 5/8	22 3/4 and 30
375	8 and 14 1/8	20 3/4 and 30
400	8 and 14 5/8	18 5/8 and 30
425	8 and 15 1/8	16 5/8 and 30

Turns counted from the inside turn outward.

Although a transmitting set using the flat spiral oscillation transformer is not as easily tuned as some other types, yet when the adjustments have once been made and tabulated it is practically as efficient as other types. It has the advantage of being one of the simplest, most rugged, and compact forms which can be installed in a field set.

Receiving Set, Type B

The receiving set consists of an inductively connected transformer with broadly tuned secondary circuits, galena, or other similar detector, high-resistance telephones, etc., provided with the necessary switches for tuning to different wave lengths. The primary circuit includes the antenna, primary coil, series condenser or not as may be needed, and counterpoise. The antenna is connected to the primary coil through switches which put into circuit a variable number of turns, steps of 10 turns being inserted by one dial switch and single turns by the other. The total number of primary turns is thus the sum of the numbers on the two dials indicated by the two switch arms, which can be varied by single turns from one to the whole number in the coil. For wave lengths shorter than the fundamental wave length of the antenna, a fixed condenser is inserted in series with the primary coil by throwing the switch near the binding post marked "G" to the position "In," as shown in Figure 1. For the longer wave lengths the switch is thrown to the other position, short-circuiting the condenser, and thus leaving only the coil in circuit. The secondary circuit includes the secondary coil, detector, and the stopping condenser shunting the telephones. The coil is variable only by sections, marked "100," "200," etc., the smaller numbers to be used at the shorter wave lengths and the larger ones at the longer wave lengths. The position of the secondary coil within the primary—that is, the coupling—is variable, and for the sake of convenience a scale is provided so as to be able to note the different adjustments. The coupling is closest when the secondary is inside the primary, in which case the scale reading is 0, and vice versa, the coupling is loosest when the secondary is drawn outside the primary and the scale reading is 40.

Short Waves

Primary condenser in series.

(Switch on "In" contact.)

Wave length (in meters).	Primary turns.	Secondary turns.	Coupling scale.
200	18	100	20
300	26	200	20
400	36	200	20
500	47	300	20
600	60	300	20
700	74	400	25
800	88	400	30
Etc.	Etc.	Etc.	Etc.

Long Waves

Primary condenser short-circuited.

(Switch not on "In" contact.)

Wave length (in meters).	Primary turns.	Secondary turns.	Coupling scale.
300	24	200	20
400	30	200	20
500	38	300	20
600	46	300	20
700	56	400	25
800	65	400	30
900	76	400	30
1,000	91	400	25
1,100	107	400	25
1,200	125	400	30
1,300	144	400	25
1,400	162	400	25
Etc.	Etc.	Etc.	Etc.

Tuning of the Receiving Set

First, the detector must be adjusted to a sensitive point by means of the test buzzer, the note of which should be clearly heard in the receiving telephones when it is held near the antenna or counterpoise wires or the coil windings. When the wave length of the sending station is known, the number of turns in the primary and secondary coils and the coupling should be set according to the values in the above table, which will be approximately correct for all sets using the standard antenna. When the wave length is unknown, then signals can be found only by repeated trials of different combinations of turns and couplings, in which, however, *consistent* sets of values may be taken from the table. When once the signals have been heard such further adjustments of primary and secondary turns and coupling should be made as will give the maximum sound in the telephones. In general it will be found that when there is interference or static troubles the sharpest tuning and the best protection from interference will be obtained when the loosest coupling is used; that is, when the secondary is pulled out as far as possible and still hear the desired station. It will be noticed that for some wave lengths there are two different possible combinations in the primary circuit, either without a condenser and a few primary turns or with a condenser and more primary turns. It is impossible to tell which combination is the better without actual trial. In general the best coupling between the circuits will vary with the damping of the transmitting station, close coupling being possible with highly damped transmitters, and loose coupling necessary with feebly damped transmitters.

In changing the coupling between the two circuits by means of the handle on the secondary coil care must be taken to see that the contacts on the various studs are not loosened, as otherwise the signals may be lost entirely or the tuning made much broader on account of high resistance that may be introduced at these contacts.

If the receiver is used with the standard antenna and signals are being received from an unknown station, the table of wave length can be used to determine approximately the wave length of the unknown station.

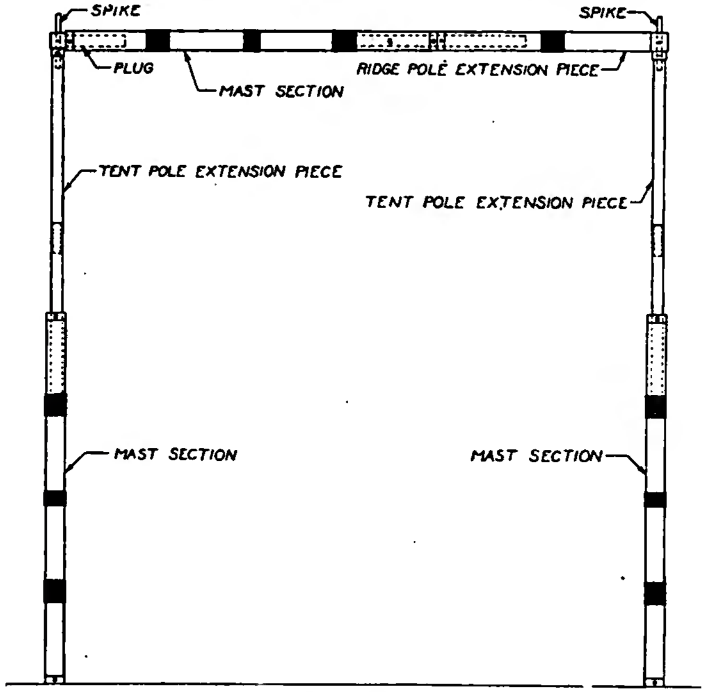


Figure 2—Shelter tent pole-erection

Shelter Tent

This tent is similar in dimensions and construction to the standard "common" wall tent issued by the Quartermaster's Department, but is made of lighter material and is not provided with ridge pole or uprights. In erecting the tent the extra sections furnished with the mast should be used as the ridge pole and uprights as follows: One hollow section, one plug, and one extension piece for the ridge, and one section, one extension piece with spike for each upright. The method of erection is illustrated in Figure 2.

Insulating Device

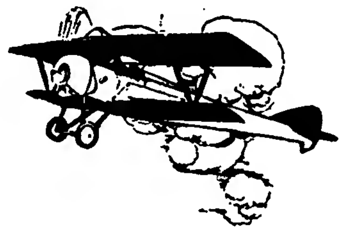
A device is provided for use in insulating the antenna when the shelter tent is used in damp weather, consisting of a square piece of sheet rubber with small marginal holes for lacing into the ventilator at either end of the tent, and a tube attached to the center for admitting the antenna lead. When in use, sufficient slack should be left in the antenna lead to form a drip loop outside of the tent, and if found necessary a piece of heavy insulated wire can be used as a leading-in wire.

Packing

The set is normally packed on three mules, but in emergency may be packed on two. In normal packing the first mule carries the generator and six sections of the mast. The second mule carries the operating chest, four sections of the mast, antenna, counterpoise, accessories, bag, etc. The third mule carries the tent, with tent pins and extension pieces folded inside, four sections of the mast, flag kit, lanterns, etc. In emergency packing with two mules, the first

How to Become an Aviator

The Sixth Article of a Series for Wireless Men in the Service of the United States Government Giving the Elements of Aeroplane Design, Power, Equipment and Military Tactics



By HENRY WOODHOUSE
Author of "Text Book of Naval Aeronautics"

THE student having mastered, through previous lessons in this series, the theory of flight and the fundamentals of design of aeroplane lifting surfaces and controls, knowledge of rigging is next in order.

As an infantryman's first care is for his feet, and a cavalryman for his mount, so must the military aviator know his means of locomotion, his aeroplane. The army does not require the dismounted soldier to be a chiropodist, or the cavalryman a veterinarian, no more than the aviator is expected to be an expert mechanic. But he must know whether or not his machine is in condition, and what he may expect of it, without recourse to another's judgment. With the engine out of order a safe landing can be made, but when something goes wrong with the rigging there is trouble ahead. Should the rigging be wrong, even though nothing breaks, speed is lessened and stability and control made less effective.

Rigging an aeroplane properly presupposes knowledge of the stresses it is subjected to and the strains which may appear. Aeroplane materials are of the size and weight which combine greatest strength and least weight. A knowledge of them is important.

Stress is the load which a body bears. It is generally expressed thus: $L \div A = S$, where L is the load, A the square inches contained in the cross-sectional area, and S the resultant stress. For example, with an object measuring in cross-section $3'' \times 2''$ (an area of 6 sq. in.) and required to support a total load of 12 tons, the stress would be $12 \div 6 = 2$ tons.

Strain is deformation produced by stress.

If a spar is known to collapse under a maximum stress of 1200 lbs., in a training machine it would be subjected to no greater stress than 100 lbs.; thus where known stress of an object is 1200 lbs, and the maximum stress it is called upon to endure is 100 lbs., then 1200 lbs. ÷ 100 lbs. = 12, representing:

The Factor of Safety, which is ordinarily expressed by the resultant of known collapsing strength divided by maximum stress the object is called upon to endure.

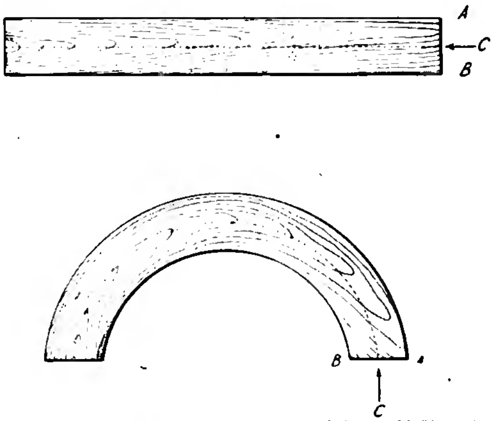


Figure 26—Compression and tension stresses produced by wood bending

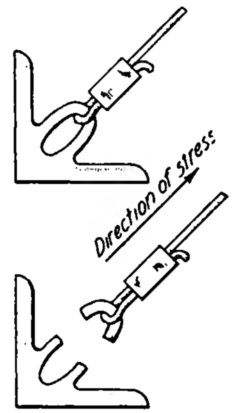


Figure 27—An illustration of shearing

STRESS AND STRAIN FORCES

Strength of materials must be understood from the viewpoint of strength in compression, tension, bending, torsion and shearing. For example, wire is designed to take tension but not compression, wood takes compression but not shearing, bolts are suited to shearing, etc.

Compression—The stress of pressure produces a crushing strain, best exampled by the stress on interplane struts.
Tension—The stress of pull, tending to elongation, exampled by all wires.
Bending—A combination of tension and compression exampled by the bending of wood, the outside fibres tending to pull apart, the inside to go together.
Shearing—A cutting off sideways by a pull such as is exerted on an eyebolt or pin.
Torsion—A twisting stress, a combination of the forces of compression, tension and shearing, such as is received by the propeller shaft.

Bending—Figure 26 illustrates how the combination of compression and tension stresses are produced by bending. The upper view shows a straight piece of wood, the top line (*A*), the center line, or "neutral axis" (*C*) and the bottom line (*B*) being all of equal length. In the lower view the same piece of wood is bent. Then center line (*C*) is still the same length, but the top line (*A*) is further from the center and therefore longer. This is due to the stress of tension producing the strain of elongation; the upper portion is therefore in tension, which increases with its distance from the center. Meanwhile, the bottom line, under the strain of crushing produced by the stress of compression, has become shorter than the center line. At the center line, therefore, there is neither tension nor compression and the wood nearest the center is under considerably less stress than that near the top and bottom lines. Thus the center may be hollowed out without appreciably weakening the wood, which makes it possible to save about 25 per cent. of the weight of the wood used in the construction of an aeroplane.

Shearing—In Figure 27 a wire exerting pull on an eyebolt is shown. The lower view illustrates how the stress may shear an eyebolt.

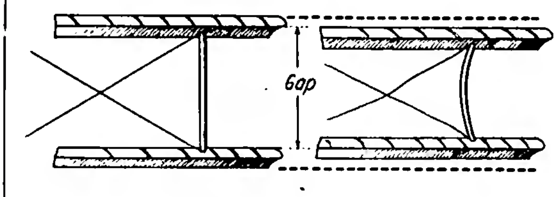


Figure 28-a Figure 28-b
Effect of strut bending under stress

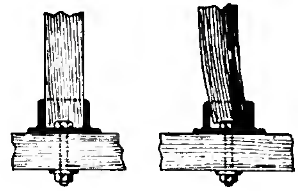


Figure 29
Strut properly and improperly bedded

STRENGTH OF WOOD UNDER STRESS

Upon the care exercised to have struts kept perfectly straight and evenly bedded into sockets rests the strength of wood under compression. A stick 1 inch in diameter and 36 inches long, if kept perfectly straight can perhaps bear a ton weight without breaking, but if it were not straight, or had started to bend, a compression of 50 pounds would break it. Weight being of the greatest importance in aeroplane design, the wooden parts are kept as far as possible in direct compression. To save weight is the aim of all designers and in consequence an aeroplane's factor of safety is ordinarily low. The required stresses for parts in direct compression may be safely taken, however, if they meet the requirements which follow:

Straightness—Spars and struts must be perfectly straight. Viewed in cross-section, these supporting members are elliptical in shape (stream lined); the center of strength is therefore midway between the points of greatest transverse width. If the stress of compression is not equally distributed about this point the strut will bend, because tension will be created on one side and compression on the other. The effect of a strut bending is shown in Figures 28-a and 28-b. In the former the wire stays are taut and the proper gap between wings maintained. With the strut bent, as in Figure 28-b, the gap is lessened and the wires have become slack, efficiency in flight being thereby lessened.

Fit—Struts and spars must fit their sockets accurately and be bedded correctly. While snugness is essential, the wooden portions of the structure must slide into their sockets or fittings by pushing; a hammer is never required. The bottom should fit the socket exactly. In Figure 29, strut *A* is correctly bedded; strut *B* is not snug at the bottom, in consequence of which the compression stress is not evenly distributed about the center of strength and a bending stress is produced.

In assembly, the customary test consists of painting the bottom of spars and struts before they are fitted to sockets; the paint must be distributed over the entire bed when the strut is withdrawn.

Condition—Struts and spars must be undamaged. If the wood is scored or dented, and the strut or spar should be subjected to a bending stress, the outside fibres receive the greatest strain (as explained on the preceding page) and the collapse will come at the imperfect point. Cross grain, knots and similar blemishes are prohibited for the same reason.

The wood must also be well varnished to keep the moisture out. Variation in the dampness of the atmosphere causes wood to expand and contract, the danger in this variation being that this expansion and contraction is not evenly distributed and the symmetry of the spar or strut is lost.

WOOD FOR AEROPLANES

Practically all of the aeroplane's framing is constructed of wood, one reason for this being that flaws can easily be detected; consequently, wooden parts are seldom painted, preservation being secured by the use of varnish which brings out clearly any defects. Lightness, strength and rigidity are the prime requirements for flying machine construction. Certain woods best fulfill these, better in fact than any metal. This may be illustrated by a comparison of spruce with aluminum, lightest of the metals.

A cubic foot of spruce weighs 27 pounds.
A cubic foot of aluminum weighs 162 pounds.
Tensile strength of spruce per square inch is 7,900 pounds.
Tensile strength of aluminum per square inch is 15,000 pounds.
Compression strength of spruce per square inch is 4,300 pounds.
Compression strength of aluminum per square inch is 12,000 pounds.

On the cubic foot basis, the weight of spruce has a decided advantage over metal. Aluminum's weight is 6 times greater; brass about 19 times greater; nickel and steel about 18 times; copper about 20 times.

While wood is not as strong as steel of the same size, the construction of struts requires a certain thickness in proportion to their unsupported length, so the use of spruce, although it offers by its size more head resistance, is to be preferred because strength against bending is secured with less weight.

Preferential woods for aeroplane work are Spruce, Ash, Pine, Maple, Walnut, Mahogany, Cedar and Hickory. The selection of the right kind of lumber is largely a matter of experience, but the fundamentals are soon acquired with application to the subject.

Spruce—The strongest and most generally satisfactory material when clear grained, straight, smooth and free of knot holes and sap pockets. Combining flexibility, lightness and strength, it is used for struts and spars.

Ash—A straight-grained wood, strong in tension, springy, but heavier than spruce. It is used for main spars, longerons, engine supports, rudder post, etc.

Maple—A strong wood suitable for small parts such as the blocks to connect rib pieces across a spar.

Hard Pine—A tough and uniform wood adapted for the long braces in the wings.

Walnut and Mahogany—Uniformity, hardness and finishing qualities are the reasons for extensive use of these woods for propellers.

Cedar—Lightness, uniformity and easy working qualities recommend this wood for occasional use in fuselage covering. Three-ply wood, or veneers, are sometimes used.

Hickory—Tough, hard and springy, this is the favored material for skids and landing chassis struts.

Condensed Table of Weight and Strength

U. S. Government Specifications

Wood	Weight per cubic foot (15% moisture)	Modulus of rupture, pounds per square inch	Compression strength, pounds per square inch
Hickory	50	16,300	7,300
Ash	40	12,700	6,000
Walnut	38	11,900	6,100
Spruce	27	7,900	4,300

Linen and cord are used for wrapping wooden members to increase strength against splitting; the winding is made very tight and treated with "dope" or glue for waterproofing and also to increase the tightness. Wooden parts are ordinarily ferruled at the ends, usually with copper or tin, to prevent the bolt pulling out with the grain, to prevent splitting and to supply a uniform base.

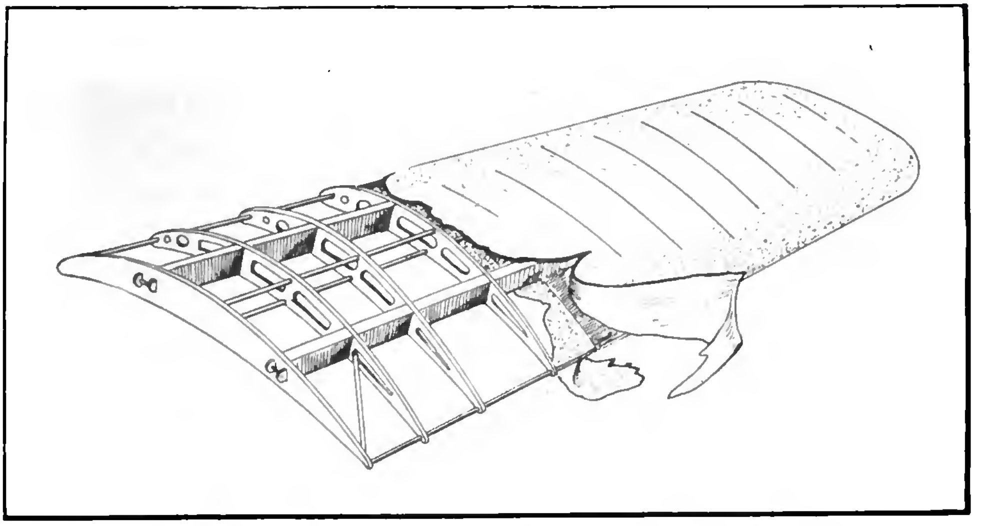


Figure 30—View of wing surface and method of applying covering

WING COVERING

Unbleached Irish linen, stretched rather loosely on the frame of the wing and then treated with "dope," is the almost universal covering for aeroplane lifting surfaces.

This fabric is woven with the "warp" of the yarn lengthwise and the "weft" across the cloth. It tests to a 60 pound tension on an inch-wide strip, and when doped shows a strength of at least 70 pounds per inch. It ordinarily weighs 3¾ to 4¾ ounces per square yard. Doped and finished, aeroplane linen weighs about 0.10 pound per square foot, inclusive of tape and varnish for both top and bottom faces of the surface.

Rubberized fabrics, formerly used, were discarded because of the necessity for stretching them tightly by hand on the frame, and because they tightened in dampness and sagged in dry weather.

The strips of the linen wing covering are sewed together by machine, forming a bag which slips easily over the framework, seams running diagonally across the wing. Figure 30 illustrates a partial covering on the wing framework.

DOPE

Dopes for coating linen wing coverings are of several kinds, but all are some compound of cellulose acetate or nitrate, soluble in ether or in aceton. Through doping, the linen is tightened up on the frame and given a smooth, weather-resisting finish.

The United States Army requires four coats of nitrate dope, this covering being varnished with two coats of spar varnish after the dope has set; this acts as waterproofing and protects the dope from peeling. Doped fabrics are best cleaned by soap and water.

Trade names of commercial dopes include: Cellon, Novavia, Emaillite, Cavaro and Titanine.

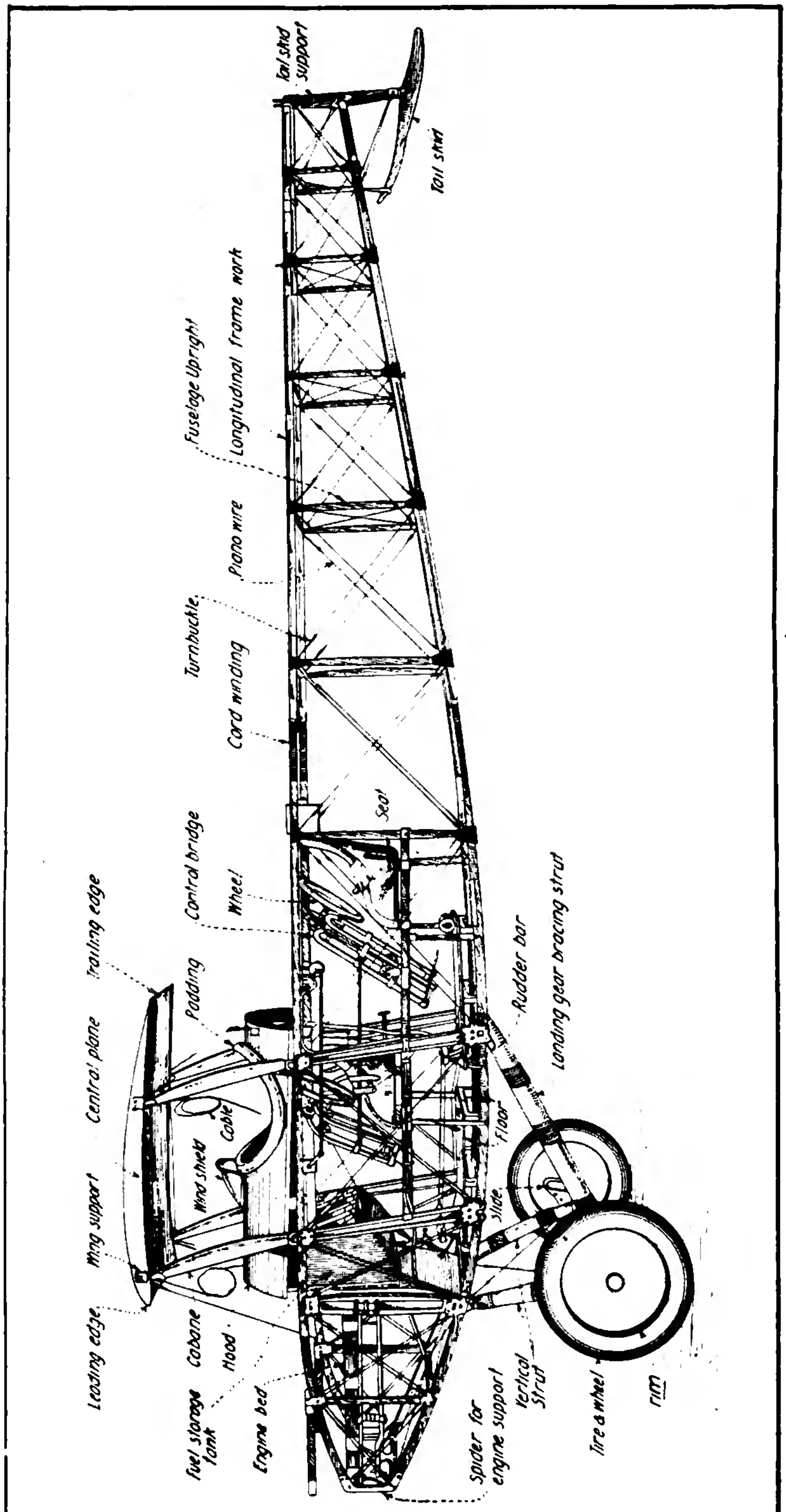


Figure 31—General view of an aeroplane with fuselage covering removed, showing details of body construction.

METAL FITTINGS AND WIRE

STEEL

Chrome nickel or vanadium steel, specially heat-treated, is often used for bolts, turnbuckles and pins. When parts are to be bent, special care must be taken that the heating is not done unequally. Serious weakening may result.

Cold rolled steel, used largely for ferrules, clips and fittings in aeroplane construction, is harder than mild annealed steel, works easily and wears well. Its grain is well marked and it should be remembered that it is weakest across the grain. Sharp bends should never be made and, unless one is familiar with annealing, any required bend should be made slowly in a vise. The jaws of the vise should be protected by thick copper pads to prevent nicking the plate.

OTHER METALS

Copper and tin are used for tanks and ferrules of wire joints.

Where rust resisting qualities are essential on metal fittings, "monel" metal is extensively used. It is composed of 60 per cent nickel, 35 per cent copper and 5 per cent iron.

Aluminum is unreliable and is never used in important fittings.

Metal is subject to crystallization and fatigue.

Crystallization—Constant vibration and jarring which causes easy breakage at a particular point.

Fatigue—Repeated strains of bending and twisting result in loss of "springiness" of metal, lessening its strength. This is known as fatigue.

WIRE

Two types of wire are used on aeroplanes: solid-drawn, for all minor bracing purposes; flexible cable, for control, flying and landing wires.

Aviation wire—This is a single wire, piano grade. While it is strongest for its weight, it forms kinks easily when coiled and may be seriously injured by a blow. Its main use, therefore, is for braces in the protected fuselage and wings.

Aviator strand—This is 7 or 19 wires stranded together and used for tension wires because of its elasticity, permitting it to be bent around parts of small diameter.

Tinned aviator cord—This is a cord or rope stay, composed of seven strands of 7 or 19 wires twisted into a rope. The wires are galvanized as a protection against rust, but where the heat required for galvanizing will injure hard or small wires, they are tinned. It is in general use for controls, and although less strong as the same size in single wire, has the advantage of not being seriously injured by a single weak spot.

The seventh article of this series, which will appear in the February issue, will deal with the assembly of military aeroplanes, describing practical erection and rigging.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE IX

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

EDITOR'S NOTE.—This is the ninth installment of a condensed course in wireless telegraphy, especially prepared for training young men and women in the technical phases of radio in the shortest possible time. It is written particularly with the view of instructing prospective radio operators whose spirit of patriotism has inspired a desire to join signal branches of the United States reserve forces or the staff of a commercial wireless telegraph company, but who live at points far from wireless telegraph schools. The lessons to be published serially in this magazine are in fact a condensed version of the textbook, "Practical Wireless Telegraphy," and those students who have the opportunity and desire to go more fully into the subject will find the author's textbook a complete exposition of the wireless art in its most up-to-date phases. Where time will permit, its use in conjunction with this course is recommended.

The outstanding feature of the lessons will be the absence of cumbersome detail. Being intended to assist men to qualify for commercial positions in the shortest possible time consistent with a perfect understanding of the duties of operators, the course will contain only the essentials required to obtain a Government commercial first grade license certificate and knowledge of the practical operation of wireless telegraph apparatus.

To aid in an easy grasp of the lessons as they appear, numerous diagrams and drawings will illustrate the text, and, in so far as possible, the material pertaining to a particular diagram or illustration will be placed on the same page.

Because they will only contain the essential instructions for working modern wireless telegraph equipment, the lessons will be presented in such a way that the field telegraphist can use them in action as well as the student at home.

Beginning with the elements of electricity and magnetism, the course will continue through the construction and functioning of dynamos and motors, high voltage transformers into wireless telegraph equipment proper. Complete instruction will be given in the tuning of radio sets, adjustment of transmitting and receiving apparatus and elementary practical measurements.

This series began in the May, 1917, issue of THE WIRELESS AGE. Beginners should secure back copies, as the subject matter presented therein will aid them to grasp the explanations more readily. If possible, the series should be followed consecutively.

COUPLED TRANSMITTER CIRCUITS IN RADIOTELEGRAPHY

METHODS OF COUPLING

(1) We have explained in previous lessons how a wireless telegraph aerial may be set into excitation by a **high voltage transformer** or an **induction coil.**

(2) Marconi observed that more powerful oscillations can be made to flow in the aerial circuit of a wireless telegraph transmitter by first generating the radio-frequency currents in a **closed oscillation circuit.** On account of the increased capacity of the closed circuit over that of the aerial circuit, it permitted the use of larger power inputs for the same wave length, spark frequency and voltage.

(3) Hence the **"plain aerial"** or **"directly excited"** transmitter was soon replaced by the coupled transmitter.

(4) There are four general methods in spark telegraphy for setting the aerial wires into electrical oscillation:

(1) **By direct excitation;**
(2) **By inductive coupling;**
(3) **By conductive coupling;**
(4) **By electrostatic coupling.**

(2), (3), and (4) are also known as indirect methods of coupling. Each method will be discussed further on.

WAVE LENGTH AND FREQUENCY

(1) The student should recognize the relation between the **frequency of the oscillations flowing** in the **aerial** or **open oscillation** circuit and the length of the **radiated electrical waves.**

(2) If the frequency of the aerial current is known, then the length of the radiated wave is determined by the equation

$$\lambda = \frac{V}{N}$$

Where* λ = the wave length in meters;

V = the velocity of propagation of electric waves in meters per second;
= 300,000,000 meters per second;
N = the oscillation frequency.

Hence, if N, the oscillation frequency = 1,000,000 cycles per second, then the wave length $= \frac{300,000,000}{1,000,000} = 300$ meters.

Similarly, an oscillation frequency of 500,000 cycles corresponds to a wave 600 meters in length.

*Greek Lambda.

(3) It is manifest that currents of extremely high frequency radiate comparatively short waves, and those of low frequency, comparatively long waves.

(4) The longest wave length on record employed for wireless telegraph transmission is 18,000 meters. The frequency of the antenna current at this wave length must be $\frac{300,000,000}{18,000} = 16,666$ cycles per second, which is nearly a current of audiofrequency.

(5) The natural wave length of a simple vertical wire earthed at one end is approximately 4.3 times its length. Therefore a vertical wire 100 feet in length, if set into excitation, will radiate a wave 4.3 x 100 or 430 feet in length. Since one meter equals 3.25 feet, the wave length is approximately 130 meters.

(6) The natural wave length of an aerial can be computed from knowledge of its inductance and capacity. If its inductance L be expressed in centimeters (1,000 centimeters=1 microhenry) and its capacity C in microfarads, then

$$\lambda = 38\sqrt{L\ C}$$

Assume that by measurement the inductance of an aerial is found to be 100,000 centimeters and the capacity .001 microfarads, then the wave length $= 38\sqrt{100,000 \times .001} = 38\sqrt{100} = 380$ meters. This is a fair average value for a ship's aerial.

(7) The **wave lengths** allotted by the International Radio Telegraphic Convention for **ship use** are 300 and 600 meters. Either of these waves must be used for calling another station, but after communication is established, waves of any length between 300 and 600 meters may be employed.

Waves from 600 to 1,000 meters in length are used by Naval stations for ship to shore communication.

By special permission, vessels may, under exceptional circumstances, be granted licenses to employ waves in excess of 1,600 meters.

High Power stations for continent to continent communication employ waves up to 15,000 meters in length. The latter figure corresponds to a wave more than nine miles in length.

(8) We frequently speak of the **wave length of the closed oscillation circuit.** Reference is made to a particular frequency of oscillation, and the length of a single wave in the resulting wave motion if the circuit were radiative. Thus, if the frequency of a given closed circuit is 1,000,000 cycles per second it would correspond in the case of a radiating circuit to a wave 300 meters in length.

(9) It is essential that the open and closed oscillation circuits of a radio transmitter be adjusted to the same **natural** frequency of **oscillation** or the **same wave length.** They are then said to be in electrical resonance and it is only when they are substantially so adjusted that the maximum transfer of energy from one circuit to the other is obtained.

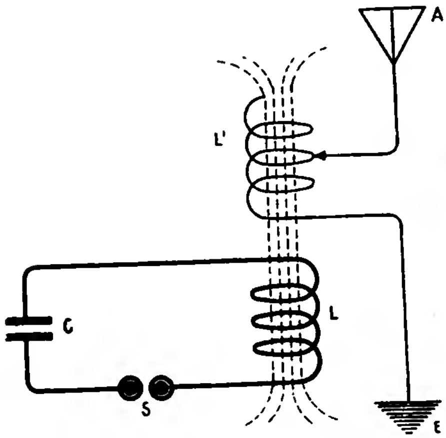


Figure 82

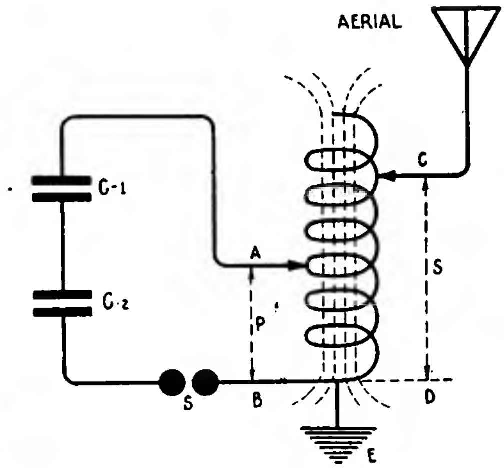


Figure 83

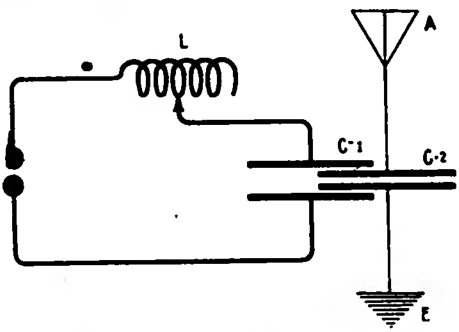


Figure 84

OBJECT OF THE DIAGRAMS

(1) To indicate the various modes of coupling the closed and open circuits of a radio transmitter.
(2) Figure 82. To show the circuits of an inductively coupled transmitter.
(3) Figure 83. To show the circuits of a conductively coupled transmitter.
(4) Figure 84. To show the circuits of an electrostatically coupled transmitter.

PRINCIPLE

Very powerful oscillations can be set up in an aerial circuit by generating them in a closed oscillation circuit which on account of its increased capacity permits more power to be employed for the same spark frequency and voltage. These oscillations are transferred to the aerial circuit through an oscillation transformer by electromagnetic induction.

DESCRIPTION OF THE DIAGRAMS

In Figure 82 the closed oscillation circuit consists of the condenser C, the primary winding of the transformer L, and the spark gap S. The **aerial** or **antenna** circuit includes the elevated wire A, the secondary winding, L^1, and the earth connection E.

In Figure 83 a single coil acts as an **auto-transformer** to transfer energy from the closed oscillation circuit to the open circuit. The closed circuit consists of the condensers C-1, and C-2 connected in series, the spark gap S, and the primary winding of the oscillation transformer which comprises the turns A to B. The secondary winding of the oscillation transformer comprises the turns C to D, the complete open circuit including the secondary coil, the antenna, and the earth connection.

In Figure 84 the closed oscillation circuit embraces the spark gap, the tuning coil L, and the condenser C-1. The open circuit comprises the aerial A, the aerial **condenser C-2,** and the earth connection E.

OPERATION

In Figure 82 the radio frequency oscillations flowing through the coil L generate a magnetic field which cuts through the turns of L^1 inducing therein oscillations of the same frequency, and if the circuits are in substantial resonance the maximum transfer of energy takes place.

In Figure 83 the flux generated by the current flowing through turns A to B acts inductively on the remaining turns of the coil setting up in the aerial circuit oscillations of similar frequency. Part of the energy of the closed circuit, however, flows into the antenna circuit by direct conduction.

In Figure 84 the electrostatic field set up between the plates of the condenser C-1 acts inductively upon the plates of the condenser C-2, the oscillations generated in the closed circuit thus being impressed upon the open circuit. This diagram represents coupling by electrostatic induction; direct or conductive electrostatic induction may also be used.

QUES.—Which of the methods of coupling shown in Figures 82, 83 and 84, is most extensively employed in commercial wireless telegraphy?

ANS.—The inductively coupled system is employed in the majority of installations.

QUES.—Why is this so?

ANS.—Because the inductive method permits the character of the radiated wave to be closely adjusted with the greatest ease. To illustrate: If the primary winding L is placed close to L^1 the aerial circuit will radiate a broad wave which will interfere with receiving stations not accurately tuned to its wave length; but if the primary winding L is drawn away from L^1 a sharper wave will be radiated which will only influence receiving stations accurately tuned to it.*

QUES.—What is the advantage or disadvantage of the conductive method of coupling?

ANS.—The principal advantage lies in its simplicity, a single coil being employed to act as the oscillation transformer. The principal disadvantage is that unless the earth connection is supplied with a special contact clip any change in the wave length of the open and closed circuits will change the coupling. That is to say, the same coupling cannot be held as the inductance of the open and closed circuits is increased or decreased. More clearly, it is difficult to obtain a certain degree of coupling without destroying the adjustments for resonance.

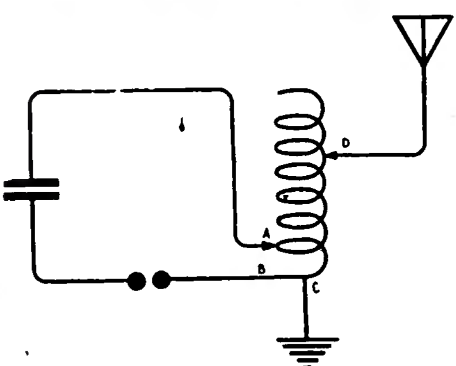


Figure 85

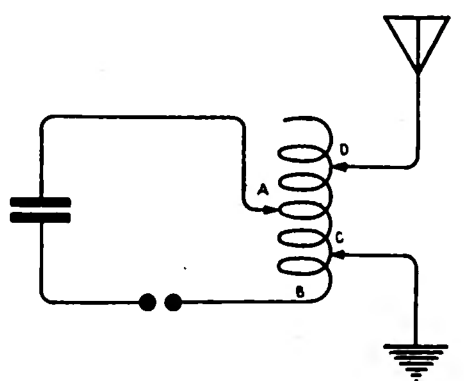


Figure 86

Figures 85, 86—Showing the possible conditions under which loose coupling may be obtained with an auto-transformer. In Figure 85 the turns connected in the aerial circuit from C to D may be placed at the upper end of the coil and those connected in the closed oscillation circuit A to B at the lower end of the coil. This decreases the **mutual inductance** *between the primary and secondary turns and therefore reduces the coupling.*

In the diagram Figure 86 the capacity of the condenser of the closed oscillation circuit is such that in order to establish resonance with the aerial circuit not more than a half turn of the oscillation transformer between points A and B is required. Hence, the mutual inductance is at a minimum and the coupling is accordingly decreased.

*This point will be explained more in detail in connection with the spark dischargers of modern transmitters.

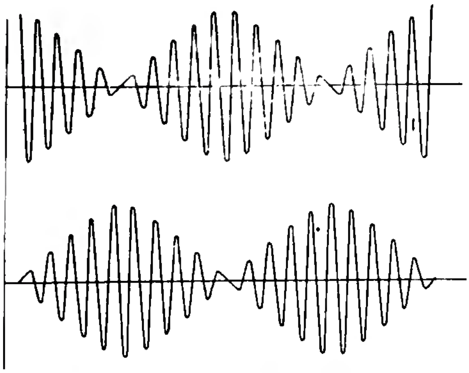


Figure 87

OBJECT OF THE DIAGRAMS

(1) Figure 87. To show diagrammatically the resulting oscillations in a coupled wireless telegraph transmitter in which the spark gap gives imperfect quenching of the primary oscillations.

(2) Figure 88. To show the resulting oscillations in a properly adjusted wireless telegraph transmitter, i. e., (1) where the discharge gap is constructed for quenching or (2) where the coupling is sufficiently loose to assist the quenching of an improperly cooled gap or an improperly designed transmitter.

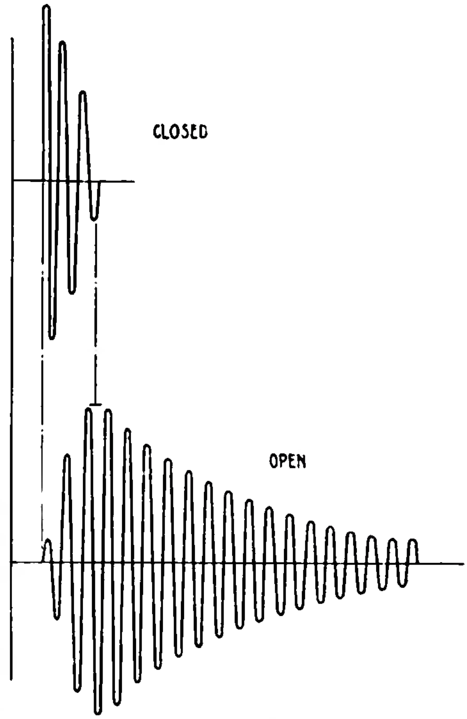


Figure 88

PRINCIPLE

By proper design of a wireless telegraph transmitter, the oscillations flowing in the closed circuit can be quenched out after two or three swings. The aerial circuit will then be set into oscillation at its own frequency and damping, and the radiated energy will be confined to a single wave length.

If the spark gap does not quench properly or if the coupling between the primary and secondary of the oscillation transformer is too close there will be an interchange of energy between the secondary and primary circuits which will cause the circuits to oscillate at two frequencies. The aerial will, therefore, radiate two waves of different length.

DESCRIPTION OF THE DIAGRAMS

In Figure 87 are shown the resulting antenna oscillations generated by a transmitter in which the spark gap does not quench properly. It will be noted that when one group of oscillations reach their maximum value, the other group are nearly at zero. In the sense of a complete second, these two groups of oscillations occur simultaneously, but in the sense of a small fraction of a second they do not reach their maximum amplitudes simultaneously.

Figure 88 depicts the oscillations in the closed and open circuits in a properly adjusted transmitter, i.e., one where reliable quenching takes place. Here the closed circuit oscillates until the antenna currents reach their maximum value. Then the oscillations of the closed circuit, due to the sudden increase of the spark gap resistance, are quenched out permitting the antenna to oscillate at its natural frequency and damping. A single wave is therefore radiated.

SPECIAL REMARKS

(1) Quenching of the primary oscillations can be obtained with practically any type of transmitter provided the coupling is sufficiently loose, but in properly constructed spark dischargers, good quenching can be obtained with very close coupling and hence a greater amount of energy is transferred to the antenna circuit resulting in a more efficient transmitter.

(2) The best gaps for quenching the primary oscillations are the so-called **"quenched" or multiple plate gaps and the rotary gaps.** The quenched gap consists of a number of copper plates the sparking surfaces of which are carefully ground, the plates being separated by an insulating gasket of approximately .01 of an inch in thickness. By providing a discharger consisting of several such gaps in series, the primary oscillations are rapidly quenched out and re-transference of energy from the aerial circuit to the closed circuit is thereby prevented. The quenching of the primary oscillations is probably due to the rapid dissipation of the heat of the spark discharge through the copper

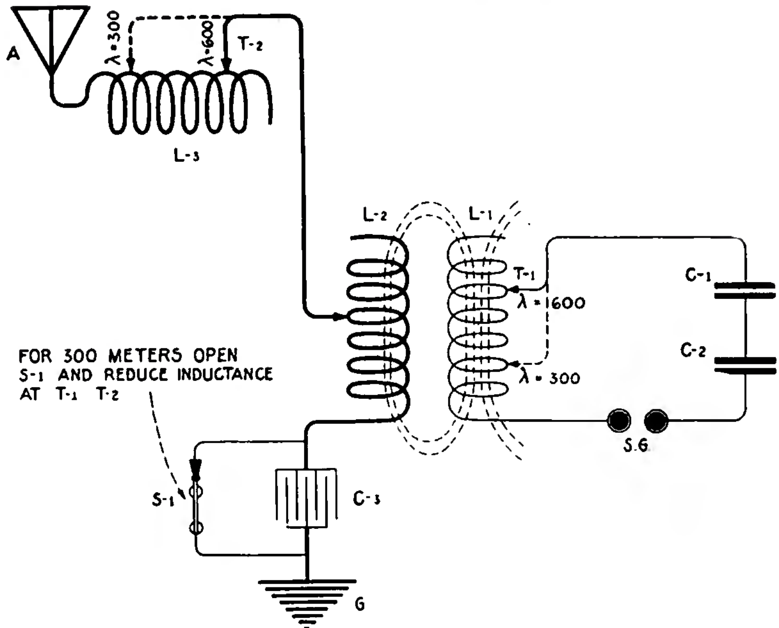


Figure 89

OBJECT OF THE DIAGRAM

(1) To outline the complete radio-frequency circuits of a spark transmitter.
(2) To show how the length of the wave radiated by a wireless telegraph aerial can be increased or decreased within the station.

PRINCIPLE

The length of the wave radiated by a wireless aerial may be increased by connecting a coil of wire (radio-frequency inductance) in series at the base, or it may be decreased by connecting a condenser in series.

For maximum efficiency, the spark gap circuit (closed oscillation circuit) must be accurately tuned to resonance with the aerial circuit.

DESCRIPTION OF THE DIAGRAM

In figure 89 the open oscillation circuit comprises the aerial A, the aerial tuning inductance L-3, the secondary winding of the oscillation transformer L-2, the short wave condenser C-3, and the earth connection G.

The closed oscillation circuit comprises the spark gap S-G, the high voltage condensers C-1 and C-2, and the primary winding of the oscillation transformer L-1.

OPERATION

If the open and closed circuits have been tuned to the standard waves of 300 and 600 meters, the procedure for changing from one wave length to the other is as follows:

Assume that the two circuits are set to radiate a wave of 600 meters, then to reduce the radiated wave to 300 meters proceed as follows:

(1) Cut out turns at the coil L-3;
(2) Open switch S-1 on the short wave condenser;
(3) Cut out turns in the primary winding L-1.

In special cases it may be necessary to insert a different number of turns at the winding L-2 for the two waves, and also, if the condensers C-1 and C-2 have capacity in excess of that required for a certain wave length, the capacity must be reduced to a value commensurate with the required wave length.

SPECIAL REMARKS

(1) The open and closed circuits may be tuned to resonance as follows: By means of a wavemeter, tune the closed circuit to one of the standard wave lengths. Then connect a hot-wire ammeter in series with the open circuit. Cut in or out turns at L-2 and L-3 until the hot-wire ammeter gives a maximum reading. The two circuits now oscillate in electrical resonance, and it is under this adjustment only, that a maximum amount of energy will be induced in the open circuit.

QUES.—To what value in practice can the natural wave length of a transmitting aerial be increased?

ANS.—In general, it will hinder the efficiency of the transmitter to raise the wave length of an aerial by more than four times its natural length. The resistance of the added inductance at values in excess of this will occasion energy losses.

QUES.—What precaution must be taken if the capacity of the closed circuit condenser must be reduced for the 300-meter wave?

ANS.—In general, in order to prevent arcing at the spark gap either the voltage of the transformer must be reduced or a reactance coil be inserted in series with the primary winding.

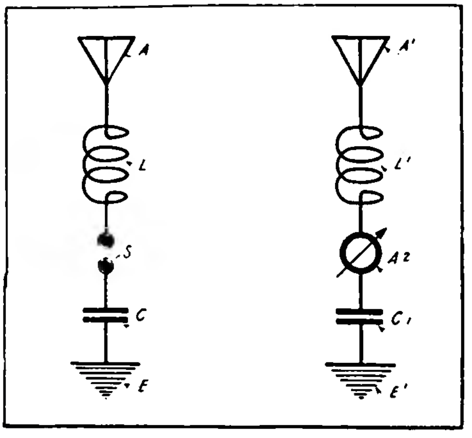


Figure 90

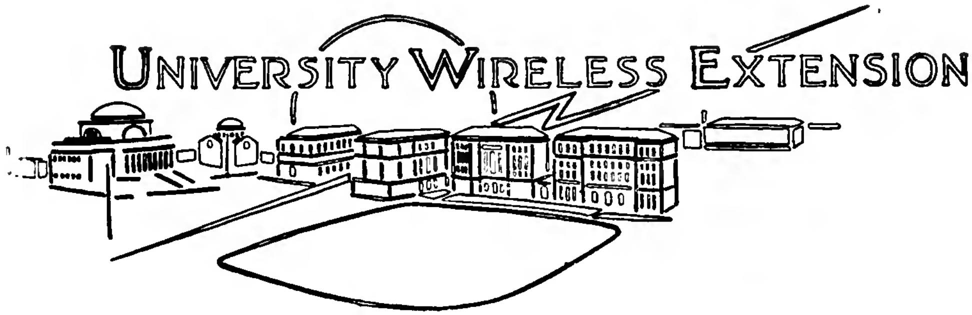
Showing how the aerial of a wireless receiving station may be tuned to resonance with the transmitting aerial. Assume that aerials A and A^1 are identical in every respect, i. e., that they possess same values of inductance and capacity throughout. Similarly, assume the coils L and L^1 possess identical values of inductance. Assume further that L and L^1 are cut out of the circuit. Then if aerial A, is set into oscillation by being charged at the spark gap S, maximum current will flow in aerial A^1 as would be indicated by the reading of the meter A^2. The two circuits are now in electrical resonance and the maximum transfer of energy takes place.

Now, the wave-length of the aerial A, can be increased by inserting, let us say, two turns of wire in the circuit at L. Then to establish resonance in aerial A, two turns must be added at the coil L^1. Similarly, if a condenser C of, let us say, .0005 microfarad is connected in series with the aerial A, the length of the radiated wave will be decreased and a condenser C, of similar capacity must be connected in series with the aerial A^1 to establish resonance. This, basically, is the method by which the receiving aerial is tuned to the transmitting aerial, but the student should keep in mind that "open oscillation" circuits only, are under consideration. Modern radio systems contain an **open** *and* **closed** *circuit at the transmitter, and an* **open** *and* **closed** *circuit at the receiver.*

Continuing our explanation of tuning; if the aerial A^1 is shorter than A, then if A is excited with all turns of L cut out, a few turns must be inserted in the circuit of the Aerial A^1, and L^1, to establish resonance.

Transmitting and receiving aerials of similar values of inductance and capacity are rarely encountered in wireless practice. Hence, it is necessary to provide both the transmitting aerial and the receiving aerial with a variable inductance and a variable condenser in order that the transmitter may radiate waves of different length, or that the receiver may respond to waves of different length.

(To be continued)



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 XIII

A SYSTEM of radio telephonic control involving both an Alexanderson alternator for the direct generation of the radio frequency energy and one or more pliotrons for the modulation and control thereof is shown in Figure 163. As will be seen, the radio frequency alternator is coupled inductively to the antenna by

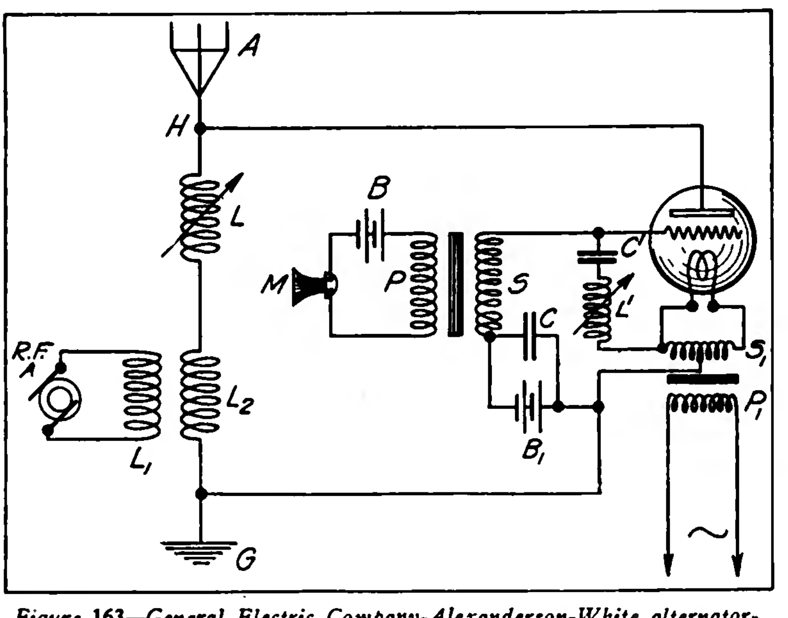


Figure 163—General Electric Company-Alexanderson-White alternator-pliotron radiophone transmitter

the coils L_1 and L_2. The antenna is tuned by the variable inductance L, and the top H of the tuning inductance is the point of highest potential within the station building. (Of course, the highest potential produced by the set is at the relatively inaccessible top of the antenna.) The filament of a large pliotron is connected to the ground, and the plate of the pliotron to the point H at the top of the tuning inductance. If the filament is heated by alternating current, the mid-point of the step-down transformer secondary whereby this is accomplished is connected to ground thus equalizing the thermionic current in all parts of the filament as much as possible (as indicated in the description of Figures 64 and 65). If the grid of the pliotron is kept at a very negative potential, the effect on the antenna energy will be practically nothing. As the grid becomes less negative, the pliotron permits increasingly more radio frequency current to pass through in rectified half cycles, thus withdrawing energy from the antenna. In other words, the output of the alternator either passes into the antenna system or into the pliotron bulb. It is found by experience that the fact that the pliotron absorption takes place only for half cycles does not affect this conclusion.

It will be noted that the grid is normally maintained at a negative potential by the battery B_1, which battery is shunted by the condenser C which acts as an audio frequency by-pass. The secondary of the audio frequency transformer S is also included in the grid circuit, and thus the grid potential is also caused to vary in accordance with the speech forms. In thus controlling the antenna energy by the pliotron, a curious difficulty arises. The impressed radio frequency plate potentials are quite high, and there is capacitive coupling between the plate and grid *within the bulb* since these metallic masses are, in effect, the parallel plates of a condenser. In consequence, there will be induced smaller, though still troublesome, radio frequency potential variations on the grid. During the positive half cycle, a positive potential is induced on the grid which may be much larger than the potential supplied to the grid from the telephone transmitter. This action, therefore, prevents control. This would render the system inoperative, but the effect is avoided by the introduction of the radio frequency short-

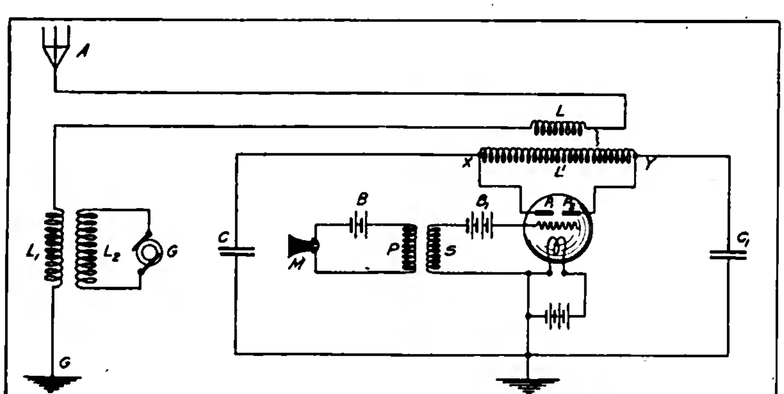


Figure 164—General Electric Company-Alexanderson alternator-pliotron control radiophone transmitter

circuit $L'C'$ between the grid and the filament, whereby no radio frequency potential variations can occur on the grid.

Another form of the same general type is shown in Figure 164. In this form also the control system of energy absorption by the pliotron is used, but in addition an appropriate radio frequency transformer LL' is provided. This raises the applied voltage to a value most suitable for the pliotron actually available. In other words, instead of absorbing a given amount of energy at low voltage and high current it is absorbed at high voltage and low current. Furthermore, there are provided two plates P_1 and P_2 of the pliotron so that absorption occurs during both half cycles. The actual appearance of the step-up transformer which has been used experimentally is given in Figure 165. It is an open core auto transformer consisting of a number of flat coils hung on wooden rods. One or two of the central sections are tapped to form the primary and the whole set of coils, terminating at wires X, Y constitute the secondary. Special forms of end shields designed to prevent excessive corona and break-down are mounted at the ends of these sets of coils. The exact mode of operation of this transformer is described in "Proceedings of the Institute of Radio Engineers," Volume 3, Number 2, page 138. This transformer has very low losses, so that it becomes possible to transform from 250 volts to 100,000 volts at 100,000 cycles. Under these conditions, the inductance of the transformer system was such that 2 amperes appeared at the center of the secondary winding. A study of the action of this transformer shows that if the decrement of the secondary tuned circuit be increased (by the pliotron) from its normal value of about 0.008 to about 0.8, the effective impedance of the system will increase from 125 ohms to 12,500 ohms. One unusual characteristic of this method of varying the radio frequency resistance of the antenna, by inserting therein the primary of a transformer the secondary circuit of which contains a pliotron, is that maximum secondary current naturally corresponds to minimum antenna current.

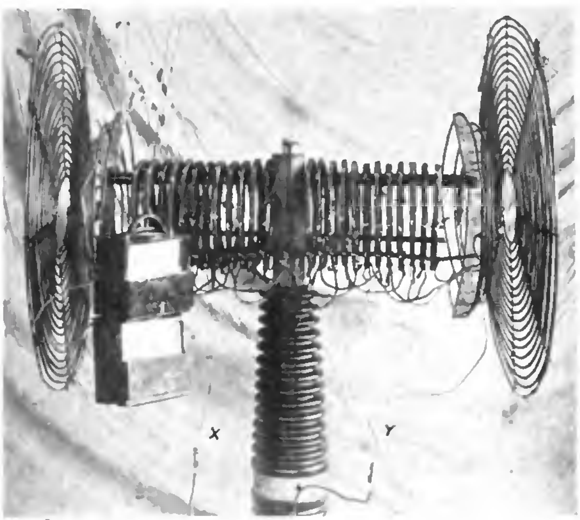


Figure 165—Step-up transformer for radio-frequency high voltage transformation

This system of control enabled radiophone communication between Schenectady and Pittsfield, a distance of 50 miles (80 km.), a small 2 K. W. alternator running at 90,000 cycles being used as the source.

(h) **FERROMAGNETIC CONTROL SYSTEMS.** We pass now to a highly valuable group of control systems wherein the magnetic properties of the iron cores of inductances are utilised. They depend on the following principle. The permeability of iron is not constant; that is, the magnetic flux or induction through the iron core of an inductance is not directly proportional to the applied magnetising force (in ampere turns) but varies in the manner which was discussed in the description of Figure 96, though in connection with a different application to frequency changes. In consequence, the inductance of such a coil is dependent on the current. Starting with very small magnetisation, the permeability rapidly increases to a maximum and then slowly drops till it reaches the value unity for very high flux densities. Similarly, beginning with a small current through an iron core inductance, the inductance of the coil first rises rapidly, and then drops slowly. This point will be illustrated hereafter.

We shall consider only two radiophone systems based on this principle, since these two are the only ones in actual use at present. They are the system of the Telefunken Company, as devised by Dr. Ludwig Kühn and others, and the General Electric Company's system, as devised by Mr. E. F. W. Alexanderson.

Dr. Kühn was led to work out the first mentioned system by his failure in 1912 to control directly approximately 7 kilowatts of radio frequency energy by 72 microphones! The first circuit devised by him is shown in Figure 166. Here circuit 2 contains the radio frequency alternator *G* and the primary *P* of an ordinary transformer. We shall call the current in this circuit i_1. The next

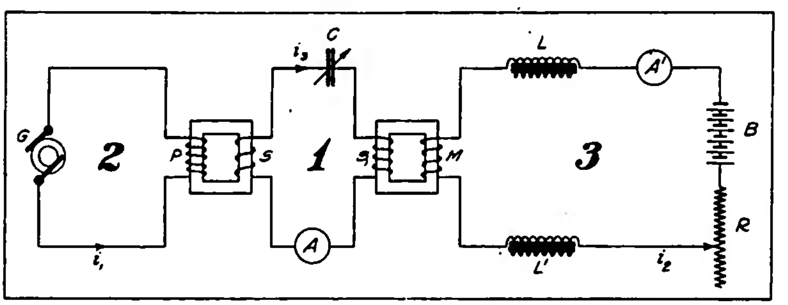


Figure 166—Control of radio frequency current in resonant circuit by variation of magnetisation of iron core of inductance

circuit, 1, contains the secondary *S* of the same transformer, an iron core inductance S_1, a tuning condenser *C*, and the ammeter *A*. In this circuit we have the current i_3. Circuit 3 contains the battery *B*, a variable resistance *R*, the ammeter *A'*, two choke coils *L* and *L'* to prevent radio frequency currents flowing in this circuit by induction from S_1 to *M*, and the magnetising coil *M*. If circuit 1 be tuned to resonance and then circuit 3 be closed, the inductance of S_1 will be changed because of the change in permeability of the iron core. In consequence, the current in circuit 1 will drop as the direct current in circuit 3 is increased. Conversely, we might arrange to have full resonance current in circuit 1 with a moderate direct current flowing through *M*, and in this case diminishing (or increasing) the direct current would cause the alternating current in circuit 1 to drop. This, then, is a system whereby the radio frequency current in circuit 1 may be caused to follow variations in the current in circuit 3.

The control characteristic of a somewhat improved system of this type, shown in Figure 169 below, is given in Figure 167. Vertically is plotted the radio frequency current in the antenna and horizontally the magnetising force (i. e., the product of amperes and turns). It will be seen that the control is linear between point *A* (corresponding to 10 amperes antenna current) and *C* (corresponding to 40 amperes). A change in ampere turns of 1,100-600 or 500 is necessary to effect this change in antenna current. The reason why the curve of Figure 167 bends at *C* is shown in Figure 168, which is the magnetisation curve of the iron core of the controlling inductance. It will be seen that the control must be much more effective for magnetising currents lying between the value *OA* and *OB* than for values lying between *OB* and *OC*, since the difference between *BE* and *AD* is considerably greater than the difference between *CF* and *BE*.

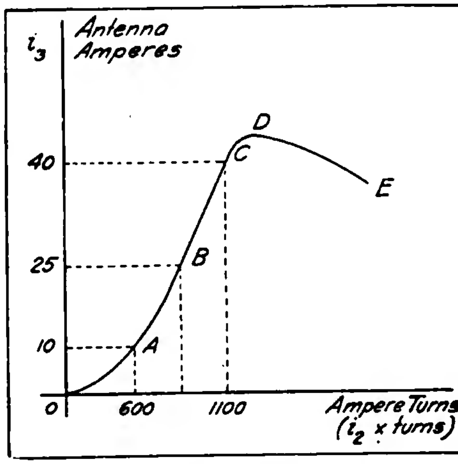


Figure 167—Control characteristic of resonant circuit containing iron core inductance of variable magnetisation

A control system of the type shown in Figure 166 will be most effective under the following conditions. (By effectiveness is meant a maximum change in the alternating current i_3 for a given change in the direct current i_2.)

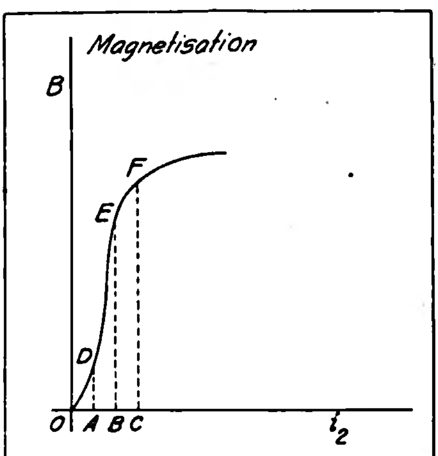


Figure 168—Iron magnetisation curve

1. When a given amount of change of direct current energy in circuit 3 causes the greatest possible change in the inductance of S_1;
2. When the damping of circuit 1 is a minimum, so as to give sharp resonance phenomena;
3. When the couplings between the various circuits are suitably adjusted;
4. When the ratio of the continually present inductance in the circuit 1 to the variable component of inductance in that circuit is a minimum.

Some of these requirements are incompatible with each other. For example, requirements 2 and 4 may easily conflict. A rational compromise must then be effected. As far as requirement 2 is concerned, this will require the use of very thin sheets of special iron as the core of the inductance S_1. In fact, sheets 0.001 inch (0.02 mm.) to 0.002 inch (0.04 mm.) are recommended for this use.

An improvement on the system of control shown in Figure 166 is given in Figure 169. It will be seen that in this case the magnetising coil *M* controls the

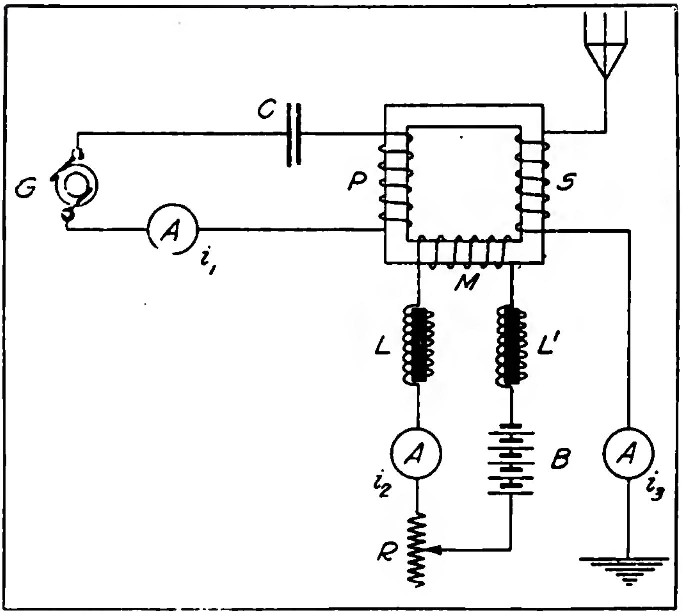


Figure 169—Telefunken Company-Kühn system of antenna current control

inductance P of the radio frequency alternator circuit and also the inductance S in the antenna circuit. Consequently both circuits may be detuned and the resulting change in antenna current for a given change in magnetising current i_2 will be considerably enhanced.

A further study of Figure 167 will indicate that the portion AC of the control characteristic should be as long as possible, and as straight and steep as possible. It was feared at first that working with iron core inductances in the radio frequency circuits, hysteresis effects might distort the speech so as to make it unrecognisable. Experiment, which is an unfailing criterion in such matters, demonstrated conclusively that this fear was groundless. Care must be taken, however, not to exceed the limits of antenna current imposed by the straight line portion of the control characteristic. For an actual characteristic given in Figure 167, the change in antenna energy between 10 amperes and 40 amperes would be 5.4 K.W. with the antenna used. In use for radio telephony, a somewhat more limited range of control was used.

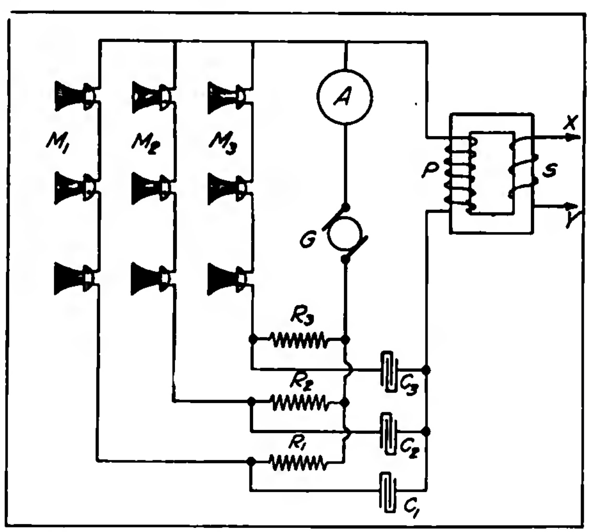


Figure 170—Telefunken Company-Kühn system for utilising microphones in parallel on direct current

In order to secure the necessary control speech current, Dr. Kühn devised the series-multiple arrangement of microphones shown in Figure 170. This is considered at this point instead of under "Microphone Control Systems" because no radio frequency energy is supposed to pass through the microphones and they control only indirectly through a ferromagnetic inductance. Each of the microphone banks M_1, M_2, M_3 is fed from the same generator G and through its individual large resistance R_1, R_2, R_3. Across each microphone is shunted the primary P of the telephone current step-down transformer and the corresponding one of the three condensers C_1, C_2, C_3. The output is taken from XY. The action is simple. Whenever the microphone resistance increases, the current through its series resistance remains nearly constant but the current through it diminishes. The excess current tends to find its way through P and the corresponding condenser. This arrangement of microphones is easily seen to be stable. The telephone transformer PS must be carefully designed. In practice it is a 10-to-1 step-down transformer with a total iron path of about 13 cm. (5 inches). The primary and secondary volt-amperes are nearly equal, the leakage, resistance, iron losses, and magnetising current being all reduced to a minimum.

It will be noticed from Figure 169 that there is a marked tendency to induce radio frequency currents in the magnetising circuit including M, since M is, in effect, the secondary of a transformer of which P is the primary. Drastic means must be taken to avoid this because of the damage to the battery and microphones which would be done and the loss of output energy resulting. In Figure 169 ordinary iron core choke coils are indicated as the means whereby the radio frequency currents are choked off, but this means would almost always be entirely insufficient. The distributed capacity of such a coil would cause it to interpose, but little impedance to the radio frequency currents, in general. A more usual means is by the use of the loop circuit shown in the left of Figure 171. As is well known, the reactance of such a loop measured between the points U and V becomes infinite at the frequency for which the loop is resonant, provided there are no losses in L and C. Even if there are small losses in L and C, the impedance will become very high. An improved method whereby unusually high impedances can be secured by the coils used in practice is shown in the right hand portion of Figure 171. Here L_1 and L_2 are two coils wound in opposite directions on the same core (not of iron). L' and L'' are small inductances widely separated from each other. L_3 and L_4 constitute a double coil similar to L_1 and L_2. The tuning condenser C' is inserted as shown. For the audio frequency telephone currents, L_1 and L_2 form a system of very low inductance as do L_3 and L_4. In fact, the inductance between U and V for telephone currents is only 20 microhenrys in one practical instance. On the other hand, for the radio frequency currents the impedance is extremely high.

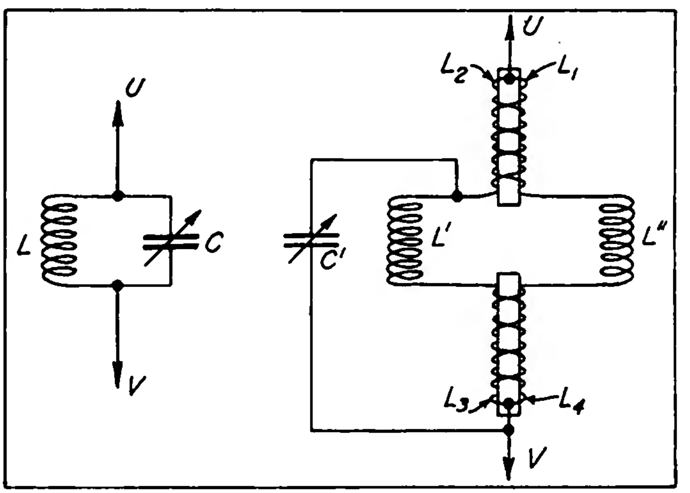


Figure 171—*Ordinary and Telefunken Company-Kühn radio frequency choke systems*

The latest and most improved pattern of these radiophone sets is shown in outline in Figure 172. As will be seen, the generator G of radio frequency energy is placed in a tuned circuit including C and the primaries P_1 and P_2 of the frequency changers. (A description of these frequency changers has already been given in connection with Figures 96 through 100.) The secondaries S_1 and S_2 of the frequency changers are in the antenna circuit in series with a necessary tuning inductance. The direct current generator G_1, is arranged to supply the direct current magnetisation of the frequency changers by the coils M_1 and M_2. The two gaps in the circuit of this generator at UV are supposed to be filled with choke systems such as those of Figure 171, the lettering corresponding. The telephone control current produces *changes* in the otherwise constant magnetisation of the frequency changer cores in passing through the coils M' and M''.

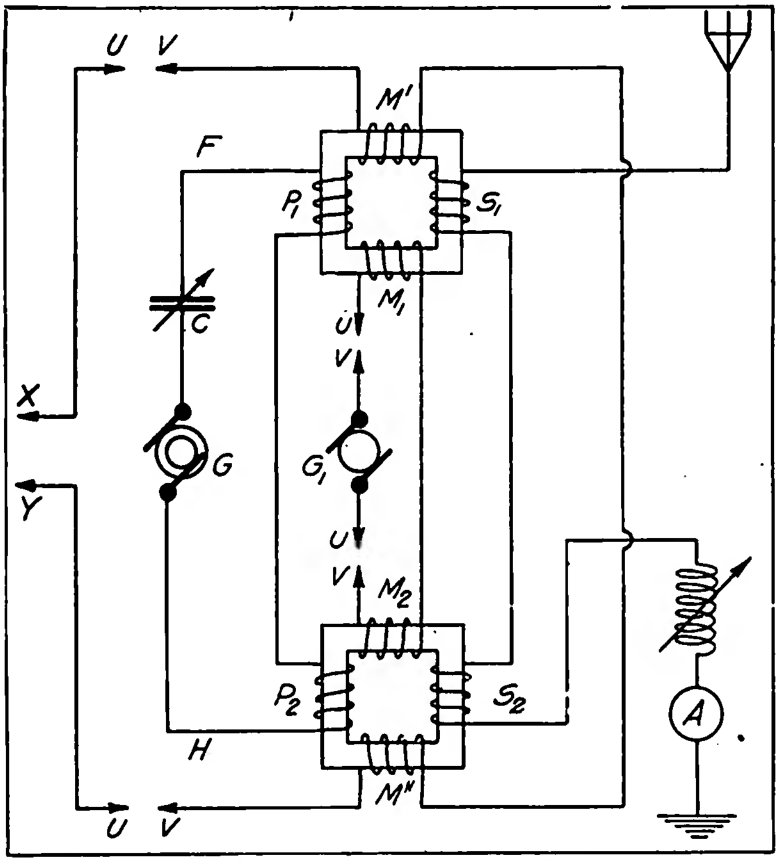


Figure 172—Telefunken Company-Kühn radiophone transmitter, 1913

The telephone currents originate in the gap XY which corresponds to the terminals XY of Figure 170, the remainder of the microphone system being omitted from Figure 172 for the sake of simplicity. For the same reason, the choke systems at points UV in the telephone control circuit are only indicated. It will be noted that the system here shown differs from the simpler system of Figure 169 not only in the use of the frequency changers but also in the separate constant direct current magnetisation and separate telephone control current magnetisation. Instead of having only one set of frequency changers, the terminals FH may themselves be the output terminals of one or more frequency changers these being placed where the generator G is indicated.

An actual radiophone set of this type is shown in Figure 173. This set is supposed to be run from 110 volt direct current mains. A motor drives the 10 K. W., 10,000 cycle alternator, which is similar to that shown and explained

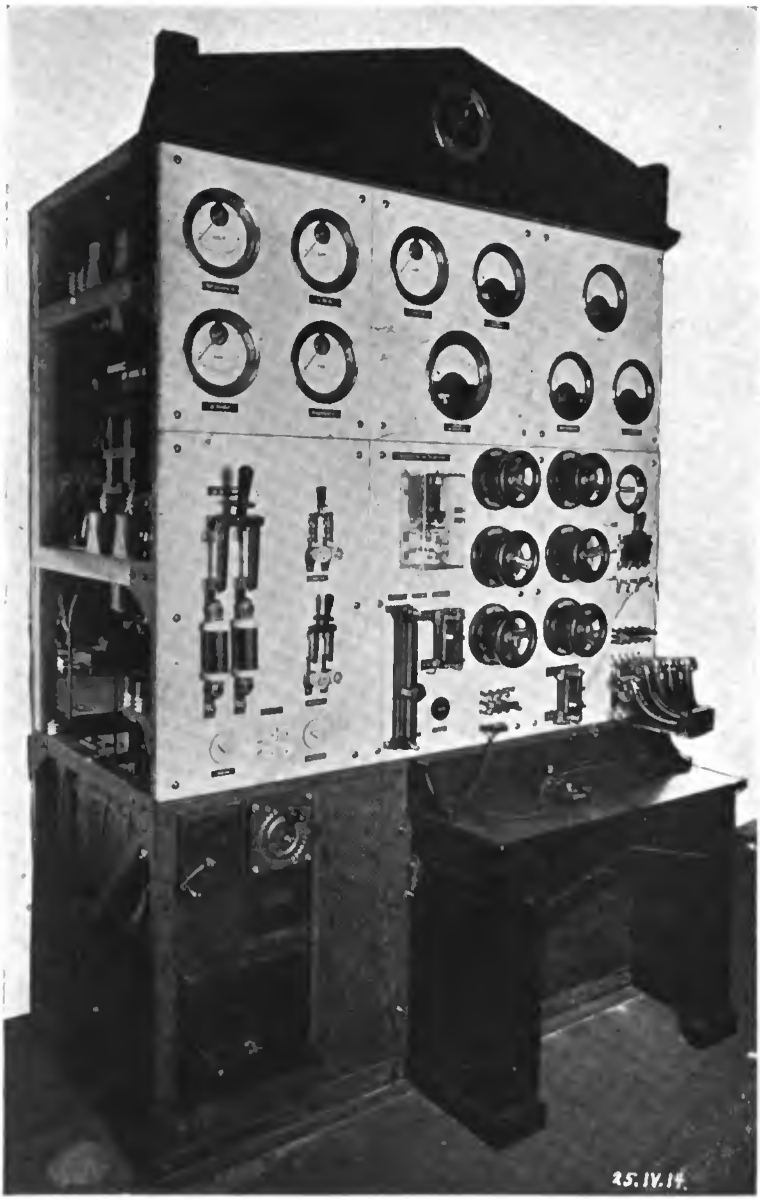


Figure 173—Telefunken Company 1 K. W. alternator-frequency doubler radiophone transmitter

in connection with Figures 101 and 102. The frequency may be raised in four steps to 160,000 cycles corresponding to 1,880 meters wave-length. In the middle of the top crown panel is a control stroboscope for watching the telephone control. This device is a small neon or carbon dioxid vacuum tube rapidly rotated by a small motor. It is connected through a small capacity to a high potential point of the antenna system, and when there is subtained radiation, a uniform circular band of light caused by the rotating tube indicates this fact. If a musical sound affects the microphone transmitter, the circular band of light is broken into narrow radial bands, and the relative brightness of the center of the bands and the darkness of the middle of the space between them indicates very roughly the completeness of the modulation. However, such instruments are far from quantitative, being at best rough indicators. The top row of instruments are respectively for the direct current supply voltage, the current supplied a special small motor, the excitation (field) direct current, the 80,000 cycle telegraph control key circuit, and a 0-to-40 ampere antenna ammeter. The second row of instruments are the large motor ammeter, the "magnetising" current, an 80 ampere ammeter for the 10,000 cycle output circuit, a 10 ampere ammeter for indicating the alternating current from the microphone transformer (corresponding to XY of Figure 170), and the antenna current ammeter for telephony. The lower left panel carries the large driving motor switch, the magnetising current switch, and control switches and fuses for the stroboscope and the ventilating fan motor. The center lower panel carries the key relay (for telegraphy) a field rheostat, the frequency regulating device of the musical tone producer for ordinary telegraphy (simulating a spark station), and the wheels which control the tuning inductances (variometers) of the 10,000 cycle circuit, the 40,000 cycle circuit, and the 80,000 cycle key circuit. On the right hand lower panel are the control wheels of the inductances in the 20,000, 80,000, and 160,000 cycle (antenna) circuits, the frequency meter for musical tone telegraphy, and 8 or 10 microphones suitably arranged. The desk carries the telegraph key and the bottom panel to its left the motor starters and regulators. The entire outfit can put about 6 kilowatts into the antenna at 1,900 meters for telegraphy and several kilowatts for telephony. Some figures given by Dr. Kühn indicate that a microphone output of about 4 watts (or 20 volt-amperes), corresponding to a control alternating current of 8 amperes through the 30 turns of the 40 microhenry control windings on the final transformers, suffices to control several kilowatts, the energy amplification being as great as 1,000.

With a set similar to that shown, using the Nauen antenna and at a wave-length near 5,000 meters, speech was transmitted from Berlin to Vienna, a distance of 340 miles (550 km.), the received words having an audibility of 100. Professor Kann, listening at Vienna, stated that there was unusually heavy atmospheric disturbances. The speech was clear but the vowels were emphasized while the consonants seemed sometimes to be almost missing. On the other hand, singing was faultlessly transmitted. How far these effects were due to the heavy strays and how far to iron distortion of the speech forms is not stated.

We consider next a further development of the ferro magnetic control systems, namely Mr. Alexanderson's magnetic amplifier as designed for the General Electric Company. Prior to considering this device, the parent idea from which it sprang will be given. This was a so-called "telephone relay." It was a moderately high frequency alternator of the inductor type the field of which was varied by the speech current. In consequence the output of the machine was similarly modulated. The rotor of the machine is shown in Figure 174. The iron teeth had to be laminated because of the variations in the field produced by the speech current. This was a serious limitation of the machine. The stator of the machine is similarly shown in Figure 175. The zig-zag winding of the alternator around the teeth is clearly visible. Underneath this winding are field windings. To avoid the limitation mentioned above, the modern magnetic amplifier was invented, this being a device which has practically the same effect, when placed across the terminals of a radio frequency alternator, as would speech variation of the field thereof.

Let us consider first the operating characteristics of an Alexanderson radio frequency alternator, namely the 50 K. W., 50,000 cycle machine shown in Figure 113. These characteristics are shown in Figures 176. It will be seen that if 50 ohms of external resistance are shunted across the machine terminals, the current (at the point *W*) will be 17 amperes. As this load resistance is diminished, the current rises along the dashed curve to the point *Q*. This corre-

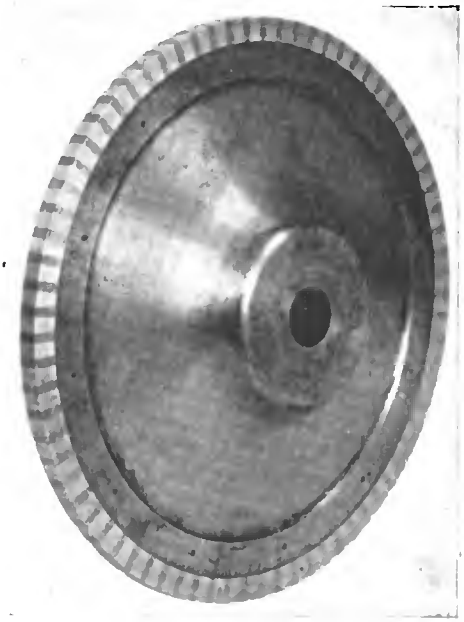


Figure 174—General Electric Company-Alexanderson telephone control relay rotor

Figure 175—General Electric Company-Alexanderson telephone control relay stator (field and armature)

sponds to zero resistance, across the alternator and to a current flow of 63 amperes. This current, since the load is a pure resistance, is in phase with the voltage (neglecting machine impedance), and the curve has been repeated symmetrically to the left of the current axis by the curve *QX*. If various reactances (in the form of resistance-free inductance) are placed across the terminals of the machine, the curve *QV* is obtained for the relation between current and external reactance in ohms. Thus the point *V* corresponds to 50 ohms reactance or 0.00016 henry at 50,000 cycles. The current in this case lags behind the electromotive force since the load is inductive. If 50 ohms of capacity reactance, which corresponds to 0.064 microfarad at 50,000 cycles, and is indicated at the point *U*, be placed across the machine, a current of 24 amperes is obtained. As the external capacitive reactance is diminished, the current increases, reaching a maximum of 71 amperes at 8 ohms corresponding to 0.40 microfarad at 50,000 cycles. On leaving the point *P* of maximum current, with diminishing external reactance and corresponding external capacity load, the curve drops again to the point *Q*. In the portion *QPU* of the curve, the current leads the voltage since the load is capacitive. It will be seen that the curve *UPQV* is nothing more than the resonance curve of the system made up of the alternator armature and the external load. Since the capacity reactance for resonance is 8 ohms, the inductive reactance of the alternator armature must have the same numerical value. Con-

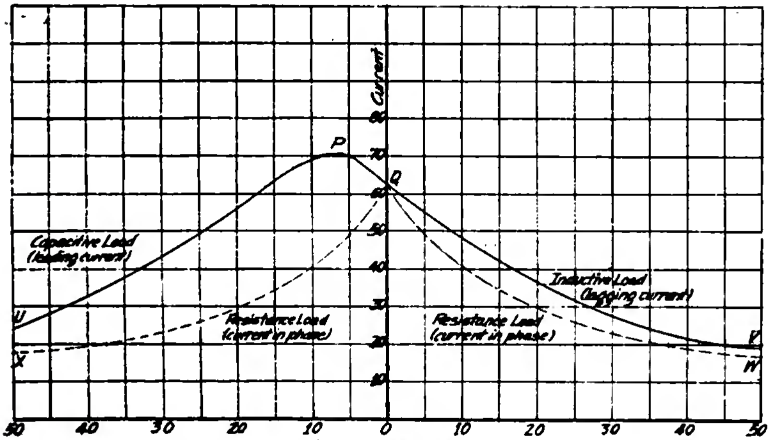


Figure 176—Load characteristics of 50 K. W., 50,000 cycle Alexanderson alternator

sequently the inductance of the armature must be approximately 26 microhenrys at 50,000 cycles, an interestingly low value.

The same material is plotted in another fashion (based on the curves given by Mr. Alexanderson in an earlier publication) in Figure 177. The curves given differ from those of Figure 176 only in that alternator terminal volts and load current are plotted instead of external impedance and load current. It may be noted that the 0 per cent. power factor curve is that of a *pure* inductive or capacitive load; that is, one which is resistance-free. In the same way, the 100 per cent. power factor resistance curves are with a load consisting of *nothing but resistance.* While not quite so clearly visible, the resonance phenomenon is indicated here also.

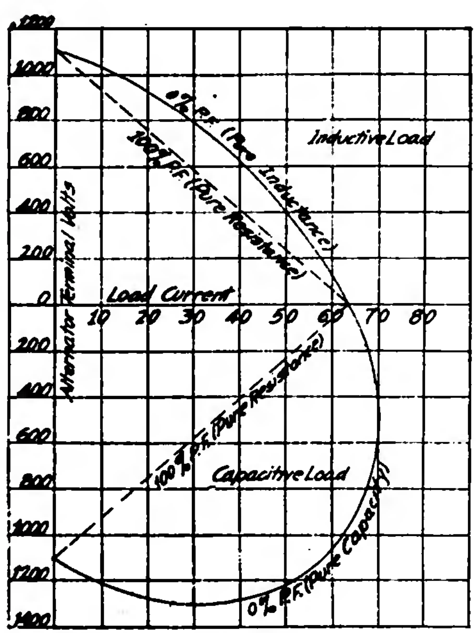


Figure 177—Load characteristics of 50 K.W., 50,000 cycle Alexanderson alternator

The general arrangement of the magnetic amplifier in its simplest form are represented in Figure 178. The nature of the iron structure is sufficiently indicated. Coils L_1 and L_2 are wound over the two middle cores, connected in parallel, and the combination shunted across the radio frequency alternator *A.* (Coils L_1 and L_2 are placed in parallel rather than in series since theory and experiment agree in predicting a more effective control by such connection.) It will thus be seen that the iron core inductance L_1 L_2 is placed across the alternator terminals. If this inductance is varied by any means, the right hand curve of Figure 176 will indicate the current variation through the inductance. Consequently the antenna current will also vary in the opposite sense, and a marked degree of antenna current control would be thus obtained. The mode of varying the inductance of coils L_1 and L_2 is also shown clearly in Figure 178. It is by means of the coil L_3 through which passes a direct current from the battery B which current can be suitably varied by the control resistance R. It will be seen that L_3 is wound over the cores of both L_1 and L_2 and thus there will be therein no radio frequency induction from the latter. This is important, and constitutes a marked advantage of Mr. Alexanderson's magnetic amplifier over the device used by the Telefunken Company and shown in Figure 172. The actual appearance of the amplifier is given by Figure 179. The magnetising control coils L_3 are indicated as in Figure 178. The two sets of coils corresponding to L_1 and L_2 are also indicated. The coils L_1 are partly hidden by the cross piece. It may be mentioned that a number of further designs of more advanced character have been adopted recently for the magnetic circuits of the amplifier, but the principle remains unchanged.

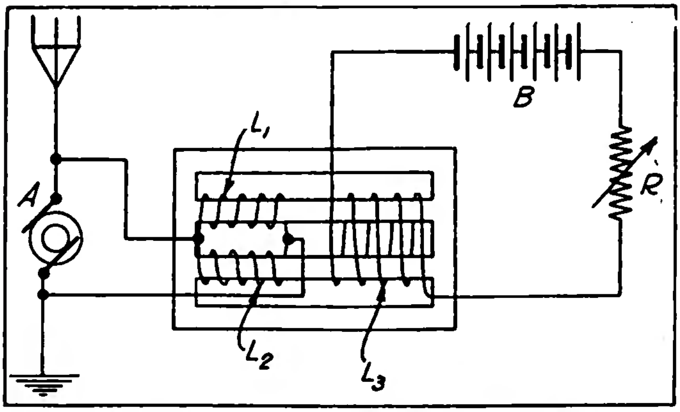


Figure 178—General Electric Company-Alexanderson magnetic amplifier (shunt connected to alternator, multiple connection of coils)

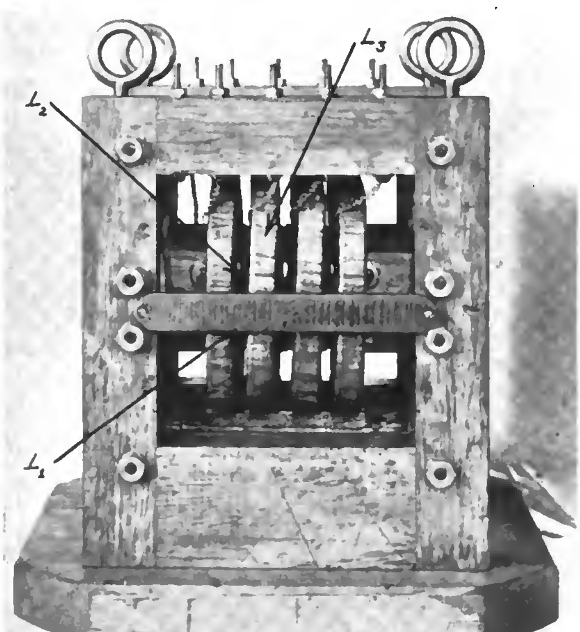


Figure 179—General Electric Company-Alexanderson "magnetic amplifier" radiophone control

The actual behavior of the amplifier is well represented by Figure 180. This shows the impedance of the amplifier, expressed in ohms, plotted against the radio frequency current passing through it for various direct currents through the magnetising coils L_3. It will be seen that for no magnetisation (curve ABC) the impedance varies from 32 to 70 ohms between 60 amperes of radio frequency current and 20 amperes. With 0.7 ampere d. c. magnetisation, the variation is somewhat in the opposite sense, namely between 27 ohms and 15 ohms for the variation of radio current, the impedance of the amplifier remains nearly constant around 8 ohms for the same extreme variation of radio frequency current through it. Considering the line *ADGK*, it is clear that with 60 amperes radio frequency passing through it, the amplifier impedance changes from 32 ohms to 8 ohms as the direct current magnetisation is increased from 0 to 2.0 amperes. Similarly, at 55

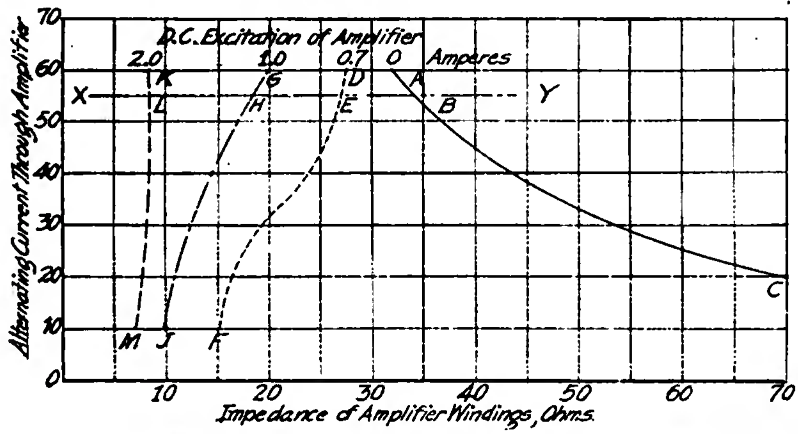


Figure 180—Characteristics of Alexanderson magnetic amplifier

amperes radio frequency current through the amplifier, corresponding to line *XY*, a somewhat wider variation is obtained. It is thus perfectly clear that the amplifier is a markedly effective device as a variable impedance for radio frequency currents. The same data as that represented in Figure 180 is given in different form in Figure 181, which gives the corresponding voltage-current curves of the amplifier. It will be seen that the current through the amplifier at 400 volts impressed radio frequency may be varied from 5 amperes (for no d.c. magnetisation) to 50 amperes with 2.0 amperes magnetisation. At 1,200 volts applied radio frequency, a current variation of 15 to 60 amperes (i. e., from 18 to 72 kilovolt-amperes) is obtained with a variation of the d.c. magnetisation of only 1 ampere, a full illustration of the usefulness of the device.

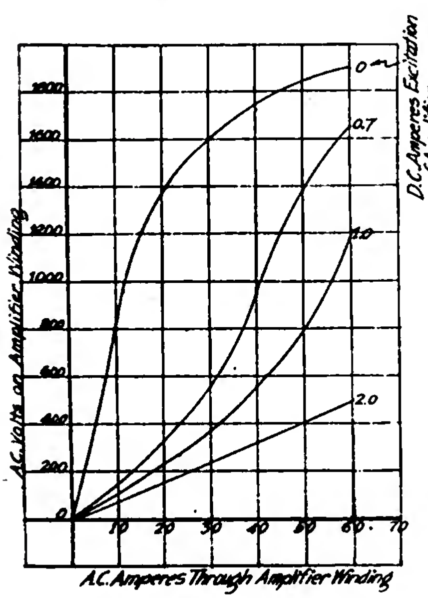


Figure 181—Characteristics of Alexanderson magnetic amplifier

In order to secure the maximum linear control and to prevent certain undesired effects, several condensers are inserted into the amplifier circuits as shown in Figure 182. The first of these is the series condenser C_1 which is placed between the high potential point of the alternator and a point leading to one side of the amplifier (through several other condensers to be considered below). The effect of the series condenser on the stability of operation of the amplifier and otherwise is illustrated in Figure 183. This curve shows the current flowing from the alternator as ordinate plotted against the external impedance in ohms. The dot-

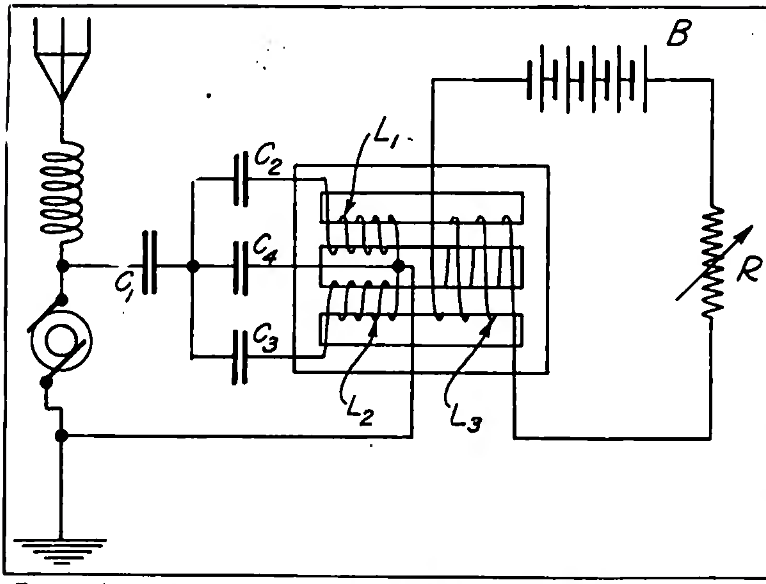


Figure 182—General Electric Company-Alexanderson magnetic amplifier; with series, short-circuiting, and shunt condensers

and-dash curve shows the effect of a purely inductive load and is the same as curve *QV* of Figure 176. The dashed curve for the amplifier alone is not far from curve *ABC* of Figure 180. To the left of the vertical axis is drawn the corresponding curve of the constant impedance of 8 ohms, this being a capacity of 0.33 microfarad. The curve in question is the vertical line marked 0.33 μf. Inserting such a condenser at C_1 will give the resulting curve to the right marked "amplifier + 0.33 μf." This curve represents a stable state of affairs. At the extreme left, the vertical dashed line shows the constant impedance of 48 ohms corresponding to a series condenser of 0.067 microfarad. The curve marked "amplifier + 0.067 μf." is the result of using this series condenser and has an unstable portion to the left of the vertical axis. This corresponds to an *increase* of current with an *increase* of impedance across the alternator. The

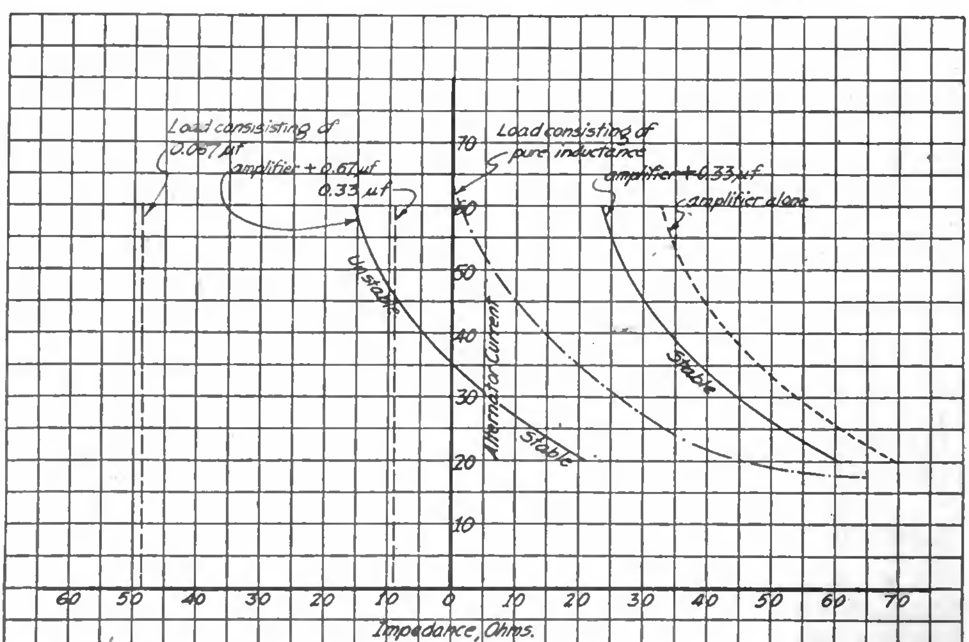


Figure 183—Effect of series condenser on stability of magnetic amplifier

same effect is shown in Figure 184 in different form, this Figure representing alternator terminal voltage vertically and current through the amplifier and condenser horizontally. The curve marked "amplifier + 0.33 μf." is a rising curve practically throughout, whereas the curve for the "amplifier + 0.125 μf." shows a falling portion corresponding to *increasing* current with *diminishing* voltage. This is what we have called a condition of "negative resistance" such as is experienced, for example, in the Poulsen arc. Accordingly, this unstable region is unusable and may lead to self-excited oscillations in the amplifier system, which is a normally undesirable condition.

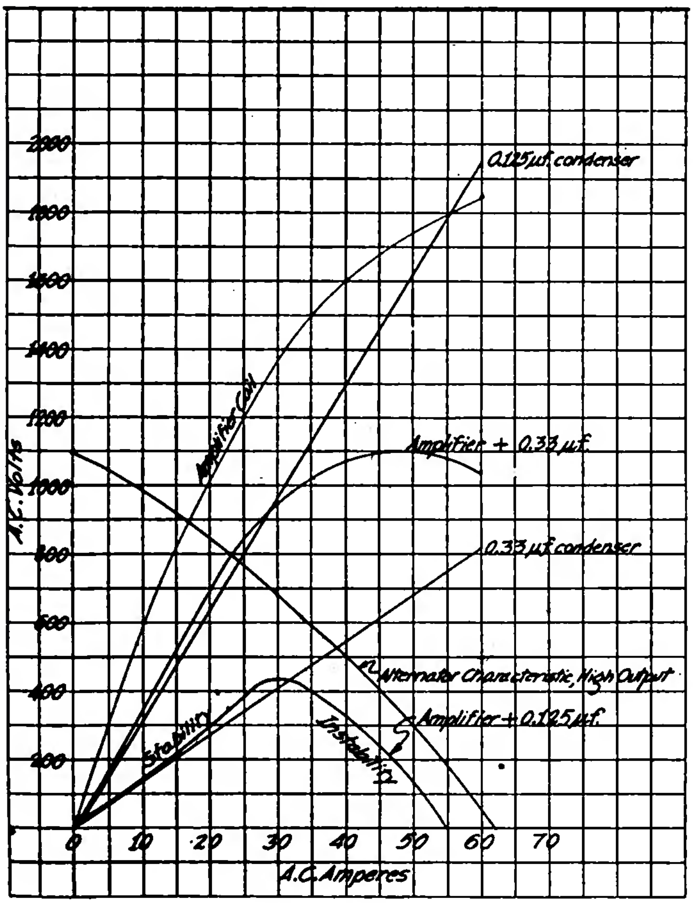


Figure 184—Effect of series condenser on stability of magnetic amplifier

The effect of the series condenser C_1 in Figure 182 is to give a great increase in the sensitiveness of the system and also to give a linear control characteristic. The control characteristics for several values of the series condenser are shown in Figure 185, which should be carefully compared with Figures 115 through 117. Curve *A* of Figure 185 shows the relation between *antenna current* in the arrangement of Figure 182 and the d.c. *amperes in the magnettising coil* of the amplifier (L_3 in Figure 182). It is the real control characteristic of the system when used for radio telegraphy and telephony. Curve *B*, obtained with a series condenser of 0.33 microfarad, shows practically complete and linear modulation except for excessive control to the left of the point *B*, this corresponding to greater amplifier magnetising currents than about 2.8 amperes. To the left of this point the control reverses as indicated in Figure 5 which corresponds to this case. Between *Y* and *Z* of that figure we are working on portion *BD* of curve *B* of Figure 185, but between *X* and *Y* of that figure we are working on the reversed portion of curve *B* of Figure 185. It need hardly be said that in practice this condition can be and is easily avoided. A smaller series condenser of 0.125 microfarad gives control characteristic *C* of Figure 185. This is a steeper control than those of the preceding cases, but it is incomplete and therefore not chosen. Some study will convince the reader that these con-

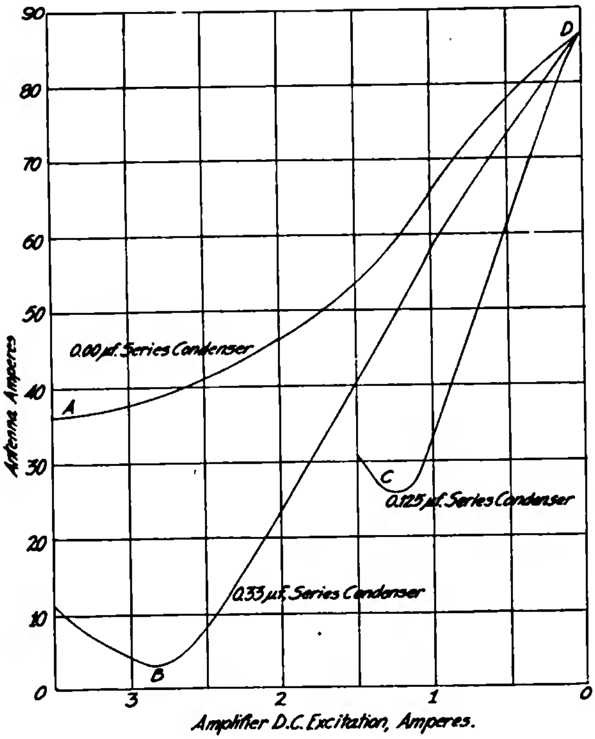


Figure 185—*Control characteristics of magnetic amplifier*

moderate effective resistance and iron losses.

The second condenser considered, namely, C_4, in Figure 182, is known as the shunt condenser. Its function, according to Mr. Alexanderson, is to cause the amplifier to take a leading, instead of a lagging current at low excitations and to increase the sensitiveness of the arrangement. According to Mr. Louis Cohen, it may rather be treated as forming with the amplifier a loop circuit the impedance and effective resistance of which change very markedly near a resonant frequency.

The third condenser (actually the two condensers C_2 and C_3) is known as the short-circuiting condenser. It will be noticed that there is a closed circuit $L_1C_2C_3L_2$ in which audio frequency currents may be induced if telephonic currents flow in the control winding L_3. These would be short-

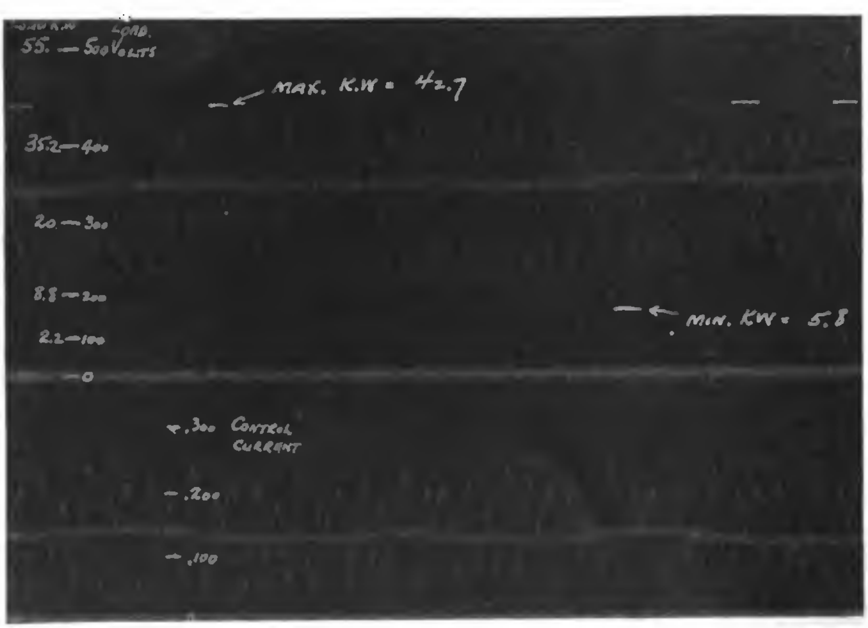


Figure 186—*Oscillograms showing controlling telephone current and controlled antenna output of General Electric Company-Alexanderson* 50 *K. W. alternator and magnetic amplifier* circuited except for the two condensers just mentioned, and the control would become ineffective. The condensers C_2 and C_3 are so chosen that their audio frequency reactance is very high while their radio frequency reactance is quite low. In this way the radio frequency currents may still flow practically undeterred through the amplifier coils while the audio frequency currents are almost entirely prevented from doing so.

The combination of these various condensers gives a high degree of control. Experiment shows that the amplification, defined as the radio of (maximum antenna kilowatts minus minimum antenna kilowatts) divided by (effective kilovolt-amperes in the control circuit), varies from 100-to-1 to as much as 350-to-1. This is under the linear conditions necessary for control in telephony. The perfection of the control is well illustrated in Figure 186. The lower oscillogram shows the control current in L_3 in Figure 182, while the upper curve shows the antenna kilowatts. It will be seen that a variation of control current of 0.2 ampere changes the antenna kilowatts from 5.8 to 42.7, a variation of nearly 37 kilowatts! The Author believes this to be the largest amount of radio frequency (or other) energy ever controlled by a telephone transmitter. It will be noted that the antenna kilowatt curve is inverted relative to the control current curve, the peaks in one corresponding to the crests in the other. This is the result of the control characteristic of Figure 185, which shows that *large* antenna currents correspond to *small* control currents and vica versa.

This is the thirteenth of a series of articles on "Radio Telephony," by Dr. Alfred N. Goldsmith. In the fourteenth article, to be published in the February issue, the subjects discussed by Dr. Goldsmith include radiating systems, receiving systems, detector and amplifier types, selectivity in reception, interference with radiophone reception, telephone receivers, and receiving apparatus.

The Red Cross Asks for Old Tracing Cloth

AMERICAN manufacturers, architects, and all draftsmen are called upon to render an important service to their country. When the workman has finished with the piece of cotton or linen cloth used in his trade, it is flung aside to be destroyed. The Red Cross is asking now for that discarded material. All over the country thousands of women are earnestly engaged in the manufacture of surgical dressings to be used in the hospitals for our wounded soldiers and sailors. The problem of getting enough white goods for this work is enormous. As long as the war goes on the work must go on if we are to live up to the humanitarian ideals typified to the world today by the Red Cross.

Two kinds of cloth are available—draftsman's tracing cloth and old linen and cotton articles to be donated from private households and, often in large quantities, from hotels. These can be easily collected and handled by the modern laundries, which have now been called upon to perform this work for the Red Cross. With their facilities for collecting, washing, sterilizing and delivering to the local chapters, the laundries are in a position to perform an invaluable service and the least that other trades can do, is to help them in every way. If any manufacturer, architect, or draftsman will go to the slight trouble of calling up either the local Laundry Owners Association or one of the large laundries of his city, he will find them only too glad to send for such cloth as he can give them.

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

Damped and Undamped Wave Receiver for Long and Short Waves

In anticipation of the "grand opening" to which all good amateurs are looking forward, I have designed and built an oscillator cabinet for the reception of long and short damped and undamped waves, a description of which may prove of interest to your readers.

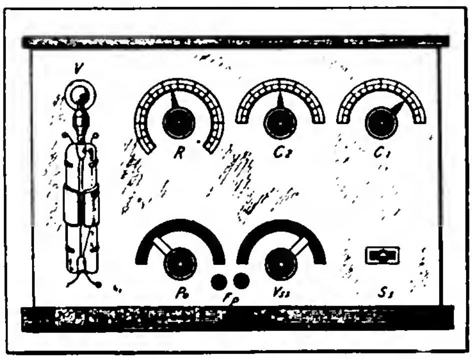


Figure 1—1st prize article

The apparatus I have devised is shown in Figures 1 and 2, Figure 1 showing the general external appearance of the cabinet and Figure 2 the complete circuit diagram. I have also furnished in the table, Figure 3, complete data for the various coils employed in the open and closed oscillation circuits. The general idea of my design was to mount compactly in one cabinet all apparatus required for a complete receiver of the type mentioned, with the exception of the tuning coils which are mounted separately.

The following instruments are mounted on the finished cabinet and an explanation of the lettered parts given follows:

B, high voltage battery;
C-1, Secondary shunt condenser, .001 microfarad capacity;
C-2, Plate circuit condenser, .001 microfarad capacity;
C-3, Telephone condenser, .001 microfarad capacity;
C-4, Grid condenser, .0001 microfarad capacity;
V, Three-element vacuum valve;
R, Filament rheostat;
Po, Potentiometer for high voltage battery;
Vss, Variable static shunt;
Fp, Telephone binding posts;
S-1, Changeover switch (secondary circuits).

The symbols used in the diagram of connections (Figure 2) are explained as follows:

A is the battery for lighting the filament;
S-2 the switch for changing the aerial and ground connections from a long to a short wave in the primary circuits and vice versa;
L is the inductance.

The variable static shunt shown prevents the accumulation of extra high potential on the grid condenser. It was made by marking heavily with a pencil on a thin piece of bakelite of the shape indicated at Vss, Figure 1. A piece of brass moves over the pencil mark thus providing a leak of variable resistance.

The changeover switch, S-1, was made by connecting four two-point switches with a piece of bakelite to which a composition knob is attached. This knob is screwed on a short bolt

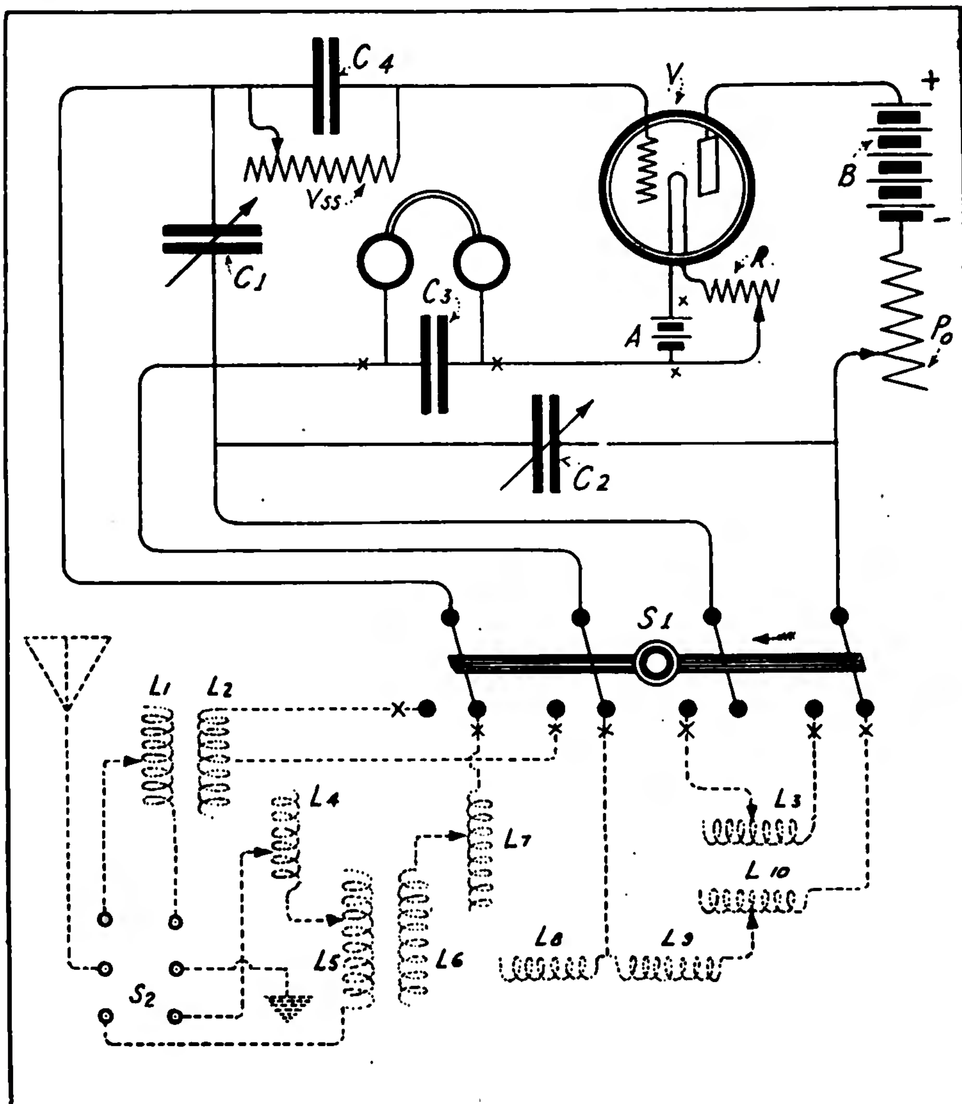


Figure 2—1st prize article

which protrudes through the cabinet in a slot cut for it.

The points marked X are connected to binding posts which, with the exception of the telephone posts, are mounted at the rear of the cabinet.

No connection is made with the switch contact marked with an arrow.

The material required for the cabinet is listed as follows:

Top, 19 inches by 8 inches by ¼ inch; ends, 8½ inches by 7 inches by ½ inch; base, 19 inches by 8 inches by ½ inch; sides, 18 inches by 8½ inches by ¼ inch.

Quarter sawed oak which has been waxed and stained should be employed.

In addition to acting as a simple amplification receiver, the valve can be set into a state of oscillation and employed for the reception of signals by the "beat" method. The adjustments for beats are made roughly with the inductance, but the final adjust-

	Short wave set			Long wave set						
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}
Length	7.3"	7.6"	7.6"	40"	12"	12"	40"	6"	6"	40"
Diameter	4"	3.5"	3.5"	6"	6"	5"	6"	5"	4"	6"
Size of s.c.c. wire	26	32	32	24	24	30	30	24	30	30
Number of turns	350	550	550	1538	481	754	2513	231	377	2513

Figure 3—1st prize article

ment is obtained through condensers C-1 and C-2 respectively.

The dimensions given for the coils will permit the reception of waves up to approximately 13,000 meters with a single wire inverted aerial L 60 feet in height and 300 feet in length.

For the short wave receiver (200 to 3,000 meters) a smaller aerial is necessary.

The inductance L-8 and L-9 comprise an oscillation transformer which aids in tuning, and through which the regenerative effects are obtained.

By simply throwing switches, S-1 and S-2, in the proper direction either long or short damped or undamped waves may be received.

No provision has been made in this apparatus for opening the filament battery circuit except by turning the rheostat pointer to zero. It may prove advisable to add a two-point switch to the cabinet for this purpose.

A complete set of dimensions with the various coils included in this apparatus appears in the followirg table:

Ross Moorhead, *Ohio.*

SECOND PRIZE, FIVE DOLLARS

A Short Cut for Experimenters

The six tables in this article I have prepared according to the usual rules for changing C.G.S. or electro-magnetic and electro-static units of capacity, inductance, resistance, current, potential and electrical power to practical units.

Although many wireless experimenters are not in the habit of making mathematical calculations except at long intervals, they have occasion now

CURRENT—TO CHANGE UNITS

Magnetic to practical multiply by 10	Static to magnetic divide by $3x10^{10}$
Magnetic to static multiply by $3x10^{10}$	Static to practical divide by $3x10^{9}$
Practical to static multiply by $3x10^{9}$	Practical to magnetic divide by 10

Practical Units Amperes			Electromagnetic Units	Electrostatic Units
1 000 000		10^6	10^5	$3x10^{15}$
100 000		10^5	10^4	$3x10^{14}$
10 000		10^4	10^3	$3x10^{13}$
1 000	(1 Kiloamp.)	10^3	10^2	$3x10^{12}$
100		10^2	10	$3x10^{11}$
10		10	1	$3x10^{10}$
1	(1 Ampere)	1	10^{-1}	$3x10^{9}$
.1		10^{-1}	10^{-2}	$3x10^{8}$
.01		10^{-2}	10^{-3}	$3x10^{7}$
.001	(1 Milliamp.)	10^{-3}	10^{-4}	$3x10^{6}$
.000 1		10^{-4}	10^{-5}	$3x10^{5}$
.000 01		10^{-5}	10^{-6}	$3x10^{4}$
.000 001	(1 Microamp.)	10^{-6}	10^{-7}	$3x10^{3}$
		10^{-7}	10^{-8}	$3x10^{2}$
		10^{-8}	10^{-9}	3x10
		10^{-9}	10^{-10}	3x 1

and then to change from one system of units to another. This is especially true in connection with calculations of inductance and capacity.

These tables will not only serve to check arithmetical calculations but will permit the desired changes from one system of units to the other without the usual mental effort. The tables also are of considerable assistance in the use of exponential notations as many decimal equivalents therefor are given.

Summed up in their entirety, we have in these tables, a perspective view of the relation between the practical, the electro-magnetic, and the electrostatic systems of units.

E. M. KINGLEY, *New Jersey.*

RESISTANCE—TO CHANGE UNITS

Static to practical multiply by $9x10^{11}$ | Magnetic to practical divide by 10^9

PRACTICAL UNITS			ELECTROMAGNETIC UNITS	ELECTROSTATIC UNITS
		10^{11}	10^{20}	1/9x 1
		10^{10}	10^{19}	$1/9x10^{-1}$
		10^{9}	10^{18}	$1/9x10^{-2}$
		10^{8}	10^{17}	$1/9x10^{-3}$
		10^{7}	10^{16}	$1/9x10^{-4}$
1 000 000	(1 Megohm)	10^{6}	10^{15}	$1/9x10^{-5}$
100 000		10^{5}	10^{14}	$1/9x10^{-6}$
10 000		10^{4}	10^{13}	$1/9x10^{-7}$
1 000		10^{3}	10^{12}	$1/9x10^{-8}$
100		10^{2}	10^{11}	$1/9x10^{-9}$
10		10	10^{10}	$1/9x10^{-10}$
1	(1 Ohm)	1	10^{9}	$1/9x10^{-11}$
.1		10^{-1}	10^{8}	$1/9x10^{-12}$
.01		10^{-2}	10^{7}	$1/9x10^{-13}$
.001		10^{-3}	10^{6}	$1/9x10^{-14}$
.000 1		10^{-4}	10^{5}	$1/9x10^{-15}$
.000 01		10^{-5}	10^{4}	$1/9x10^{-16}$
.000 001	(1 Microhm)	10^{-6}	10^{3}	$1/9x10^{-17}$
		10^{-7}	10^{2}	$1/9x10^{-18}$
		10^{-8}	10	$1/9x10^{-19}$
		10^{-9}	1	$1/9x10^{-20}$

INDUCTANCE—TO CHANGE UNITS

Static to practical multiply by $9x10^{11}$ | Magnetic to practical divide by 10^9
Magnetic to static divide by $9x10^{20}$

PRACTICAL UNITS HENRYS			ELECTROMAGNETIC CENTIMETERS	ELECTROSTATIC UNITS
		10^{11}	10^{20}	1/9x 1
		10^{10}	10^{19}	$1/9x10^{-1}$
		10^{9}	10^{18}	$1/9x10^{-2}$
		10^{8}	10^{17}	$1/9x10^{-3}$
		10^{7}	10^{16}	$1/9x10^{-4}$
		10^{6}	10^{15}	$1/9x10^{-5}$
100 000		10^{5}	10^{14}	$1/9x10^{-6}$
10 000		10^{4}	10^{13}	$1/9x10^{-7}$
1 000		10^{3}	10^{12}	$1/9x10^{-8}$
100		10^{2}	10^{11}	$1/9x10^{-9}$
10		10	10^{10}	$1/9x10^{-10}$
1	(1 Henry)	1	10^{9}	$1/9x10^{-11}$
.1		10^{-1}	10^{8}	$1/9x10^{-12}$
.01		10^{-2}	10^{7}	$1/9x10^{-13}$
.001	(1 Millhenry)	10^{-3}	10^{6}	$1/9x10^{-14}$
.000 1		10^{-4}	10^{5}	$1/9x10^{-15}$
.000 01		10^{-5}	10^{4}	$1/9x10^{-16}$
.000 001	(1 Microhenry)	10^{-6}	10^{3}	$1/9x10^{-17}$
		10^{-7}	10^{2}	$1/9x10^{-18}$
		10^{-8}	10	$1/9x10^{-19}$
		10^{-9}	1	$1/9x10^{-20}$

ELECTRIC POWER—TO CHANGE UNITS

Practical to static multiply by 10^7 | Magnetic to static multiply by 1
Practical to magnetic multiply by 10^7 | Static to practical divide by 10^7
Magnetic to practical divide by 10^7

Practical Units Watts			Electromagnetic and Electrostatic Units	
100 000 000		10^8	10^{15}	
10 000 000		10^7	10^{14}	
1 000 000		10^6	10^{13}	
100 000		10^5	10^{12}	Dyne centimeters
10 000		10^4	10^{11}	per second
1 000	(1 Kilowatt)	10^3	10^{10}	or
100		10^2	10^9	Ergs per second
10		10	10^8	
1	(1 Watt)	1	10^7	
.1		10^{-1}	10^6	
.01		10^{-2}	10^5	
.001	(1 Milliwatt)	10^{-3}	10^4	
.000 1		10^{-4}	10^3	
.000 01		10^{-5}	10^2	
.000 001	(1 Microwatt)	10^{-6}	10	
		10^{-7}	1	

POTENTIAL—TO CHANGE UNITS

Static to magnetic multiply by $3x10^{10}$ | Magnetic to static divide by $3x10^{10}$
Static to practical multiply by $3x10^2$ | Magnetic to practical divide by 10^8
Practical to magnetic multiply by 10^8 | Practical to static divide by $3x10^2$

Practical Units Volts			Electromagnetic Units	Electrostatic Units
1 000 000	(1 Megavolt)	10^6	10^{14}	$1/3x10^4$
100 000		10^5	10^{13}	$1/3x10^3$
10 000		10^4	10^{12}	$1/3x10^2$
1 000	(1 Kilovolt)	10^3	10^{11}	1/3x10
100		10^2	10^{10}	1/3x 1
10		10	10^9	$1/3x10^{-1}$
1	(1 Volt)	1	10^8	$1/3x10^{-2}$
.1		10^{-1}	10^7	$1/3x10^{-3}$
.01		10^{-2}	10^6	$1/3x10^{-4}$
.001	(1 Millivolt)	10^{-3}	10^5	$1/3x10^{-5}$
.000 1		10^{-4}	10^4	$1/3x10^{-6}$
.000 01		10^{-5}	10^3	$1/3x10^{-7}$
.000 001	(1 Microvolt)	10^{-6}	10^2	$1/3x10^{-8}$
		10^{-7}	10	$1/3x10^{-9}$
		10^{-8}	1	$1/3x10^{-10}$

CAPACITY—TO CHANGE UNITS

Magnetic to practical multiply by 10^{15} | Static to practical divide by 9x10[illegible]

Practical Units Farads	Microfarads		Electrostatic Centimeters	Electromagnetic Units
10^9	10^{15}		$9x10^{20}$	1
10^8	10^{14}		$9x10^{19}$	10^{-1}
10^7	10^{13}		$9x10^{18}$	10^{-2}
10^6	10^{12}		$9x10^{17}$	10^{-3}
10^5	10^{11}		$9x10^{16}$	10^{-4}
10^4	10^{10}		$9x10^{15}$	10^{-5}
10^3	10^9		$9x10^{14}$	10^{-6}
10^2	10^8		$9x10^{13}$	10^{-7}
10	10^7		$9x10^{12}$	10^{-8}
1	10^6	1 000 000	$9x10^{11}$	10^{-9}
10^{-1}	10^5	100 000	$9x10^{10}$	10^{-10}
10^{-2}	10^4	10 000	$9x10^9$	10^{-11}
10^{-3}	10^3	1 000	$9x10^8$	10^{-12}
10^{-4}	10^2	100	$9x10^7$	10^{-13}
10^{-5}	10	10	$9x10^6$	10^{-14}
10^{-6}	1	1	900 000	10^{-15}
10^{-7}	10^{-1}	.1	90 000	10^{-16}
10^{-8}	10^{-2}	.01	9 000	10^{-17}
10^{-9}	10^{-3}	.001	900	10^{-18}
10^{-10}	10^{-4}	.000 1	90	10^{-19}
10^{-11}	10^{-5}	.000 01	9	10^{-20}
10^{-12}	10^{-6}	.000 001	.9	10^{-21}

The Wireless Class for Women

An Outline of Its Progress to Date, Including the Director's Report to the National Council and an Exclusive Interview

"IN wireless, a new profession heretofore exclusively for men, is now open to women. Fifty years ago women had to contend with the same difficulties in entering the medical profession as the women have had in entering the wireless field, and yet to-day, the most conservative of the colleges, such as Harvard and Columbia, urge women to study medicine. It will not be very long when the value of women's services in this new field will be recognized."

The foregoing observation was made in the office of THE WIRELESS AGE by Mrs. Herbert Sumner Owen, Director, Wireless Class for Women, upon the occasion of her retirement from this field of war endeavor.

By way of illustrating how the class for women was brought to its present efficiency, Mrs. Owen told the following, in an exclusive interview:

"On the seventh of March, 1917, the registration for the Wireless Class for Women at Hunter College was opened. For this class Hunter College had contributed the space and Mr. E. J. Nally, vice-president and general manager of the Marconi Company, the necessary equipment. Fifteen applicants registered and the class was opened on March 12th. It was simply an experiment. It was my belief that a demand existed, and Mr. Nally and Hunter College were willing to co-operate, in order to find out whether there was a substantial number

A class in wireless telegraphy for women of young women who desired to make themselves efficient for wireless operating, taking the same course and submitting to the same test that men undertake.

"At that time the Marconi School thought it impossible to admit women to its classes, and the East Side Branch of the Y. M. C. A., after putting the question before its educational committee, decided also against admitting women to their classes. But the class opened on March 12th, nevertheless, and ever since there has been a steady flow of applicants; more than 150 women have applied for the various courses which have been instituted.

"In May a few of the more advanced and able students were offered membership in the Marconi School; this was our first real recognition. During the summer an intensive course of ten weeks' duration was offered to teachers, not with the idea that they could become radio operators in that short space of time, but to obtain a comprehensive view of the ground that would have to be covered more at leisure and in greater detail.

"Between March 12th and December 1st, I had under my directorship at Hunter College, three evening divisions, one afternoon division and the intermediate class with sessions from 9 to 4, five days a week, for ten weeks. One student of the Intensive Class went up for the Government test and secured a second grade commercial license.

"Hunter College, however, had no further space to give to the steadily increasing number of applicants, and the Y. M. C. A., in October, reconsidered its decision against the admission of women students and offered the services of an instructor and the use of the apparatus, equipment and class room. The class of nineteen women began work there on October 22nd."

Mrs. Owen now relinquishes her connection with the training of women to be wireless operators and the Wireless Class for Women passes out of existence. Hunter College has incorporated this division in their evening courses and becomes financially responsible for it. The Marconi School has thrown open its doors to admit women students, and the East Side Y. M. C. A. has done the same. Added to these is the College of the City of New York, which until recently shut its doors against women. The college has now decided to admit women, and among the various courses opened to them is a class in radiotelegraphy comprising the elementary engineering branches of the art.

With the opening of the year 1918, when Mrs. Owen's retirement became effective, she submitted the following report to her National Council:

On December 19, 1917, I received from Hunter College, through Professor Lewis D. Hill, a formal notification that the College desired to take over and incorporate in their evening courses, the Division of wireless students installed there. The Division consisted of thirty-five students when transferred.

Professor Hill writes me that in addition to assuming charge of the future of the Division he also becomes responsible for the small financial deficit remaining due the instructors on January 1st, 1918. These instructors are: Professor Hill, Ensign Otto Redfern, U. S. N. R. F., Chas. T. Manning, of the Marconi Company, Miss Catherine Archer, Miss Chess and Mrs. Tuzo.

On January 2nd I wrote Mr. Nally, vice-president and general manager of the Marconi Company, as follows:

Dear Mr. Nally:—

Hunter College has decided that the evening division of the Wireless

Class for Women is of sufficient importance for them to desire to incorporate it in their evening courses, and proposes to take it over and become financially responsible for it.

In the circumstances my intimate connection with this division of the Wireless Class will be severed, and I shall no longer be at Hunter College. Consequently, I surrender with many thanks to you the apparatus which you so generously loaned me for the use of the Wireless Class. As you know, your kindly co-operation made the class possible; without you it could not have existed. Please accept my personal thanks and those of the class, for whom I speak, for your great kindness.

Should Hunter College need the use of the apparatus, may I ask you to be good enough to allow it to remain in their possession so long as the evening division of the Wireless Class is a success.

With reiterated thanks,

Faithfully yours,

ERNA VONR. OWEN.

At my request, Mr. Nally most kindly consented to continue to Hunter College the loan of the apparatus which he had loaned me for the Wireless Class, addressing to me the following letter:

Dear Mrs. Owen:—

You have reason to be proud of your achievement and what you have done shows at least one instance where a woman performed a man's work, and in a manner of which any man might well be proud.

My congratulations, and best wishes for your continued progress.

Very sincerely yours,

E. J. NALLY.

In this connection I feel I must express again for myself the deep appreciation we have of the importance of Mr. Nally's kindness. Had the class not had the use of this apparatus it could not have come into existence, as Hunter College had only space to offer us. It had no radio equipment, and until the class had proved itself, no appropriation could be secured to buy the equipment.

The following students hold first grade commercial licenses: Elizabeth Rickard, Elsie Merz, Georgina Davids, Aline McDonald, Mrs. J. H. Hawley, Mary Murray, E. M. Rhodes, Eleanor Vredenburgh, Alice Davison, Adele Brown, Harriet Ransom, Vera K. Van derWater, Beatrice Eakins and Slora Hamilton. First grade emergency licenses are held by: Helen Campbell and Elise vonR. Owen. The following hold second grade commercial licenses: Mrs. Eila Haggin, Mrs. R. P. Sheehan, M. B. Davey and Evelyn Reading.

Miss Abbie Putnam Morrison has enlisted in the United States Naval Reserve as a "First Grade Electrician-R.", and is on call at present. She is at the Marconi School in the daytime, and in the evening class at Hunter College is preparing to take her Government test so that she may be ready when she is summoned.

While we have not yet placed any of our licensed radio operators, there is a perceptible change in the attitude of the powers that be.

The Marconi School has received a request for two code instructors for a buzzer class in New York, and Mr. Bucher has recommended two students of the Wireless Class for Women.

Professor Lewis D. Hill has recommended that graduates of the Wireless Class be employed as instructors in the buzzer classes being established by the Signal Corps of the Army. There is a great demand for such instructors, far greater than it is possible to supply at present.

The Monthly Service Bulletin
of the
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Founded to promote the best interests of radio communication among wireless amateurs in America

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A Suggestion for Association Members

FRANK R. MOSS.

THE special type of electron relay which I show in the accompanying drawing, figure 1, has never been tried experimentally, but a man of scientific which in turn will operate a common sensitive telegraph relay (preferably of the polarized type) to work a call bell.

The fundamental principle upon which

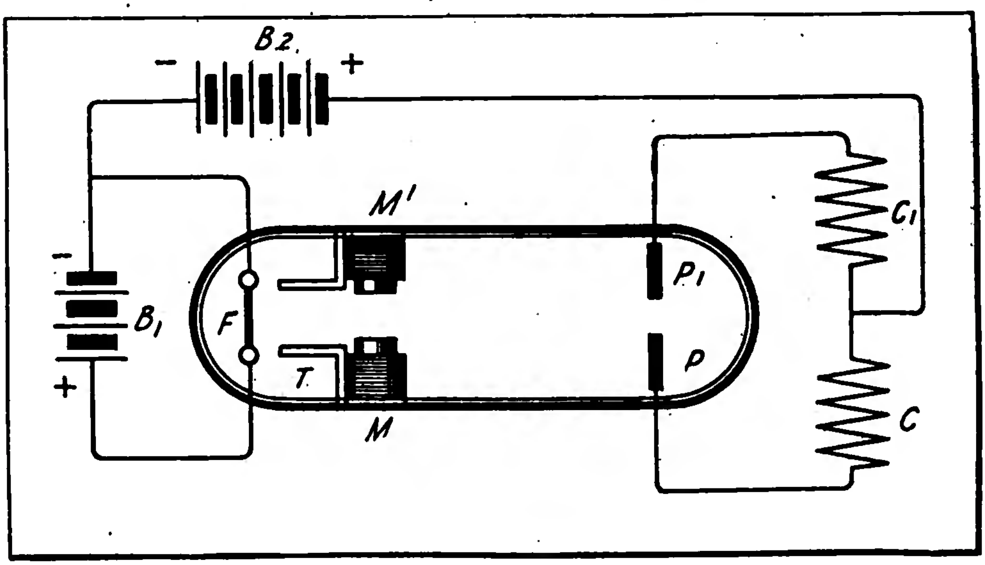

Figure 1

standing has stated that he saw no reason why it wouldn't work.

The object of the device is to provide a relay which can be connected in the local circuit of an ordinary receiving set, the working of this apparatus is based follows: If the filament F is brought to incandescence by battery B-1, and furthermore, a second battery, B-2, is con-

(*Continued on page* 348)

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The text matter rapidly leads into more advanced experiments, complete data being given, for instance, for the construction of a wavemeter, and instructions for its use under all conditions. This includes tuning, the measurement of inductance capacity of a wireless telegraph aerial, and general methods of calibration. The measurement of the logarithmic decrement is treated in a way easily understood by the beginner. The design and working drawings for several types of low power transmitters are included, covering the construction of a quenched spark gap and apparatus associated therewith.

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(*Continued from page 342*)

nected to the two plates P and P^1, a steady flow of electrons from F, to P and P^1 will take place. And due to the fact that both P and P^1 are charged to the same potential, the flow of electrons from the filament will divide equally, and as a result an equal amount of current will flow through coils C^1 and C.

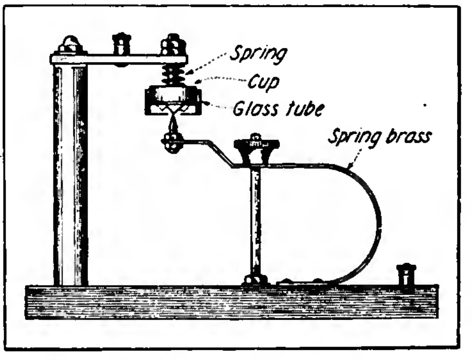
In the space between the filament F and the plates P, P^1, are placed two magnet coils M and M^1, consisting of a considerable number of ampere turns. These are connected in series and in turn with the local detector circuit of a standard receiving system.

If these magnets are connected in the circuits of a receiving system in which, for instance, the effect of the incoming oscillations is to increase the local battery current, then previous to the receipt of signals, there will be a slight deflection of the electrons from their normal path; for the purposes of illustration we may assume this to be in the direction of plate P. Then when incoming oscillations flow through the detector circuits, electrons will be deflected to a greater degree so that practically all of them will impinge upon plate P. Owing to the slightly increased potential of plate P, a still greater flow of electrons will be drawn from the filament F, so much so that the circuit from F to P^1 is practically broken. Then, as a result, if the telegraph relay is inductively coupled to the coil C^1, it will receive a pulse of current which will draw over its armature. This in turn may close the circuit of a call bell.

It would, of course, be possible to connect the telegraph relay in series with either plate P or P^1, but now that the fundamental principle is understood, various deviations from this circuit may be employed.

It is, of course, essential, in the operation of this device, that the circuits PC and PC^1 have identical values of resistance, and that the plates P and P^1 be symmetrically placed in respect to the filament F. It will also be observed that this apparatus can work in one of two ways: the increase of current through circuit P, for instance, may be made to close a telegraph relay, or the decrease of current through circuit P^1 to open the circuit of a telegraph relay.

Members of the N. A. W. A. who have facilities for construction of a device of this kind would greatly oblige the writer if they would inform him through the columns of THE WIRELESS AGE of the results obtained.



A dust-proof detector

A Dust-Proof Detector of Simple Design

The accompanying diagram shows how the amateur may, with parts that he can find about his workshop, construct a dust-proof detector which will permit extremely close adjustment. It will be observed that a crystal is mounted upside-down and that a short pointed tack mounted on a flexible piece of spring brass makes contact with the crystal. By more careful adjustment of the knob attached to the upright post, the tension of the contact point is increased or decreased.

As a further protection to the crystal, it is surrounded with a small glass tube which is about ½ inch in length.

—E. T. J.

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.

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A. L. R., New Orleans, La., writes:

Ques.—(1) I am an operator in the commercial wireless service and I would like advice on the functioning of the former valve tuner developed by the American Marconi Company. I refer to those tuners which now employ crystals but formerly the valve. What is the function of the small six-point switch on the top of the tuner marked "Long Wave and Tune"?

Ans.—(1) The function of this switch is to shift the variable condenser ordinarily connected in shunt to the intermediate circuit and to place it in shunt to the closed oscillation circuit. This permits adjustments to waves of a greater length than those afforded by the billi-condenser alone. This change is made in order that the original valve tuner will respond to the time signals from Arlington, which are sent out at the wave-length of 2,500 meters.

Ques.—(2) Where can I obtain a detailed wiring diagram of the valve tuner?

Ans.—(2) This tuner, in commercial service, is known as type 107a. The circuits are completely explained in "Practical Wireless Telegraphy," copies of which can be purchased from the Wireless Press, Inc., 25 Elm Street, New York City.

Ques.—(3) Will you please advise how the tone of the quenched spark discharger can be regulated to a musical pitch?

Ans.—(3) Provided the gaps of the quenched discharger are airtight, the adjustment for a clear pitch is generally obtained by variation of the generator voltage. It is of course essential that the speed of the alternator be adjusted so that when the transmitting key is closed the frequency is 500 cycles per second.

If the note of the quenched gap has been adjusted for clearness and the open and closed oscillation circuits of the transmitter are thrown out of resonance, the pitch of the note will be destroyed because there will be, under this condition, a smaller extraction of energy from the spark gap circuit and the potential difference across the gap will accordingly rise. A pure tone can never be obtained with a leaking gap, and consequently, possible leakage between the gaskets should be carefully watched for.

* * *

L. A. W., Seattle, Wash.:

We have carefully studied your diagram of connections for the double vacuum valve amplifier and associated circuits, and we agree that you have developed what may be considered a universal receiving set.

We presume that the iron core transformer (shunted by the condenser C-1) in the grid circuit of the first valve is intended for purposes of re-enforcing the audiofrequency current of the plate circuit back upon the grid, and if so, the diagram is correct.

We consider an apparatus such as you have constructed to be practical for the advanced experimenter, but we would not recommend the construction of such a complicated set upon the part of the beginner. As a simple circuit for the beginner, we recommend the use of but one bulb with a regenerative coil for amplifying simultaneously the audio and radio frequencies.

The sensitiveness of your set can be generally increased by placing a radio-frequency transformer between the first and second bulbs. Thus you would amplify radio-frequency currents and increased selectivity would result.

* * *

H. G. H., Craften Heights, Pa.:

You neglected to tell us the type of motor you employ to drive your rotary disc discharger, and consequently we cannot advise you how its speed can be reduced. Have you tried a series rheostat?

* * *

R. J. E., Southampton, N. Y.:

Balancing-out circuits such as are described in "How to Conduct a Radio Club" have been employed for tuning out induction from power wires, but in many cases the results have not fully justified the construction of the extra apparatus required.

We can offer the readers of The Wireless Age no advice on the vacuum valve situation as far as the amateur is concerned until the close of the war.

* * *

J. E. L., Michigan, N. D.:

The commutator interrupter which you have designed will function well enough with a one or two-inch spark coil, but not on larger powers. Severe arcing at the commutator segments would result. In general, interrupters constructed along the lines that you have suggested give no better results than the ordinary magnetic in-

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terrupter except that they are slightly more positive in action, i. e., fusing is prevented.

* * *

J. E. L., Plattsburg, W. Va.:

In our opinion you will not find sufficient room on the core of your high voltage transformer to provide a three-volt secondary giving 300 amperes. We advise that you place two layers of 00 B & S wire on the secondary winding and simply draw sufficient current for the carrying capacity of this wire.

* * *

J. V. S., Birds Island, Minn.:

We are unable to state whether the Government authorities would consider the operation of your tester coil a violation of the President's executive orders. You can best satisfy yourself on this point by communicating with the United States Naval Communication Officer at Chicago, Ill.

* * *

G. A. G., Baltimore, Md., inquires:

Ques.—(1) Please explain what is meant by radio-frequency amplification in connection with the three-electrode valve.

Ans.—(1) When the vacuum valve is connected to the secondary circuits of a receiving tuner there is repeated in the local plate circuit a radio-frequency current which is in reality the result of an increase and decrease of the voltage of the plate circuit battery. There are two methods by which this radio-frequency component of the battery circuit can be amplified. In one system the plate circuit is coupled back, either electromagnetically or electrostatically, to the grid circuit, and by the variation of the grid potential thus occasioned, considerable amplification is obtained

In the second method, the radio-frequency component of the local plate circuit is passed through the primary winding of an oscillation transformer and the terminals of the secondary winding are in turn connected to the grid and filament of a second valve in which the incoming oscillations are again amplified.

Ques.—(2) How can an operator tell when a radio-frequency amplifier is adjusted to its best operating condition?

Ans.—(2) If the operating characteristic of the bulb in use has not been obtained by laboratory experiment, the adjustment must be found by practical test. Usually, in the radio-frequency amplifying system a battery is connected in series with the grid of the valve. This battery is shunted by a potentiometer, and by means of it the potential of the grid in respect to the filament can be definitely adjusted. This permits the best operating characteristic to be obtained which is evidenced in the operator's telephone by the best strength of signals.

* * *

B. D. L., Washington, D. C., inquires:

Ques.—(1) In what part of a receiving tuner circuit should a variometer be placed?

Ans.—(1) The position of the variometer depends somewhat upon the type of circuit in use. In general, it should be placed in series with the aerial circuit, although it may be useful in certain types of apparatus in series with the secondary inductance. The advantage of the variometer is that it permits extremely close regulation of the self-induction of a given circuit.

It is particularly useful in the antenna circuit of a regenerative beat receiver. After all circuits of such a receiver are adjusted to resonance, the note of the signals in the head telephone can be varied over a considerable range of frequency by simply turning the handle of the variometer.

Ques.—(2) Will you kindly show a diagram indicating what is meant by a tuned plate circuit and one which is untuned?

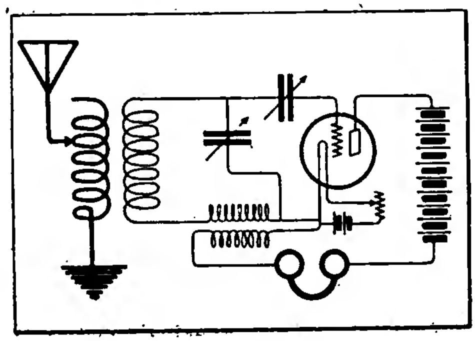

Figure 1

Ans.—(2) The diagram of Fig. 1 shows an untuned plate circuit which is inductively coupled to the grid circuit of a valve. This circuit will permit regenerative amplification.

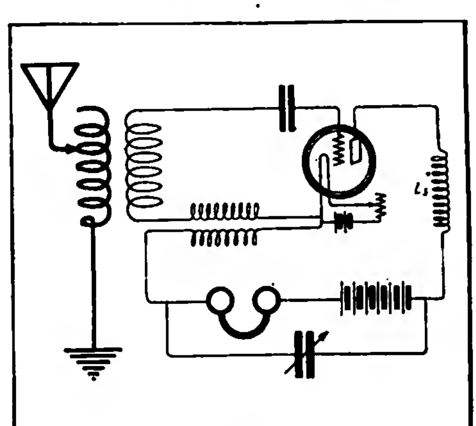

Figure 2

In Fig. 2 is shown a tuned plate circuit where, by shunting a condenser across the battery and placing a coil L-3 in series resonance with the grid circuit oscillation is secured.