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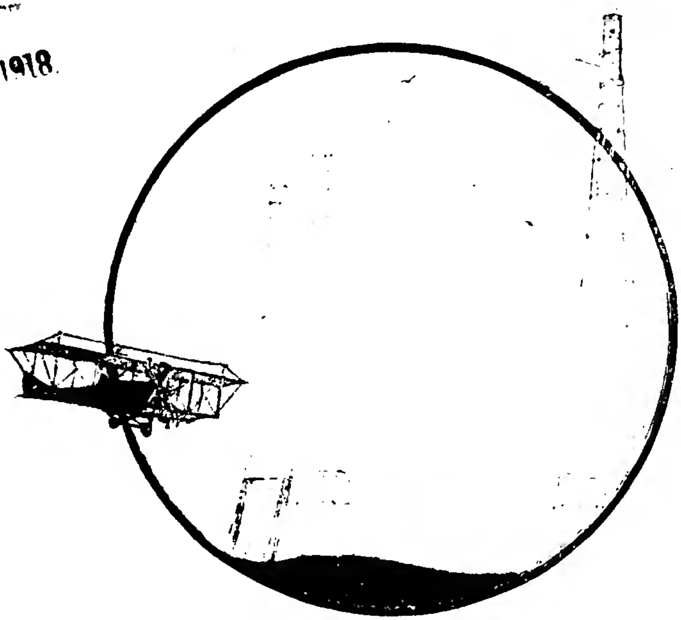

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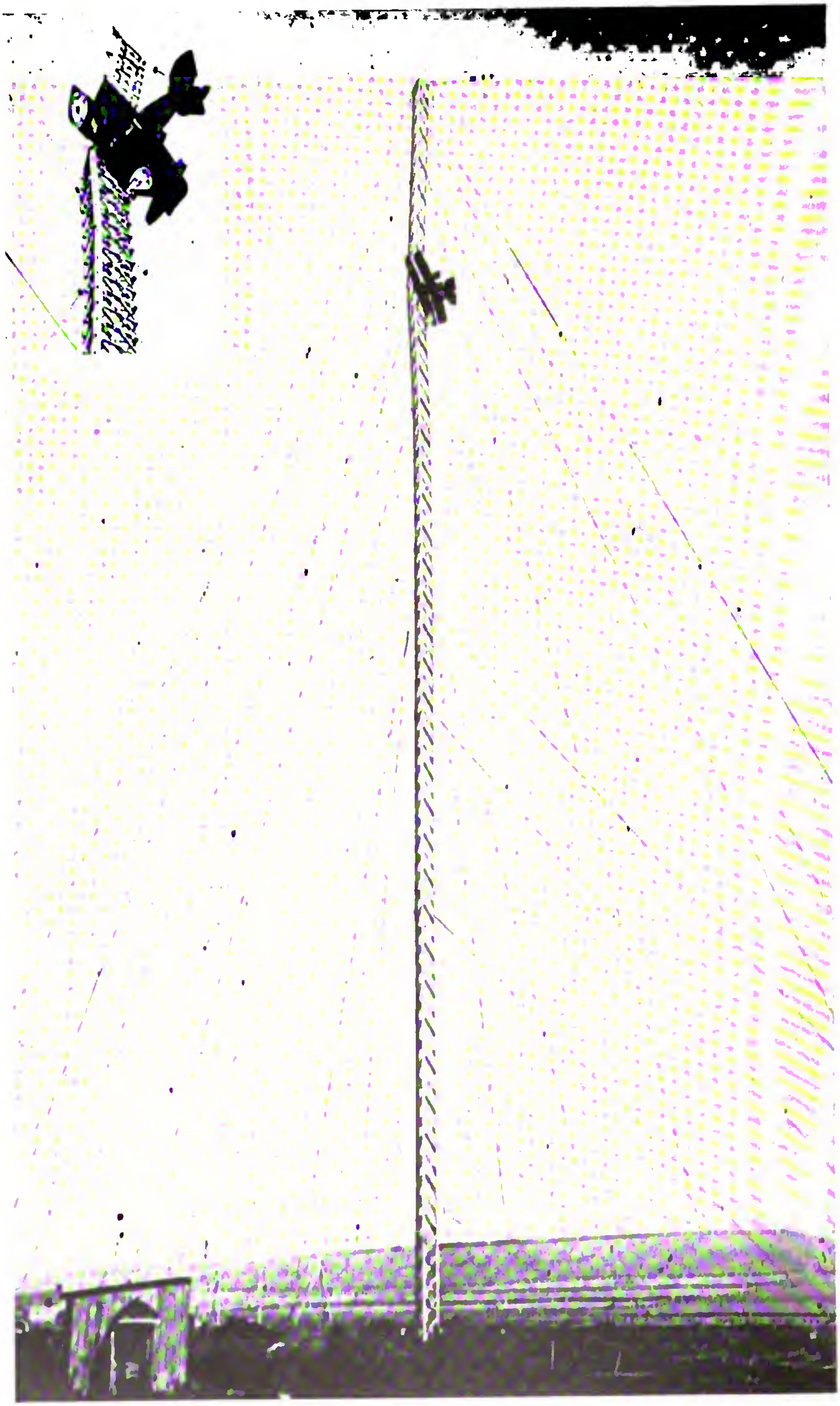


Airship Caught in the Girders Atop a Wireless Tower

THE WIRELESS AGE

WORLD WIDE WIRELESS

The Significance of the Cavite Opening

ON December 19th wireless communication was established between Washington, D. C., and Cavite, P. I., through two relay stations. These relay points are San Diego, Cal., and Pearl Harbor, in the Hawaiian islands. From Pearl Harbor to Cavite, a distance of 4,700 miles, communication will be direct. Thus will the most remote of our possessions be brought into almost instantaneous touch with the seat of government.

Recalling the days of '98, when the battle of Manila bay was fought, the Philippine cable was cut, and the nation waited in breathless suspense until the cable finally was repaired and Dewey laconically reported the victory, great progress in electrical research work has been made within two decades. We get news these days while it is still fresh, and it scarcely matters in which quarter of the world it is made. Never again, it would seem, will a duplication of the Oregon's dash around the Horn keep us in a state of nervous uncertainty for weeks. Wireless, a novelty ten years ago, has become as indispensable as it is reliable. As a means of communication it is a cable that cannot be cut and a wire that storms do not break.

Our wireless equipment is probably equal, if not superior, to that possessed by Germany. When the next step is taken, and the nation's head is enabled to communicate direct with the uttermost outpost where flies the American flag, much after the fashion of a corporation manager who presses a button and instantly is put in touch with a department subordinate, it should have the moral effect, at least, of bringing the widely separated fragments of the republic into closer unification. In any event, the present achievement stands as a Yankee challenge to German kultur.

The Women Break Down the Barriers

AFTER many years of effort women at last have succeeded in breaking down the sex barrier at the College of the City of New York. Announcement was made January 14th that the board of trustees had decided that women might enter the evening and summer classes as fully matriculated pupils, beginning with the classes of February 13th, for which registration opens January 28.

"Our admission of women in the evening session on the same basis as men," says the official announcement, "opens a big vista in education in New York for which women have long been eager. The division of vocational subjects and civic administration has attained a phenomenal growth, and female students will now obtain its advantages and other adjuncts of the entire evening session."

This development was brought about by the efforts of 100 Brooklyn women who tried to register for the last session. It is stated that there are now 500 women who have been taking the courses without prospect of degrees who will be able to compete for the A. B. degree, without payment of fees, on the same terms as men. The trustees authorized President

Sidney E. Mezes of the City College to enter negotiations with President Davis of Hunter College for the purpose of making arrangements for interchangeable work.

The plan contemplates a zone system under which each college will control the students of its particular zone, and the women of Hunter can take advantage of the City College courses where there are no similar classes in their own zone. The idea of the new plan is to have the two institutions work together.

The credits for studies pursued under the City College jurisdiction will be certified by that college and the A. B. degree will be awarded by Hunter.

Among the changes in the faculty of the College of the City of New York, taking effect February 1, Dr. Alfred N. Goldsmith, radio engineer and director of the City College wireless station, has been made an assistant professor of electrical engineering.

Station Near Where German Is Interned

A MORE strategic location could not have been chosen for an eaves-dropping wireless receiving station than was selected by William Heuer, 19 years old, when he set up in the barn of his father, Henry Heuer, on the main street of Bay Shore, L. I., the wireless apparatus that was raided on December 18th by the Naval Intelligence Bureau.

With the internment on the same day of Henry Schneider, a German jeweler, it was recalled that this Long Island village, near New York has been the scene of other alien enemy activities.

In the summer of 1915, Mme. Gadski, the opera singer, wife of Hans Tauscher, who was representative in this country of the Krupps, rented a cottage in Bay Shore. In August of that year she "entertained" Wolf von Igel, in whose offices in Manhattan the Secret Service agents found a mass of valuable evidence which is thought to have shown what part Ambassador von Bernstorff was playing in the propaganda. There were other notable Germans in the party. Leaving the meeting the party was proceeding westward a short distance from Babylon, when one of their automobiles was wrecked by collision with another car and von Igel was injured. He was taken to the Babylon Hospital where a veil of mystery was thrown about him. He remained there a week without his identity becoming known. Captain Boy-Ed, military attache of the German Embassy, was one of the distinguished visitors who were shown into von Igel's private room to "offer their sympathy."

Von Papen's eagerness to prevent it from becoming known that von Igel had been in Bay Shore on that night was not appreciated at that time. It is not known even now, in view of what was discovered through the recent arrest, whether the wireless espionage scheme was devised at that time, to be put in operation in the event of this country's entry into the war against Germany.

Heuer's station was located nine miles from the wireless station at Sayville, which is owned by German capital, but which is now under the control of the Navy Department, and about the same distance from the wireless station on Fire Island.

No one in Bay Shore suspected that young Heuer and Henry Schneider, the German jeweler, who is now interned, were operating this secret means of intercepting news of troop movements, as is charged. Schneider kept a small jewelry shop on Main street, not far from Heuer's grocery store and barn. Apparently he was paying strict attention to the warning to all Germans to "Mind your own business and keep your mouth shut." His tactics outwardly were directly opposite to those of another Main street merchant of pro-German leanings. He and his wife joined the Red Cross in the recent

The man who "tipped off" the Naval Intelligence Bureau to Schneider's actions had seen the jeweler leave his store late at night after all the stores of the village were closed. Schneider always went west. He was followed by the man who watched but who hesitated to take any steps that might arouse the German's suspicions and hinder the subsequent investigation. He was the only man who thought Schneider other than a plodding storekeeper.

Henry Heuer, the father of William, said that he washed his hands of the whole affair. The wireless apparatus, he contended, had not been operating since the war began, though it had been previously.

Hidden German Apparatus Unearthed by Dog

IF YOU place the tip of your finger on a map of the world and run it along the equator, writes "An Australian Officer" in the Wide World, you will discover the island of Nauru. This pin-point of an island is perhaps the richest spot on earth, being composed almost entirely of phosphate, of which it is said there is $950,000,000 worth actually in sight.

Prior to the war the Germans had erected a high-power wireless station on this island, the lofty mast of which is visible a couple of hours before one sights the land from a steamer.

Very soon after the struggle commenced the British authorities "rushed" the place in order to silence the great station. On the near approach of the warships the Huns in charge tried to render the station useless by hiding all the essential parts in a big cave, the existence of which was a secret.

When the station had been thoroughly dismantled and all parts stowed away in their subterranean hiding place the mouth of the cave was closed and hidden with rubbish.

Alas for the Germans! An old black dog had been an interested onlooker.

When the British looked for the wireless the dog joined the side of the victorious party and led the English sailors to the concealed mouth of the cave, where she commenced to dig.

There were sharp-witted fellows looking on, and the excited animal was soon assisted by a band of helpers who were missing nothing. They soon made the earth and rocks fly, uncovered the cave—big enough to hold a platoon—and, to their huge delight, located the missing parts. As a result in a few hours the British were in communication with their warships.

Naval Operator Under Fire in California

A MYSTERIOUS attempt to kill the operator at the United States naval radio station at Inglewood, Cal., with the probable subsequent destruction of the station's valuable electrical equipment, was made on the afternoon of December 8th, according to a report made to the Sheriff's office. The plot failed, the authorities believe, through the presence of mind and quick action of Oliver Garver, the intended victim, who switched out the lights and called the Sheriff's office, frightening away the plotters before they could carry out the first step of their plans.

Garver, an enlisted man detailed as operator at the station, was sitting with his back turned to the windows of the receiving-room on the ground floor when, without warning six shots were fired in quick succession. As the bullets whizzed close to his head and found their mark in the wall ahead of him, Garver quickly turned out the electric lights with one hand and grasped the telephone with the other.

Before the last bullet buried itself in the wall, he dropped to the floor and, lying prone in the darkened room, began to call the Los Angeles central. Foiled by the operator's quick action, and not daring to remain in the vicinity of the building, the men outside took a few parting shots in the direction of the second floor of the building, where the transmitting apparatus of the station is installed, and fled

Some of the bullet holes through the wall showed, by the angle at which they were made, that a number of shots, presumably fired after the lights were extinguished on the ground floor, were aimed in the direction of the floor above. This leads the officers to believe that the plotters were familiar with the general plan of the building and knew where the bullets were apt to find a vital mark.

Pan-American Wireless Project

THE wonders of wireless telegraphy have been made the subject of many a poetical dissertation, but the theme is one of which we never tire, because something new is always being planned or achieved.

It was a marvel when the first telegraphic communication without the aid of wires was established, but the skeptical sneered at the suggestion that any practical use could be made of the device, and, of course, were absolutely certain it could never have the range of line telegraphy.

From little more than a pretentious scientific toy, wireless was soon installed on ships, and it was thought it would be of inestimable benefit to mankind if it could only serve the purpose of calling for aid when a vessel struck upon the rocks or was foundering anywhere near a coast.

Bit by bit the plants were improved until first the seas and then the oceans were spanned. Messages to ships in midocean could be relayed to stations on the opposite side, and that seemed wonderful until it was found possible to communicate from one hemisphere to another without the aid of vessels at sea. From this it was only a step to sending wireless messages all round the globe; men at a station in the mid-Pacific talking to New York, London, Berlin, Tokio, Melbourne and Alaska.

With this accomplished science could no further go, and all that remained was for commercial enterprise so to extend its operations as to cover the whole globe with radio stations working on a business basis. Science had proved that the thing could be done, and it was for commerce to make wider and wider uses of the invention.

Of the many recent commercial extensions of wireless, perhaps the most important project is that of the Pan-American Wireless Telegraph and Telephone Co., which seeks to establish communication between the United States, Mexico, Central and South America.

With such a concern in successful operation, Pan-Americanism will be advanced as it could have been by no other means. The various republics will be brought into the most intimate touch with one another, and if better knowledge is the basis of better understanding and better understanding of better friendship the Americas may become more united than ever through the unifying influence of wireless communication.

There could be no more favorable time than the present for such an undertaking. Cut off as is the Western world from communication through trade with Europe, it has immediate need of taking every advantage of its commercial self-sufficiency. This hemisphere is a world unto itself, and, if necessary, can live unto itself so far as trade and commerce are concerned. The war having presented that necessity, nothing can assist in the work of demonstrating how self-contained we are like more immediate communication of our wants and resources.

It may well be, if this is to prove a very long war, that the Americas will foster mutual trade on a basis undreamed of in the days of peace, and to this much desired result a Pan-American wireless system can contribute largely.

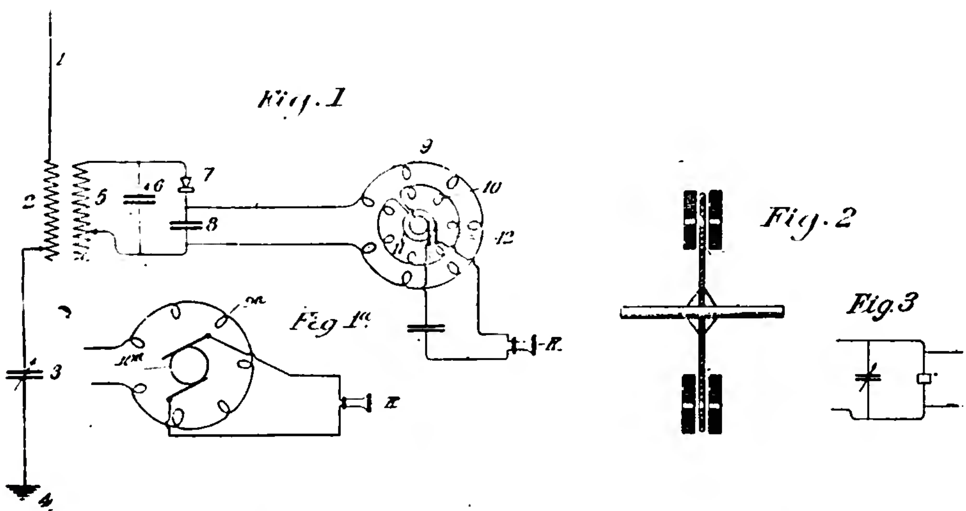
More closely welded together by commerce, we will be more of one mind on those world problems of mutual concern, and, as the essentially peaceful hemisphere, we may be promoting the universai concord of mankind.

A world united by wireless may prove more united than it could be by any other means.

Radio Science

Receiving Apparatus for the Production of Sinusoidal Alternating Currents

IT is a well-known fact that if a sinusoidal alternating current flows through the ordinary telephone receiver such as is used in a wireless telegraph system, better response is obtained from a given amount of energy if the diaphragm is acted upon at a certain natural frequency, that is, the greatest volume of sound is produced by the telephone diaphragm when its natural frequency coincides with the frequency of the current. While the foregoing statement applies to a receiving telephone passing a sinusoidal current, such is not the effect of a group of incoming oscillations when they are rectified in a radio receiving system. The telephone winding is traversed by a series of decaying pulses of direct current which obviously cannot produce the same effect on the diaphragm as a sinusoidal alternating current.



Diagrams of a recently devised radio receiving system

It has been shown by Dr. Austin of the Bureau of Standards that it requires but .0000006 of a volt to produce an audible sound in a standard type of receiving telephone when the frequency of the current is 900 cycles per second; at 60 cycles per second six hundred and twenty millionths of a volt are required to produce the same strength of signal. From this we may deduce that a given amount of energy flowing through the head telephone produces the greatest deflection of the telephone diaphragm, when the telephone windings are traversed by a current of a definite and sinusoidal frequency.

Harry Shoemaker recently devised a radio telegraph receiving system wherein the rectified currents flowing through the local receiver circuits pass through the field windings of a small alternating current generator, the armature of which contains a series condenser 13 and a telephone, *R*, as shown in figure 1.

The effect of condenser, 8, connected in shunt to the field windings, is to provide a practically continuous flow of current through the field windings of 9, a small alternating current generator.

It is evident that the circuits shown (Figure 1) are applicable to the reception of either damped or undamped oscillations, but increased response is obtained over the ordinary system on account of the fact that the armature of the alternator impresses upon the telephone, *R*, a practical sinusoidal alternating current and if the frequency of this current coincides with the natural frequency of the telephone's diaphragms, a maximum of sound is obtained.

Increased strength of signal is obtained by reason of another well-known phenomenon. With damped oscillations, for example, the energy which can be transmitted from the sending to the receiving station is proportional to the spark frequency or the number of wave trains per second, and it is advantageous to increase the number of wave trains radiated from a transmitting station provided a receiver is employed which will act quantitatively, or have its action increased by the amount of received energy. To illustrate further: with any of the well-known crystal, electrolytic, or rectifying detectors if used in conjunction with the galvanometer, the reading of the galvanometer will be approximately proportional to the spark frequency when damped oscillations are used, provided the energy or amplitude of the wave train is constant.

For instance, if 1,000 wave trains are received per second, the galvanometer will show approximately one-half the energy received that it would if there were 2,000 wave trains per second. On the other hand, if a telephone is used in place of a galvanometer, it will not give any louder signal with 2,000 wave trains per second than with 1,000 wave trains per second, and the loudness of signals depends upon the amount of energy contained in each wave train.

As mentioned before, the electromotive force to which the telephones are subjected in radio telegraph receivers is in the nature of very short impulses with considerable time intervals between such impulses. Therefore, there cannot be much building up or increase of the strength of signals due to resonance, even if the circuits are properly adjusted, that is, if the frequency of the incoming wave trains coincides with the natural period of the telephone diaphragm. But the foregoing limitations are done away with in Shoemaker's apparatus.

By properly choosing the speed of the armature, 10, a note of any desired frequency can be obtained in the telephone, *R*, during the reception of undamped waves.

Mr. Shoemaker points out that while the receiving apparatus is particularly adapted to receive undamped waves or waves having a group frequency higher than the frequency of the telephone or above audibility, it may also be used to advantage in cases where the wave trains have the desired audio frequency. In this case, the generator is modified as shown in Figure 1a, where the alternating current armature has been replaced by a direct current armature. Then, when current flows through the field windings, 10*a*, the armature circuit will be impulsed periodically by an audio frequency current and response accordingly obtained in the head telephone, *R*. A section of the proposed generator is shown in figure 2, and a modified method of connecting the generator across the rectifier, 7, in figure 3.

The Valve Receiver for Wireless Signals

AN unusual circuit for use of the three-electrode vacuum valve as a current limiting device has been brought forth in London by George M. Wright, for the English Marconi Company.

The tube as he employs it offers a striking contrast to the usual three-electrode valve, because instead of employing a high voltage battery, a very small potential difference—in fact, a fraction of a volt—exists between the plate (anode) and the grid.

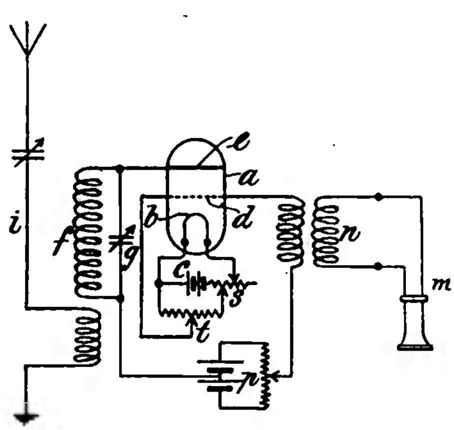


Figure 4—Wright's use of the valve as a current limiting device

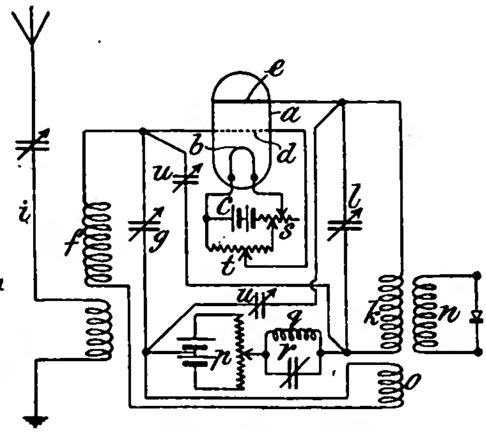


Figure 5—Two tuned oscillatory circuits conductively coupled

The valve employed as a simple detector of oscillations is shown in figure 4, and in figure 5 a modificatioon of the circuit is shown where two tuned oscillatory circuits are conductively coupled.

An inductance *f* coupled to an aerial *i* and shunted by a condenser *g* is connected to the anode *e* and through a potentiometer *p* to the grid *d*. The telephone receiver is coupled at the point *n*. The grid *d* is also connected by a variable contact to a potentiometer *t* and connected across the battery *c*.

For a given position of this variable contact, a certain limiting current can flow across the space between *d* and *e* with a given brilliancy of the lamp filament. The maximum current for any given adjustment may be called the saturation current.

The three main adjustments for placing this apparatus in operation follow:

The temperature of the filament is adjusted by *s*, the potential of the grid by the potentiometer *t*, and the most sensitive point on the rectifying curve is utilized by potentiometer *p*. The maximum strength of the signals is limited by the adjustment of *t*. More clearly, by varying the potential applied to the grid with respect to the filament, the operator can make effective only a small portion of the electronic emission from the filament. If the correct operating adjustment is thus secured, the current will quickly rise to a maximum, this maximum being limited at the same time by the adjustment of the potentiometer *p*. This arrangement gives a very sensitive detector for incoming radio signals, but prevents overpowering noises from static disturbances.

In connection with the circuit of figure 5 Mr. Wright states that the signals in the aerial are transferred inductively to the circuit *f g*, and the space between the grid *d* and the anode *e* acts as a conductive coupling between the two circuits *f g* and *k l*, by completing a circuit through *k*, *g*, potentiometer *p*, *o*, and *f*, the circuit *k*, *l*, being coupled to the detector circuit *n*. The limiting value of the current is controlled, as before, by *t*, and the sensitive point is found by the potentiometer *p*. *Q* is a choke coil and *r* a condenser shunting it. *O* is a reaction coil for balancing accidental electro-magnetic coupling between the circuits. In place of *o*, or in addition, condensers *u* may be inserted as shown, these condensers furnishing a discharge path around *k* for stray oscillations of high frequency. The circuit is arranged to transfer the high frequency current through it to the detector circuit *n* with any required limitation of signals.

The inventor states that during the practical operation of the set the limitation of signals and other responsive sounds in the receiving circuit is obtained by varying the current in the filament *b* so as to control the brilliancy thereof, and the quantity of electrons emitted. Simultaneously the position of the contact at *t* is varied to control the potential between the filament *b* and the grid *g*.

A Receiver for the Elimination of Static Signals and Harmonics

A RECEIVING apparatus applicable to either radio telegraphy or telephony, recently devised by John Carson, has an interesting provision for eliminating static or other unwanted signals. It also prevents distortion of the incoming signal at the receiving apparatus, and therefore permits the receiving telephone in a wireless telephone system to give a response which is directly proportional to the modulated energy supplied by a transmitter.

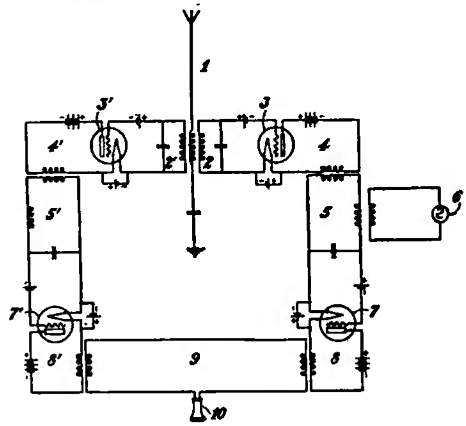


Figure 6—Diagram of circuit for partially eliminating static and foreign interference

A circuit for the partial elimination of such interference is shown in figure 6, and a more elaborate system which acts more effectively in this direction in figure 7. It will be noted that in either system the local output circuits of a number of vacuum valves are differentially connected to a receiving telephone, 10, figure 6. Also, in figure 6, there is coupled to the receiving system, 2, a radio frequency generator 6, coupled to circuit 5. The object of this generator will be explained further on.

In the carrying on of a conversation by wireless telephony, radio frequency current (above the limits of audibility) are employed at the transmitter and are modulated at an audio or "mean speech" frequency by the microphone transmitter. This radio frequency wave is termed the carrier wave, and the modulation of the carrier wave results in general, as is well known, in the transmission of three waves of frequency which may be designated as F, F + f, and F — f; where F is the frequency of the carrier wave and f the frequency of the signal wave (of audio frequency).

In the ordinary receiving system, the oscillations in the receiver are not faithful copies of the original oscillations in the transmitter, and in consequence the signals are distorted; but the Carson apparatus provides means to greatly reduce this distortion.

It is seen from the general circuit shown in figure 6 that the two receiving detector circuits are differentially connected to the same receiving device. Hence, it will be clear that the receiving telephone will not be energized since the oscillations in two similar and equal receiving arrangements oppose and substantially neutralize each other. But in this system, by coupling the generator, 6, to one of the circuits, the oscillations in the two receiving arrangements do not completely neutralize, but the neutralization extends only to oscillations which are conducive to distortion, and which should be eliminated.

In the operation it is desirable that the coupling of generator 6 to circuit 5 should be loose, in order that generator 6 shall not affect to any extent the natural oscillations in circuit 5. Connected to oscillation circuits 5 and 5′ are detectors 7 and 7′, respectively, preferably of the vacuum tube type and similar and equal as regards adjustments and operating characteristics. Differentially coupled to output circuits 8 and 8′ of detectors 7 and 7′ is coupled a circuit, 9, containing a receiving device, 10, preferably a telephone receiver. Circuit 9 is coupled to circuits 8 and 8′ in such a manner that no sound is heard in the telephone receiver when generator 6 is removed. When this condition obtains, the oscillations of audio frequency in circuits 8 and 8′, excited by the waves absorbed by the antenna 1, oppose and substantially neutralize with respect to circuit 9 and receiver 10. The operation of the system shown, when generator 6 is generating a wave of carrier frequency, will be readily understood from the explanation now to be given, from which it will be seen that not only is the quality of the received speech signals improved, but interference is also largely reduced.

The radiated wave which acts inductively on antenna 1 excites therein oscillations of the carrier frequency F, which is modulated at an audio frequency, f, and such a wave can be analyzed into three component waves of constant amplitude and frequencies, F, F + f, and F — f. These three frequencies are excited in the receiving antenna.

The suppression of two of these frequencies, yet permitting the desired frequency to operate the receiving telephone, is accomplished as follows:

Assume for definiteness that the antenna is tuned to F plus mean speech frequency. As a consequence the current of frequency F—f is reduced in amplitude as compared with the current of frequency F + f, and this reduction may be made as great as desired by sharp tuning and by providing oscillation circuits between the antenna and the detector. It can therefore be assumed that the currents of frequency F — f reaching detectors 7 and 7′ are negligibly small in comparison with the currents of frequencies F and F+f (Figure 6).

It will be readily seen that since the two paths whereby the receiving circuit proper 9 is coupled to antenna 1 are similar and equal, equal currents will be excited in the two circuits by the oscillations induced in the antenna. Therefore, if generator 6 were removed no current would be induced in circuit 9, since its connections with circuits 8 and 8′ are differential. Generator 6, however, generates a wave of constant amplitude and of carrier frequency F; the resultant wave of frequency F is therefore larger in circuit 5 than in circuit 5′, while the waves of frequency F + f are equal in said circuits.

It has been experimentally shown that the action of the valve detector is such that two waves of frequencies F and F + f presented to the input circuit excite in the output circuit audio frequency oscillations of frequencies f and 2f respectively, the latter wave being independent of the wave of frequency F, while the wave of frequency f is proportional in amplitude to the product of the amplitudes of the input waves of frequencies F and F + f. It is the wave of frequency f which reproduces speech signals, the wave of frequency 2f representing an interfering or distorting harmonic. The waves of frequency 2f being independent of frequency F are generated with equal amplitude in circuits 8 and 8′, and hence neutralize in the receiving system while the desired wave of frequency f, since its amplitude depends upon the amplitude of frequency F, is generated with greater amplitude in circuit 8 because frequency F is reinforced in that circuit by generator 6, and hence frequency f is not neutralized. In other words, the receiving system of this invention transmits to the receiver proper the wave necessary to set up sound vibrations therein which are faithful copies of the transmitted signals, while suppressing oscillations which serve only to distort the received signals.

Furthermore, the signals may be amplified by making the wave of generator 6 large as compared with the received wave. As regards static interference, the amplitude of static is in general much greater than that of the wave it is desired to receive and the interference is represented largely by an audio-wave proportional to the square of the static or interfering wave. This term is completely neutralized by the differential connections of this receiving system, which provides a large measure of protection from static or other foreign interference.

In the circuit shown in figure 7, which is designed to eliminate static or

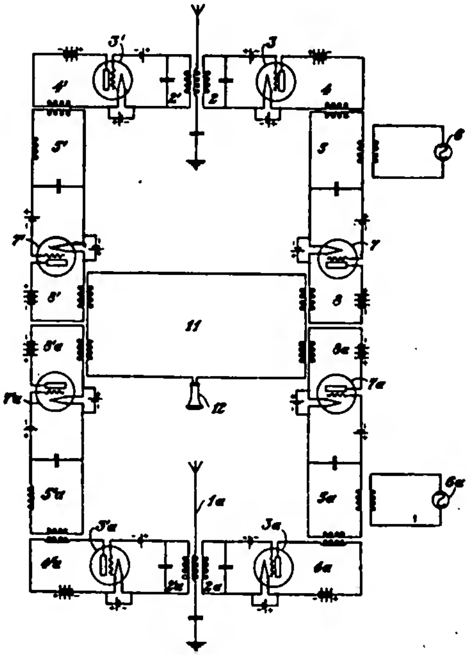


Figure 7—An effective system for the elimination of static and natural disturbances

other natural disturbances, the function of the receiving antenna, 1a, is to eliminate interference, its associated circuits being tuned to a frequency differing materially from the frequency adjustment of antenna, 1, which is tuned to the desired signal.

When a static disturbance sets up oscillations in the antenna, 1, it simultaneously excites oscillations in antenna 1a, the periodicity of the natural oscillations in antenna 1 differing by approximately 1,000 cycles per second, or mean speech frequency, from that of the wave generated by generator 6, while the periodicity of the natural oscillations of antenna 1a is that to which said antenna is tuned. Generator 6a is adjusted to generate a wave whose frequency differs from that of the natural oscillations of antenna 1a by substantially the same amount as does the wave generated by generator 6 from the natural frequency of antenna 1. Natural oscillations of the same periodicity and damping are excited in oscillation circuits 5a and 5a′ by the natural oscillations in antenna 1a, and these oscillations would produce the same low frequency oscillations in the output circuits 8 and 8a′ of detectors 7a and 7a′ if generator 6a were removed.

Owing to the presence of the continuous wave generated by generator 6a in oscillation circuit 5a the low frequency oscillations in circuits 8a and 8a′ differ just as do the low frequency oscillations in circuits 8 and 8′. Circuits 8, 8′, 8a, and 8a′ are coupled to circuit 11, including a telephone receiver 12, in such a manner that the low frequency oscillations in circuits 8 and 8′ oppose, in circuits 8a and 8a′ oppose and in circuit 8 and 8a oppose. As a consequence, the effects due to natural oscillations in antenna 1 and 1a oppose and tend to neutralize each other with respect to receiver 12. This neutralization may be made complete by adjustment of the relative amplifying powers of amplifiers 3, 3′, 3a, 3a′. It is desirable for complete neutralization that the damping factor of the natural oscillations in circuits 5a and 5a′ be substantially the same as the damping factor of the natural oscillations in circuits 5 and 5′. This may be practically attained by adjustment of the inductances in these oscillation circuits.

Wireless and the New York Police

Advantages of Radiotelegraphy Demonstrated In Practical Police Work

POLICING a city like New York is a large problem, even under normal conditions, but when a great emergency arises, the task is greatly augmented. In other cities where disaster has destroyed for a time the normal conditions of business and social life, it has often been necessary for the local authorities to call on the State militia or the Federal troops for aid in handling the situation. In New York City the necessity to call in such aid is almost eliminated, even in an emergency, because of the foresight of Arthur Woods, former police commissioner, and the late Max F. Schmittberger, who was chief inspector.

In 1915 a "preparedness" program was mapped out, with a view to giving members of the police force practical knowledge of coping with conditions far outside of ordinary police work.

The first problem was to get the members of the force into good physical condition, for which purpose the regular "setting-up" exercises of the army were adopted. During the summer of 1916, more than 3,000 members of the force experienced army camp life, under the supervision of regular army officers. The men were taught the elements of field service in detail, pitching tents, cooking and serving meals, and acquiring a knowledge of sanitation. The Army manual of arms was also taught. At the conclusion of the training period it was announced that, should emergency in the city necessitate the establishing of refugee camps, three thousand members of the police department were in a position to take full charge. The sites for such camps were then selected and arrangements made for their use. All members of the force have been listed according to their former occupations, and since many are skilled it seems that the force will be able to take care of any task that may come up.

Policemen who have had experience in signal work, are prepared to take care of communication matters, should the telephone system fail. In this connection a wireless system has been established with three stations now in operation. Members of the force who have attended the wireless school of the department have passed the government examinations obtaining licenses as first grade radio operators. Considerable extension of the wireless system and an increase in the number of operators are now being worked out. The three department wireless stations, Manhattan Headquarters, Brooklyn Headquarters and the Steamer Patrol, have proven a very useful addition to the communication system. Manhattan Headquarters is equipped with Marconi 1 kw. quenched gap transmitter, and standard receiver, the call being 2ZA. Philadelphia and Albany have been worked. Brooklyn Headquarters' call is 2ZO, has a 2 kw. Marconi synchronous rotary gap equipment, and standard receiver. KIN is the call of the Steamer Patrol, which has a ¼kw. Marconi transmitter with standard receiver.

The three department wireless stations at Manhattan and Brooklyn Headquarters and on the Steamer Patrol have been in operation for ten

Manhattan Police Headquarters Wireless Station. Sergeant Pearce in charge

months and wireless communication between Police Headquarters and the Patrol is proving of valuable assistance in police work on the water surrounding New York. Previous to the installation of the wireless system it was necessary for the boat to tie up at a dock, to enable an officer to communicate with Headquarters or the precinct by telephone. This took considerable time, particularly at night, but now when the boat is away from the pier, and anywhere between Sandy Hook and City Island or Spuyten Duyvil, communication can be instantly established with either Manhattan or Brooklyn Headquarters, and orders given or reports received. Occurrences on the water where police assistance is required, are frequently reported to Harbor A, or Headquarters, by citizens over the telephone. When the boat is at the pier it is sent to investigate, and often sends a report of the case by wireless to the radio man at Headquarters, who telephones it to Harbor A. When the boat is away from the pier such messages are given to the wireless operator at Headquarters, for immediate transmission to the boat.

A few of the many instances in which this quick communication has enabled the rendering of prompt police service are here mentioned. In each case the boat was away from the pier, but communication was effected as quickly and accurately as if connected directly with Headquarters by a telephone line.

Two barges broke away from the pier at the foot of East 54th street on May 18 at 4 a. m., and, driven by a strong wind and tide, they swept up the East River and carried three more away from the 70th street pier. The five barges drifted out through Hell Gate, in the way of the fleet of steamers that come in through Long Island Sound early every morning. The Patrol was off Staten Island when this information was transmitted by the Manhattan Headquarters' wireless station. At 5:35 a. m., Sergeant Ellis, in command of the Patrol, reported by wireless that he had found and docked four of the barges, and that the fifth had been secured by a tug.

A fire occurred in the Metropolitan Hospital on Blackwell's Island about 1 o'clock in the morning of May 21. The Patrol was cruising around the lower bay at the time, when it received orders by wireless to proceed to the fire and to stop at the East 51st Street pier, for the Battalion Fire Chief. When the fire was extinguished, wireless orders were given the boat to resume patrol.

Richmond Telegraph Bureau, on May 26, at 3 p. m., notified Harbor A of a fire on board a Municipal ferry boat, bound from New York to St. George. The information was wirelessed to the Patrol in the East River, and at 3:39 p. m. it was reported by wireless that the fire had been extinguished with slight damage.

The Brooklyn Telegraph Bureau was notified by a citizen on June 5, at 4:35 p. m., that a motor boat off Manhattan Beach was flying distress signals. The Brooklyn wireless operator sent the message to the Patrol, which was off the Navy Yard. The police boat immediately started to the rescue, and at

Wireless room on the steamer "Patrol" of the New York Police Department. Patrolman John Ward

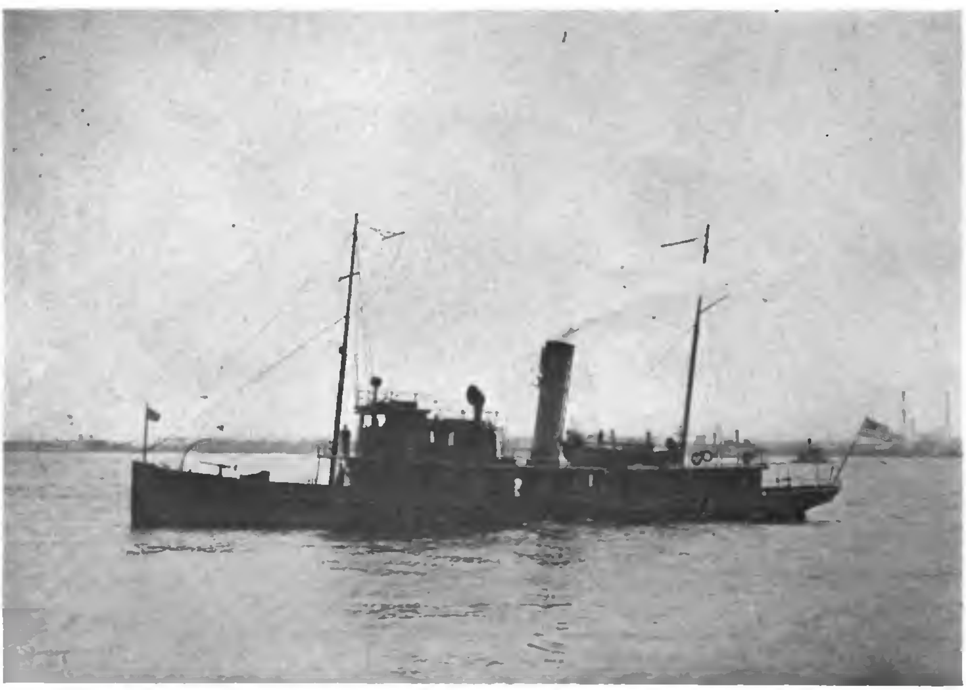
5:16 p. m., the commanding officer inquired by wireless if any further information had been received. The Brooklyn Bureau, after communicating with the citizen who reported the matter sent the following message to the boat at 5:28 p. m.: "Party in motor boat off Manhattan Beach still waving white flag. Coney Island Life Corps tried to reach them and failed." The Patrol reached the location at 6:15, just as the launch was taken in tow by a fishing steamer.

On June 13, at 10:30 p. m. a citizen notified Richmond Telegraph Bureau that a large transatlantic steamer was sinking as a result of a collision with another boat in The Narrows. The Patrol was ordered to the scene by wireless, and at 12:15 a. m., transmitted a full report of the accident to Headquarters by wireless.

A schooner which had grounded near Ellis Island in the evening of June 17, floated at high tide and drifted up the Hudson River, with no one on board. Harbor A was notified by telephone, and relayed the message through Manhattan Headquarters' wireless station. Twenty minutes later a wireless report was received from the Patrol that the schooner had been anchored and lighted.

Harbor A was notified by the pier watchman on June 20, at 9:40 p. m., that a lighter had broken away from the West 30th street pier, and was drifting up the river. The Patrol, then off the Statue of Liberty, was notified, and at 10:15 p. m., reported by wireless that the lighter, carrying a cargo of coffee valued at $50,000, had been returned to the pier.

A report was received at the Brooklyn Telegraph bureau on July 3d, at 5:25 p. m., that some people in a rowboat off Coney Island were being carried out to sea. The report was transmitted to the Patrol by the Brooklyn wireless operator and the police boat started for the scene. At 5:32 p. m.,



Steamer "Patrol" of the New York Police Department the Brooklyn bureau was notified that the rowboat had been picked up, and this information being wirelessed to the steamer an unnecessary trip was avoided.

On the national holiday, July 4th, Harbor A was notified by a citizen at 6:45 p.m. that a tug was churning up and down the East River, apparently not under control. It had been in collision with other boats. The Patrol was sent to investigate and found that two intoxicated boatmen had stolen the tug Gen. I. J. Wistar, from a pier in Brooklyn, and were having a "joy ride." The men were arrested. The case was reported by wireless at 7:50 p.m., the tug being returned to the owners but slightly damaged.

Trouble on a steamship anchored in the harbor was reported by telephone to Harbor A, on July 13, at 1:50 p.m. The Patrol was sent to investigate and it was found that a number of the crew of the steamship had been seriously stabbed during a brawl. A wireless message for an ambulance to meet the Patrol at Pier A was sent to Manhattan Headquarters at 2:10 p.m. The injured man, who subsequently recovered, was brought ashore ten minutes later and sent to the hospital in the waiting ambulance. His assailant was arrested and held.

A three-alarm fire occurred on August 20, at 3:07 a.m., at the foot of Congress Street, Brooklyn. The Patrol attended the fire, and at 5:05 a.m., sent the following report by wireless: "Fire on pier 26 under control. Steamer Barrentjetberg towed out from pier while in flames and anchored northeast end of Governor's Island, where fire was extinguished by steamer Patrol and tugs."

On August 26, at 6:50 p.m., Harbor A received a report by telephone that three coal barges were adrift in the East River, off East 10th street. The Patrol investigated, and three hours later reported by wireless that the barges had been docked at East 8th street, where they belonged.

The patrol has had the honor of conveying from its landing in Jersey City to New York, each of the six foreign Commissions that visited this country during the summer. On these occasions, use of the wireless equipments between the boat and headquarters enabled the city officials to keep in close touch with the movements of the parties. When a train with the Commission was late, Headquarters was informed by wireless from the boat which was waiting at Jersey City, and when the party boarded the boat, a wireless message to Headquarters was relayed by telephone to the Inspector in charge of the line of parade, so that the route could be cleared in time, with the least interruption of regular traffic. Altogether about 900 separate messages were exchanged between the three department wireless stations, during the first six months of 1917.

Finding Your Way Across the Sea

The urgent demands upon Captain Uttmark to prepare officers for sea duty has required this author to give almost his entire time to Government service. For this reason he has been unable to prepare the article of his series for this issue before it went to press. The March issue, however, will contain the lesson omitted.

Signal Officers' Training Course*

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

NINTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

Radio Apparatus of the Signal Corps—Part Three

IN THE January issue the U. S. Army Signal Corps radio pack set, 1913 type, was described and instructions for its operation given. In general the same instructions given for it apply to the 1915 set, which 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.
- 1 condenser.
- 1 oscillation transformer.
- 1 sending key.
- 1 spark gap.
- 1 hot-wire ammeter.
- 1 switch.

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

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.
1 flexible connector for antenna inductance.
1 connector, 2-wire, small, for receiving set.
2 spring hooks.
4 legs for chest.

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.

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.*

The essential differences in the two models are in the hand generator, the transmitting oscillation transformer, and the receiving set, a brief description of which will be given.

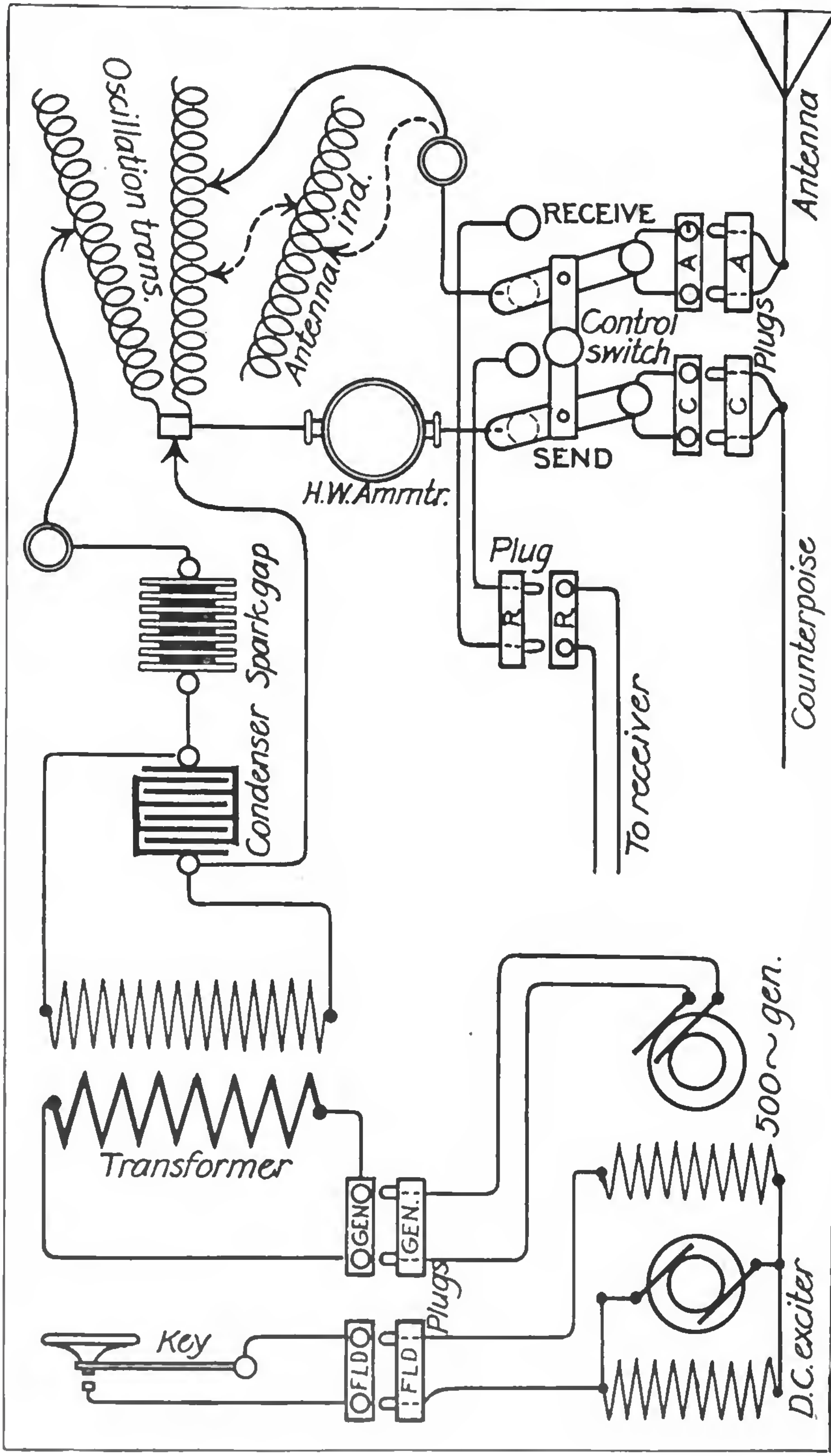


Figure 1—Wiring diagram, radio pack set, Model 1915

HAND GENERATOR

The 1915 generator is a 24-pole machine, with a speed of 5,000 R. P. M. The ratio of the gearing is 100 to 1, as in the 1913 machine, so that the speed of the handles must be 50 R. P. M. At this higher speed less pull is required on the handles and the tiring effect on the men is less than at 33 R. P. M. of the other machine.

On account of the higher speed, great care must be taken to keep the D. C. commutator clean and the brushes properly fitted to it. Failure of a machine to generate current is almost always due to a dirty commutator.

Only a nonfluid oil should be used for lubrication of the gears and ball bearings, and in the same quantity as in the 1913 machine.

OSCILLATION TRANSFORMER

The oscillation transformer consists of two open spirals inductively coupled and a third spiral which is to be used as an antenna inductance for obtaining longer wave lengths. This inductance is inserted between the oscillation transformer and the antenna by transferring the long flexible lead from the open circuit spiral to the inductance which is in turn connected to the oscillation transformer by a short flexible connection. Care must be taken to see that these added turns do not oppose the turns of the oscillation transformer; that is, the inside turns of one should be connected to the inside turns of the other.

Ordinarily the antenna inductance will not be in the circuit except a few inches from the lid of the chest.

The wiring diagram is shown in figure 1, in which the heavy wave lengths, and the dotted lines from it to the antenna inductance and antenna are for the longer waves.

The open and closed circuits of the oscillation transformer are electrically joined together at their base, to which the counterpoise is connected through the control switch and ammeter. This method of construction reduces the number of movable contacts from four to two and also has the advantage that the outside metal rings may be handled without danger of shock.

To put the set into operation: Connect the "Gen," "Fld," etc., plugs into the corresponding sockets; connect the short flexible wire from the rear binding post of the closed circuit condenser to the small angle piece extending out at right angles from the base of the oscillation transformer; connect the long wire at the opposite end of the condenser to the primary or closed circuit spiral, inserting the number of turns corresponding to the desired wave length, counting the turns from the outside turn inward; connect the wire from the control switch to the open circuit spiral, the exact number of turns to be found later by trial. The other end of the spiral is already connected to the counterpoise through the antenna ammeter.

In tuning the circuits the two spirals should be swung apart from 8 to 10 inches. After the two circuits have been brought into resonance, as indicated by the greatest deflection of the hot wire ammeter, the coupling of the two circuits should be increased or made tighter by gradually swinging the spirals closer together until the ammeter deflection just begins to decrease. If a wave meter is available or a distant station assists in the test, a single wave length or "hump" should be radiated and a clear note obtained, the number of gaps being adjusted if necessary as previously described. Care should be taken not to have too close a coupling.

When the standard closed-circuit condenser and oscillation transformer

Members of U. S. Signal Corps attaching support for wireless pole to the new auto radio truck

are used the wave lengths are very approximately given in the following table:

Wave lengths of primary or closed oscillating circuit

Wave length, in meters:	Number of primary turns.
300	2
400	3½
500	5
600	6½
700	8½
800	10
1,000	15
1,200	22

Note.—Turns counted from the outside turn inward.

RECEIVING SET, TYPE C

In the earlier sets, types A and B, the two circuits were magnetically coupled, that is, the current in the primary (open or antenna) circuit induced currents in the secondary (closed or detector) circuit by means of magnetic lines which passed from the primary coil through the turns of the secondary coil. In the present set the two circuits are *statically* coupled; that is, the current in the primary circuit induces current in the secondary circuit by means of static lines in two coupling condensers connected in the leads between the circuits. The transfer of the energy from the primary to the secondary circuit for the operation of the detector and telephones is as efficient in this type of connection as in the other. By choice of suitable values of the coupling condensers *no movement of the coils or changes in coupling* is necessary for the reception of any wave lengths within the range of the set, as is the case in the former sets. This reduces the number of adjustments for tuning from 4 to 3, and at the same time the set is much more rugged, as there are no moving parts. The values of the coupling condenser have also been so chosen as to make the set much more selective than the others; that is, it can receive signals from a station on one wave length and cut out signals from another station on a different wave length more completely than before. In addition to the above advantages, the set as a whole has been found to be more efficient than the previous types.

The type C receiving set consists of two statically coupled circuits, high-resistance telephones, stopping condenser, fine wire-galena detector, switch for short and long wave lengths, three dial switches for tuning, etc. The circuits are shown diagrammatically in figure 2.

The primary circuit consists of: (1) The antenna, which when the control switch in the cover of the chest is thrown to the "Receive" position, is connected by a double plug with flexible wires to the binding post on the set marked "A"; (2) two primary coils in series, one large and the other small, the number of turns in both of which is variable by means of the two dial switches marked "Primary." On each coil there are contacts, 0 to 24, for tuning to different wave lengths, the dial nearest to the binding post "A" being connected to the large primary for large changes in wave length and the other to the small one for small changes and fine tuning; (3) counterpoise which is connected to the binding post marked "C" through the double plug and control switch. There is no series condenser in the antenna circuit for the reception of wave lengths shorter than the fundamental wave length of the antenna, as in types A and B, as it has been found not to be generally useful.

When comparatively short wave lengths are to be received, as from 300 to 700 meters, the double-pole double-throw switch on top of the set should be thrown to the position marked "Short." This makes no changes in the primary circuit, but connects into circuit (1) the secondary coil with the dial switch marked "Secondary," with contacts 0 to 24 for tuning to different wave lengths; (2) detector and telephones.

Short wave signals should be picked up by adjustments of the large primary and the secondary dials and fine adjustments made later on the small primary dial.

When longer wave lengths are to be received, as from 500 to 2,400 meters, the D-P-D-T switch should be thrown to the "Long" position. This makes no changes in the primary circuit, but disconnects the secondary coil, which in this set is most useful only at short wave lengths, and connects the circuits as shown in the second print. As the secondary coil is not in circuit, only the two primary dials are effective in tuning.

Long wave signals should be picked up only by adjustment of the large primary dial and fine adjustments made later only on the small primary dial.

RECEIVING SET, TYPE D

This set is practically the duplicate of the type C, except that the number of studs in the three dials has been increased so as to give finer tuning.

TRACTOR SETS

The Signal Corps has designed and built two sizes of automobile radio sets, or tractor sets, as they are called—(*a*) a "divisional" tractor of 1 k. w. size; (*b*) an "Army" tractor of 2 k. w. size.

The 1 k. w. set, complete with supplies and detachment of seven men, weighs about 6,700 pounds, and on an average road is capable of making a speed of from 20 to 25 miles per hour. It carries a 60-foot sectional mast, which can be raised in a few minutes by means of guides on the roof of the tractor. The antenna is of the umbrella type, with 16 radiating wires each 75 feet long. The counterpoise is likewise of the umbrella type, laid on the ground with 8 wires, each 75 feet long. The transmitting set is of the quenched-spark type, with inductively coupled circuits adjusted to radiate waves of 600, 800, 1,000, and 1,200 meters. The receiving set is of the statically

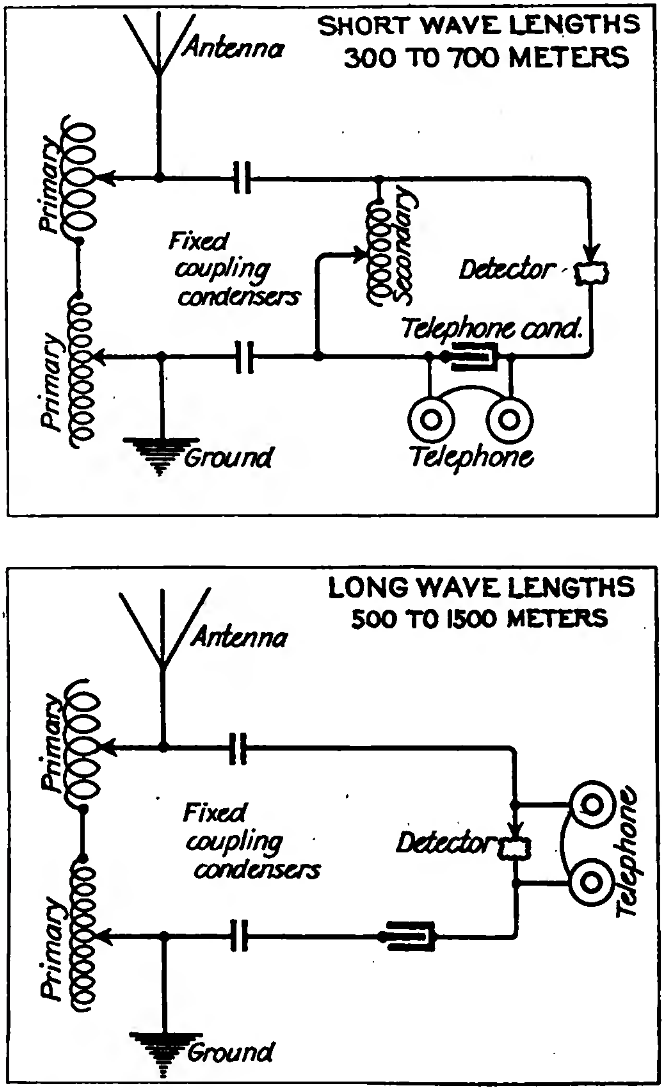


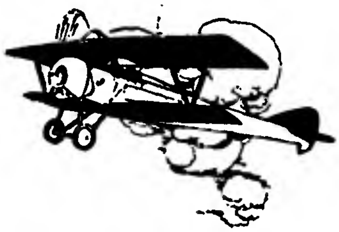
Figure 2—Type C Receiving Set. Diagrammatic circuit

coupled type similar to that in use in the 1915 radio pack sets, but of larger size and capable of reception of much longer wave lengths.

The 2 k. w. set, complete with supplies and detachment of eight men, weighs about 9,000 pounds, and on an average road is capable of making a speed of at least 15 miles per hour. It carries an 80-foot sectional mast, which is raised in a manner similar to that in the 1 k. w. set. The transmitting and receiving sets are likewise similar to those in the previous set, but capable of using much longer wave lengths.

How to Become an Aviator

The Seventh 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 careful student of this series has learned thus far the whys and wherefores of aeroplane design, i.e., the fundamental factors that make for flight efficiency. Thoroughly grounded in these principles, practical rigging of the machine may be turned to in full confidence of doing a good job. Reasonable familiarity with the use of simple tools but remains to be acquired; this is a short process of practice in their handling, the keystone of success being the exercise of care. If the preliminary study has been conscientious up to this point, the reason for each step in assembly will be clear without explanation and the requisite exactness will follow as a matter of course.

Golden Rules of Rigging

Don't hurry. If the job is a rush one, make haste slowly.

Never lay tools on the planes.

Pliers or wrenches are not for use on aeroplane bolts; a burred thread, or one damaged in any way, should be discarded.

Turnbuckles are to be started from both ends.

There should be a cotter pin for every nut and safety wires should lock all pins and turnbuckles.

Wire with a kink in it should be brought to the attention of some one in authority.

Don't hammer or pound bolts and pins into position; they must go into place by pushing or gentle tapping.

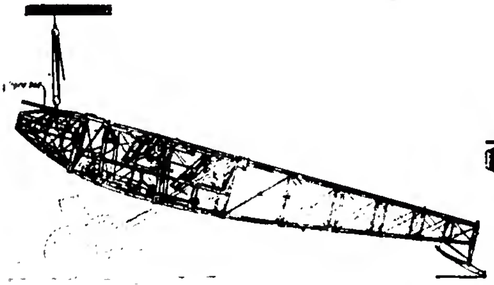


Figure 32-a—Method of attaching landing gear

Figure 32-b—Method of attaching horizontal stabilizer

ERECTION AND ASSEMBLY.

An assembled aeroplane is a trim and fairly hardy machine, but before assembly the parts are fragile. When received, the greatest care should be exercised in unpacking boxes and crates.

The order of assembly and directions follow:

Landing Gear—Mount the wheels on the axle and bolt them into place. Connect up the tail skid by pinning the front end to the spring fitting and the other end to the socket of the tail post. Now raise the fuselage to receive the landing gear. This may be accomplished by blocking, or by tackle as shown in Figure 32-a, where a line is passed under the sills of the engine bed —nowhere else—and caught by the hook of the hoisting block. Raise the front end of the fuselage until the lower clips of the longeron line up with the clips on the ends of the landing gear struts. The bolts are then passed through the aligned holes and the nuts drawn up tight. Cotter-pins are inserted in the holes drilled through the bolt, which then appear just beyond the castle of the nut. The leaves of the cotter-pins are turned backward, locking the nuts in place The gear should then be aligned in accordance with instructions on the second page following.

Horizontal Stabilizer—With the landing gear attached to the fuselage, elevate the tail of the machine, supporting it on a horse of proper height, or block until the upper longeron is level, verifying the arrangement by use of a spirit level placed on the upper longeron at the tail. See Figure 32-b. Bolt the horizontal stabilizer to the top longeron and tail post and draw all nuts tight and secure them with cotter-pins.

Vertical Stabilizer—Fasten the vertical stabilizer by bolting it through the forward part of the horizontal stabilizer and the clip at the front of the vertical stabilizer; tighten nuts and lock with cotter-pins. A double clip in the rear passes over the two bolts which fasten the horizontal stabilizer to the tail post. Attach the flexible wire cables and tighten by the turnbuckles.

Rudder—Attach the control braces so that the upper tips point toward the line of the hinge. Mount the rudder on the tail post and vertical stabilizer and insert the pins in the hinges, securing them with cotter-pins.

Elevators—Attach the control braces in the same manner as with the rudder and mount the elevators on the horizontal stabilizer by means of the hinges and pins, the latter being secured by insertion of cotter-pins in the holes drilled for that purpose.

(c) Committee on Public Information

Figure 33—Assembly of center section

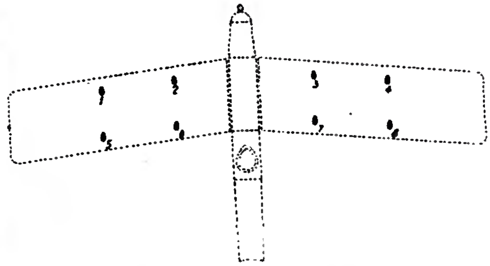


Figure 34—Curtiss strut numbering

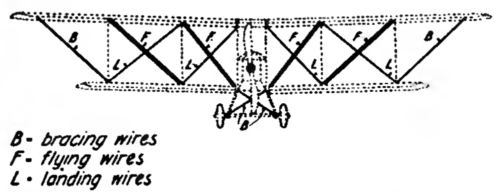


Figure 35—Method of wiring

ASSEMBLY OF LIFTING SURFACES

Center Section—The section of wing surface first attached is that which is directly over the fuselage and known as the engine section panel. With the struts fitted into the proper sockets of the wing surface, the entire section, with bracing wires attached is lifted and set into the sockets on the upper longeron. Bracing wires are then attached and the section aligned.

The method is clearly shown in the photograph, Figure 33

Main Wing Sections—While the upper lifting surfaces may be first assembled to the engine section and the lower wing then attached, it is preferable to complete assembly of the sections, or panels, before attaching them to the fuselage. The advantage of the latter method is that less adjustment is required and the correct stagger and dihedral is secured.

Figure 34 shows the numbering of struts on the Curtiss JN-4. These may be quickly committed to memory by noting that the four struts of the center, or engine section panel are not designated, and that beginning at the left from the pilot's seat, the eight remaining struts are numbered from 1 to 8.

The main struts bear a number and can easily be read from the pilot's seat; it is therefore at once evident if, through error, a strut is inverted.

Assembly—The upper wing of the left lifting surface receives struts Nos. 1 and 2 in the proper sockets. The wires are then connected to right and left by clips and adjusted by turnbuckle until the spars are straight. The wing is then set on a cushioned block, leading edge down.

The lower left wing is then brought, leading edge resting on cushioned block, to a space equal to the length of the struts. Diagonal wires are loosely connected and the spars inserted in their sockets, 5 and 6, and bolted into place.

The "landing," or single, wires and the "flying," or double, wires of struts 1 and 5 are then connected closely, so the wings may be held together while being attached to the fuselage.

Figure 35 clearly indicates the wiring of the assembled aeroplane wings.

The erection of the wing must be done with special care. Lifting by the struts or edges of the wings may result in a serious strain. Boards placed under the beams of the wing framework should be used for carrying.

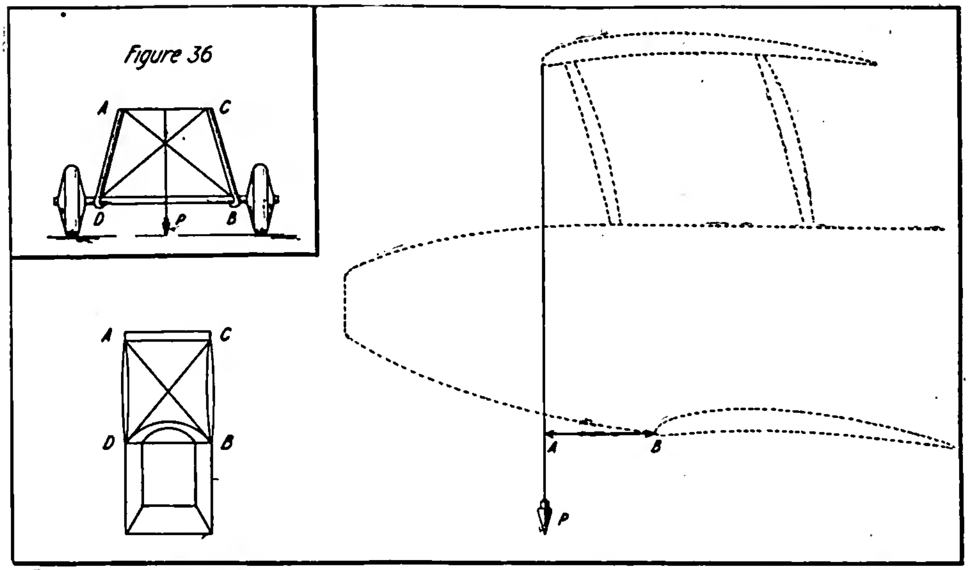


Figure 37a

Figure 37b—Stagger alignment

ALIGNING THE AEROPLANE

Correct alignment of an aeroplane is of tremendous importance. Its flying efficiency depends largely upon exactness in truing up all controls and wires and securing proper angle of incidence and dihedral. The parts should be aligned in regular order as follows:

Landing Gear—To be aligned before wings are attached to fuselage. The axle should be parallel with the lateral axis of the fuselage. Ascertain the exact center of the fuselage and the axle; with spirit level align the cross width of the fuselage. Drop a plumb line from the center of the fuselage and adjust the cross wires until it is in the exact center of the axle.

Or, if plumb bob and line are not available, adjust the cross wires so that the measurement **A-B** is exactly equal to the measurement **C-D** in Figure 36. The adjustment is made on both front and rear supports of the under carriage.

The landing gear and fuselage are aligned in the factory, but their correctness should be determined by the method just given. Before aligning, it is well to verify that the tail support still holds the fuselage horizontal.

Center Section—The bracing wires (**A-B, C-D,** Figure 37-a) are left sufficiently tightened to keep the struts straight, while the wings are being aligned.

Without Stagger—The upper longerons of the fuselage being horizontal, the struts are properly placed when they form a right angle. Adjust the sides first and then the front. Check the perpendicular alignment by measuring off an equal distance on the upper longeron back and forward of some point on the bottom of the strut; the strut will be exactly perpendicular when the distance from these two points to the top of the strut measures exactly the same. Tighten bracing wires evenly until sides and front are correctly aligned; i. e., until the measurement of corresponding points on cross wires are identical.

Staggered—The angle of strut fittings and sockets serves as a guide to the degree of stagger. The aeroplane's specifications state the stagger; for example in the Curtiss JN-4 it is 10⅝ inches. This is checked by a plumb line suspended from the leading edge of the top surface, as in Figure 37-b, and the measurement is taken between points A-B; that is, the plumb line should be 10⅝ inches in advance of the leading edge of the lower wing.

In all types of aeroplanes the specifications state how the measurement should be taken (a) along the line of the chord, or (b) horizontally.

When the stagger is verified, the wires should be tightened and the cross distances measured until one side corresponds exactly with the other. Side wires should be adjusted first, and then the front, and cross distances measured until they correspond exactly.

Main Wing Sections—The first point to determine is whether leading edges of the upper and lower wing surfaces are exactly in line with the center section. Standing on a step ladder, 15 feet to one side, a sight by eye is taken along the leading edge of the upper plane. If not straight, the adjustment for warp or bow is made by tightening or loosening the front landing wires. The same should then be done for the lower plane and the opposite wing aligned in the same manner. When the cross wire adjustments have been completed, a sight taken from both ends of the wings should show all struts in line and parallel with the center section struts.

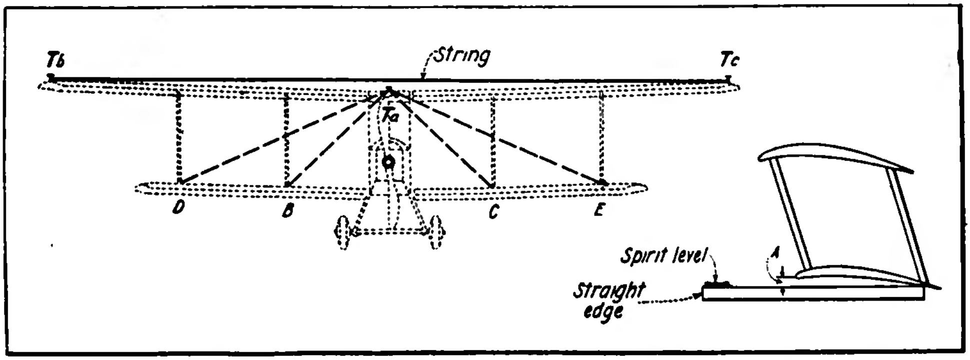


Figure 38—Dihedral angle measurements *Figure 39—Angle of incidence*

DIHEDRAL ANGLE

One method of securing the dihedral angle is shown in Figure 38, where **Ta** is a tack placed in the exact center of the center section, on the leading edge of the upper wing. The exact distance is measured off then on each side and tacks, **Tb, Tc,** placed in the leading edge of both upper wings, at a point near their tips. A string is stretched tightly between **Tb** and **Tc**. The specifications are then referred to and the dihedral angle checked. Assuming the dihedral angle to be 176 degrees, then each wing has been raised 2 degrees. The natural sine of 2° being 0.0349, this, multiplied by the distance between **Tb** and **Ta** (or **Ta** and **Tc**) gives the proper distance between **Ta** and the string directly above it.

Example:

The distance **Tb-Ta** (or **Ta-Tc**) is 16 feet=192 inches.

192 in.×0.0349=6.7 in., or the proper distance between **Ta** and the string above, if wings are set at the proper dihedral.

In making the alignment, the wings should be raised equally until the correct measurement over the center section is secured. Care should be taken that the leading edges are kept straight.

All adjustments should be made by altering the wires from the inside bays; when diagonal wires are to be tightened make sure that the opposite wires in the same bay are slackened off.

Check up the alignment by measuring (Figure 38) from **Ta** successively to points **D, B, C, E,** making certain that the distance **Ta-B** corresponds with **Ta-C,** and **Ta-D** is the same as **Ta-E.** This will show that both wings are the same height.

ANGLE OF INCIDENCE

The specifications give a set measurement for the angle of incidence. Verify the horizontal position of the top longeron of the fuselage, i. e., make certain that the aeroplane is in flying position. Then place the straight-edge underneath the center of a rear strut as shown in Figure 39. With a spirit-level, adjust the straight-edge to horizontal position. Refer to the specifications and note the set measurement given; this will require measurement from

A—the lowest part of the leading edge to top of the straight-edge, or
B—the center of the front strut to the top of the straight-edge.

This measurement must be repeated under every strut, or the lower surface where struts occur.

The measurement should not be made between struts, because the wings may be slightly warped.

If the angle is too great:

Slacken all the wires attached to the top of the rear strut and tighten all the wires attached to the bottom.

If the angle is too small:

Slacken all wires attached to the bottom of the strut and tighten all wires attached to the top.

The correct adjustment, laid down in the specifications, should be made with no greater variation than 1-16 inch. The measurements at all struts must agree, i. e., the angle of incidence all along the wing must be the same, unless the wings have a washout or washin.

Check up the stagger with a plumb line to see that it has not been disturbed while securing the dihedral.

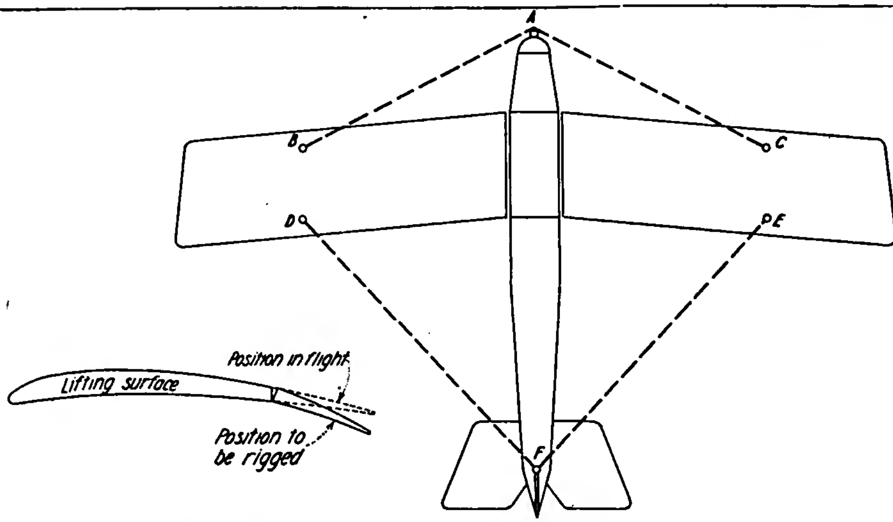


Figure 40—Aileron rigging

Figure 41—Over-all check

DROOP

When the angle of incidence and the stagger have been adjusted, one wing must be slightly drooped to correct for the torque of the propeller, where a single propeller is used in tractor aeroplanes.

With a propeller that turns to the right (clockwise) the left wing is drooped. If it turns to the left the right wing is drooped.

For machines up to 100 horsepower, the outer rear landing wire of the wing which is to be drooped is slackened until the trailing edge between outer and intermediate struts is about 1 inch lower than the rest of the trailing edge.

CONTROLLING SURFACES

Since the pilot depends upon the manipulation of controlling surfaces to manage his aeroplane, exceptional care should be taken that ailerons, elevator and rudder are properly rigged.

Ailerons, Trailing Edge (wing flaps)—With the control levers rigidly blocked into neutral position, the aileron should be rigged so its trailing edge is about ¾ inch below the trailing edge of the surface to which it is attached. In flight the angle of incidence of the surface will cause it to lift a little above the position, or to the true line. This is illustrated in Figure 40 where the dotted outline shows the position during flight.

A basis of measurement commonly used is ½ inch depression for every 18 inches of chord of the controlling surface.

Tail Stabilizer—With the weight of the tail supported by the tail skid, align the rear edge of the stabilizer so it is straight and parallel with the lateral axis of the aeroplane. Take a sight from the rear to the leading edge of the upper plane, which should be in alignment with the trailing edge of the stabilizer. Tighten the wires by turnbuckles.

Elevator Flaps—With the controls in neutral position adjust the control wires by turnbuckles until the elevator flaps are in the same plane, and sufficiently tight to eliminate lost motion.

Rudder—Adjust the control wires by turnbuckle until both foot bar and rudder in neutral position show no lost motion in control.

Over-All Adjustments—Figure 41 illustrates the measurements which are taken as a final check. The measurement **A-B** must equal **A-C** within ⅛ inch. Point **A** is the center of the propeller (in pusher types, the center of the nacelle) and **B** and **C** are points marked on the outer spars equally distant from the butts of the spars. The measurement should be taken from both top and bottom on each side.

D-F should equal **E-F**, within ⅛ inch. The rudder post is point **F**, and **D** and **E** are points on the rear struts marked as in the case of **B** and **C**. Two measurements, top and bottom, are also taken here.

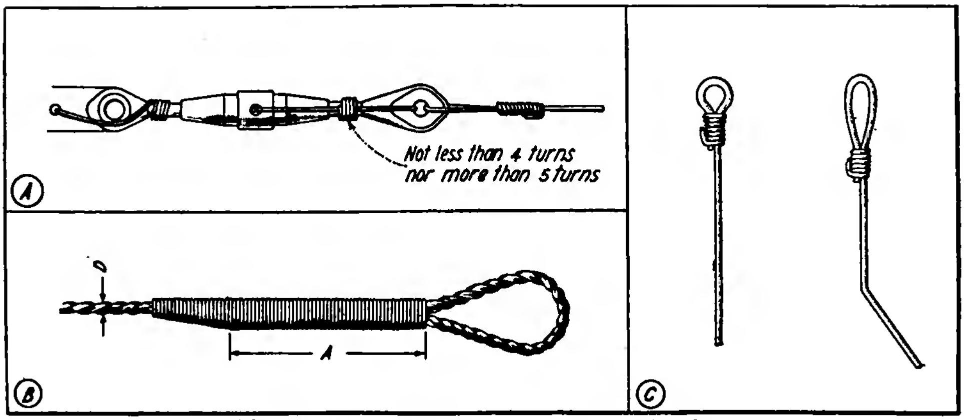


Figure 42—Turnbuckles, cables and wire loops

CONTROL CABLES AND WIRES

Adjustment of Controls—From the pilot's seat move the control levers and note if a quick movement shows lag or snatch in the movement of the control surfaces. Movement of ⅛ inch to either side should produce corresponding motion of the controlling surfaces.

Turnbuckles—The turnbuckle, which is shown in Figure 42-a, is a barrel with an eye-bolt screwed into each end; it is therefore hollow and should not be turned with pliers. It is best adjusted by passing a piece of wire through the hole in the center and using it as a lever. The illustration shows the proper method of using the locking wire, so the barrel may not turn and thereby throw the aeroplane wires out of the fine adjustments required.

Cables—Windings must be even with a stream-lined effect at the end of the winding as shown in Figure 42b. The dimensions of the winding before it tapers off (see **A,** in the illustration) must be at least 15 times as great as **D,** the diameter of the cable. Only non-acid flux should be used in soldering.

Correct Winding for Cables

Size of Cable Inches	Length of winding Inches	Breaking Strength Pounds
1-32	1½	185
1-16	1½	500
3-32	1½	1,100
7-64	1¾	1,600
⅛	2	2,100
5-32	2⅛	3,200
3-16	3	5,500*
7-32	3⅛	6,100
¼	3⅞	8,000
5-16	4¼	12,500

*For cable: loop strength is 5,100 pounds.

Control cables wear and fray out by friction with pulleys; careful examination should be made after each flight, and if a single strand is broken the cable should be replaced.

WIRE LOOPS

Wherever a loop is made with wire to connect with a fitting or turnbuckle it should be symmetrical in shape and reasonably small, with well defined shoulders A loop properly made is shown at the left of Figure 42-c, and one improperly made at the right. Where the shoulder is not properly made and the loop elongated the ferrule is likely to slip up and throw the wire out of adjustment.

When the loop is finished the wire should be undamaged. Wire bent to the degree shown at the lower end of Figure 42-c should be discarded.

TIGHTENING WIRES

Care must be exercised that wires are not too tight or extra loads will be placed on spars and struts. Wires should never be at a tension so they "sing."

THE EFFECT IN FLIGHT OF ALIGNMENT ERRORS

DIRECTIONAL STABILITY

Wrong Angle of Incidence—The aeroplane will turn toward one side if the angle of incidence of one side of the wing surface or tail surface is wrong; for drift increases with greater angle and decreases with lessened angle.

Fuselage, Rudder-fin or Struts Off Line of Direction of Flight—The aeroplane will turn off its course, for unless these are aligned they will act as a rudder.

Distorted Surfaces—The aeroplane will turn off its course if there is an improper bend in leading or trailing edge or spars, for the amount of drift will be changed on one side by increased resistance.

LATERAL INSTABILITY

Wrong Angle of Incidence—If the angle of one wing is greater, more lift will be produced on that side, with corresponding decrease on the other wing. The aeroplane's tendency will then be to fly one wing down.

Distorted Surfaces—The same tendency to fly one wing down will be observed when the camber of the wing surfaces is spoiled by some distortion, through which the lift is made unequal.

LONGITUDINAL INSTABILITY

Wrong Angle of Incidence—If the lifting surface angle is too great the nose will rise through excess of lift and a tendency to fly tail down will result. Too small an angle may cause the aeroplane to fly nose down.

Occasionally, the tail plane's angle of incidence is found to be wrong; the angle should be lessened if the aeroplane is nosing down, and increased if tail-heavy. Adjustments of this kind must be made with care, because longitudinal stability depends entirely on the tail-plane having less angle than the main lifting surfaces.

Fuselage Warped—For the reason given above, a fuselage warped up or down, thereby giving an incorrect angle of incidence to the tail plane, may result in the aeroplane nosing down or being tail heavy.

Wrong Stagger—A nose-heavy aeroplane will result if the top wing is not staggered forward to the correct degree, because the lift will then be too far back. An error of ¼ inch will make a material difference in longitudinal stability. The cause of such error is generally due to the elongation of wire loops or if wires have pulled the fittings into the wood.

FLIGHT DEFECTS

POOR CLIMB

Excepting engine and propeller trouble, the reason for an aeroplane climbing badly is generally due to (1) too small angle of incidence; (2) distorted surfaces.

LESSENED SPEED

Excepting engine and propeller trouble, poor flight speed is generally due to (1) too great angle of incidence; (2) distorted surfaces; (3) skin-friction, from dirt or mud on surfaces.

POOR CONTROL

The main causes are (1) incorrect setting of control surfaces; (2) distortion of control surfaces; (3) control cables badly tensioned.

UNCONTROLLABLE ON GROUND

When an aeroplane will not "taxi" straight the fault is generally due to (1) improper alignment of landing gear, wobbly wheels, or (2) unequal tension of shock absorbers.

The eighth article of this series, which will appear in the March issue, will describe propeller design and maintenance of air-screw efficiency; the aviation engine's principles of operation and its fundamentals of design, including a description of parts and their function in supplying motive power.

Wartime Wireless Instruction

A Practical Course for Radio Operators

ARTICLE X

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

EDITOR'S NOTE—This is the tenth 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.

CONTINUOUS AND DISCONTINUOUS WAVES

(1) In general there are two systems of wireless transmission:

(1) The discontinuous wave system,
(2) The continuous wave system.

(2) **Discontinuous waves** are used almost exclusively for ship to ship and ship to shore communication.

(3) **Continuous and discontinuous waves** are employed for transmission at **high** power.

(4) Continuous wave transmitters have had some slight use aboard vessels, but in general they require an antenna of very large dimensions which only can be erected on very large vessels. It is possible, however, that the vacuum tube oscillators at some future date may be employed to generate continuous waves at the shorter wave lengths say between 600 and 1,000 meters.*

WAVE LENGTH CHANGING SWITCH

(1) It facilitates the transmission of wireless telegraph traffic to provide the transmitter with a specially constructed switch whereby the operator may change instantly the **length of the radiated wave** without going through a series of connections and disconnections in the various circuits. In earlier wireless systems, if the transmitter, for example, was adjusted to 600 meters, in order to radiate a 300 meter wave, the operator was required to

(1) cut out turns at the aerial tuning inductance;
(2) cut out turns at the secondary winding of the oscillation transformer;
(3) disconnect the jumper around the short wave condenser;
(4) reduce the inductance or perhaps the capacity in the closed circuit;
(5) readjust the spark gap voltage for clearer tones;
(6) insert a reactance coil in the primary circuit of the high voltage transformer;
(7) change the coupling between the primary and secondary windings (for maximum antenna current).

(2) With modern Marconi transmitters all of the foregoing changes are effected simultaneously by the simple throwing of a specially constructed switch.

(3) **Commercial marine transmitters** are generally designed to radiate three standard wave lengths,—300, 450, and 600 meters; but obviously, they can be provided with any number of wave lengths. Sets have been constructed to date for the radiation of six and eight different wave lengths.

(4) The advantage derived from this arrangement in practice lies in the fact that if the receiving experimenter is interfered with by another station he may request the transmitting operator to change instantly to another wave length. Thus, the transmitting operator may change the wave length several times during the transmission of a single message, notifying the receiving operator by a special signal in order that he may change the tuning of the receiving apparatus. Traffic may thus be dispatched through severe interference.

(5) A diagram showing the functions of the wave length changing switch in Marconi panel transmitters is shown in Figure 92. Figure 91 is a fundamental wiring diagram which in a general way covers the circuits of any transmitting apparatus for the production of damped oscillations.

*Continuous wave systems will be treated in detail further on.

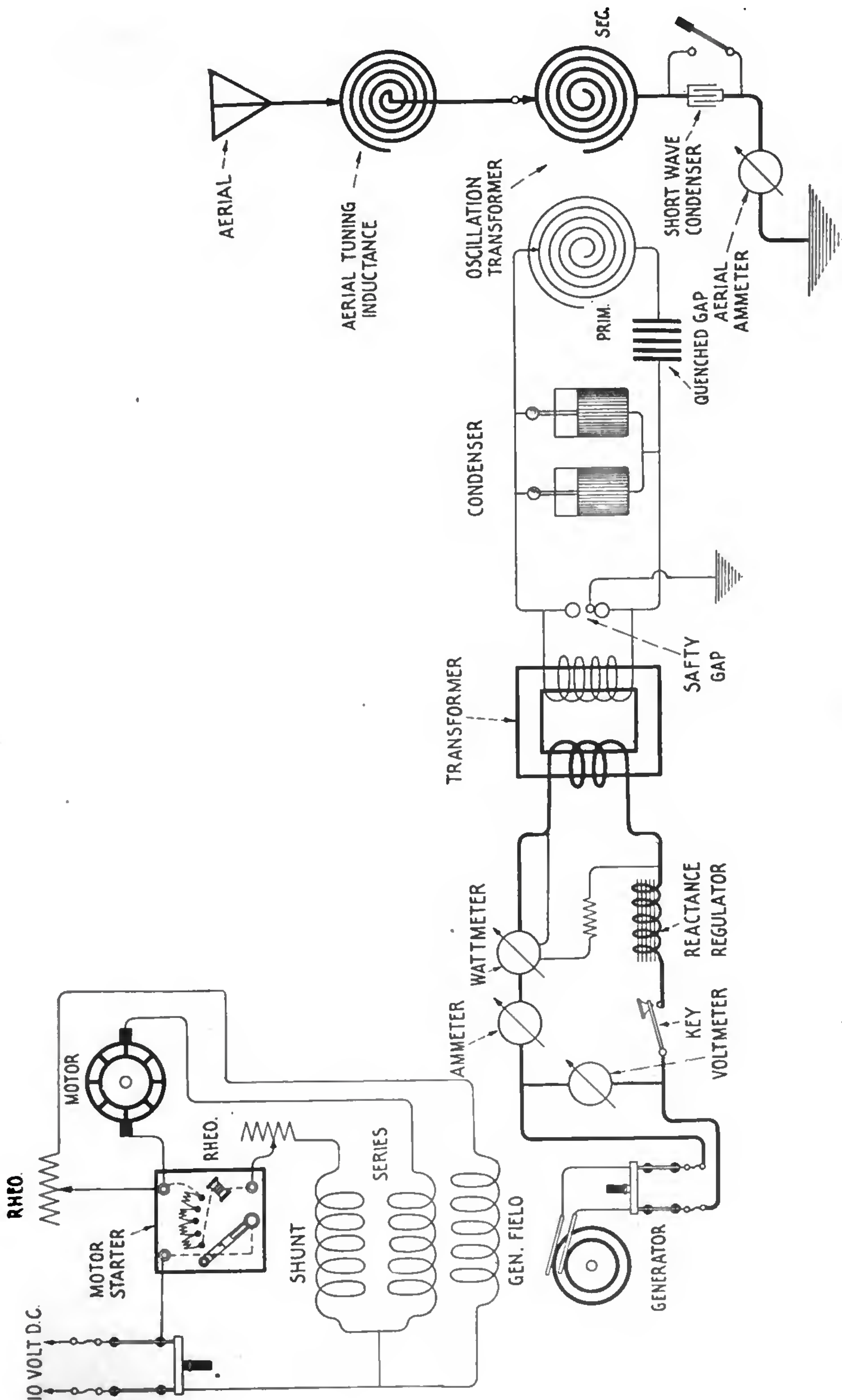

AERIAL
AERIAL TUNING INDUCTANCE
SEC.
OSCILLATION TRANSFORMER
PRIM.
SHORT WAVE CONDENSER
AERIAL AMMETER
QUENCHED GAP
CONDENSER
SAFTY GAP
TRANSFORMER
WATTMETER
REACTANCE REGULATOR
AMMETER
KEY
VOLTMETER
MOTOR
RHEO.
SERIES
SHUNT
GEN. FIELD
GENERATOR
RHEO.
MOTOR STARTER
110 VOLT D.C.

Figure 91

OBJECT OF THE DIAGRAM

(1) To show the fundamental circuits of a spark transmitter for the production of damped oscillations.

DESCRIPTION OF THE DRAWING

The complete transmitting set shown in figure 91 consists of the following apparatus:

(1) A motor generator to convert direct current to alternating current;

(2) A starting box to regulate the flow of current through the motor armature during the starting period;

(3) Field rheostats to regulate the frequency and the voltage of the generator;

(4) A step-up transformer to raise the voltage of the alternating current to a value in excess of 10,000 volts;

(5) An ammeter to measure the current flowing through the transformer;

(6) A voltmeter to measure the voltage at the terminals of the alternator;

(7) A wattmeter to measure the power input to the transformer;

(8) A reactance regulator to regulate the flow of current through the primary winding of the transformer;

(9) A telegraph key to permit the current to be interrupted in the form of the dots and dashes of the Morse code;

(10) A battery of condensers for the production of radio-frequent oscillations;

(11) A spark discharge gap to discharge the energy stored up in the condenser;

(12) An oscillation transformer to transfer current at radio-frequencies from the condenser circuit to the aerial circuit;

(13) An aerial ammeter to determine conditions of resonance between the condenser circuit and the aerial circuit;

(14) A short wave condenser to decrease the wave length of the antenna circuit;

(15) An aerial tuning inductance to increase the wave length of the antenna circuit;

(16) An aerial changeover switch to shift the aerial alternately from the transmitting apparatus to the receiving apparatus;

(17) An aerial to radiate energy in the form of electromagnetic waves.

OPERATION

The apparatus shown in Figure 91 functions as follows: Direct current at pressure of 110 volts enters the motor armature at the starting box setting the motor into rotation. The alternator, in turn, generates alternating current at pressures varying from 110 to 500 volts and at frequencies varying from 60 to 500 cycles according to the design of the machine.

When the telegraph key is closed, alternating current flows from the generator through the primary winding of the high voltage transformer. The flux generated by the primary coil cuts through the secondary coil inducing therein current at pressures varying from 8,000 to 25,000 volts (commercial practice), according to the ratio of the secondary and primary turns.

The frequency of the generator can be adjusted within certain limits by means of the motor field rheostat. If resistance is added at the motor field rheostat, the motor increases its speed and accordingly the frequency of the generator increases. This increase of speed also increases the voltage of the alternator. The voltage of the alternator can be reduced by adding resistance at the generator field rheostat. By cutting out resistance at the generator field rheostat a stronger magnetic field will result and the voltage of the generator will increase.

The terminals of the secondary winding of the high voltage transformer are connected to the terminals of a battery of condensers in which the energy is stored up temporarily in the form of an electrostatic field. When the charge for each alternation of the charging current has attained its maximum value the condenser discharges across the spark gap through the primary winding of the oscillation transformer. This discharge consists of a number of oscillations of radio-frequency.

The frequency of the oscillations can be changed as follows:

By subtracting turns at the primary winding of the oscillation transformer the frequency of the oscillations increases, or by adding turns at the primary winding of the oscillation transformer, the frequency of oscillation reduces to a lower figure.

A reduction of the capacity of the high voltage condenser increases the frequency of the oscillations, but an increase of capacity lowers their frequency.

When the closed circuit is set into electrical oscillation, it acts inductively on the secondary winding of the oscillation transformer setting up in the aerial wire currents of similar frequency, and a portion of their energy is radiated from the aerial in the form of electromagnetic waves. In a single wire aerial system, the wave length of the resulting wave motion is approximately 4.3 x the length of the oscillator, but in the case of a multiple wire aerial, the **natural frequency** of oscillation is determined from knowledge of its inductance and capacity.

The length of the radiated wave, in fact, varies inversely as the oscillation frequency. The higher frequencies such as 500,000 and 1,000,000 cycles per second correspond to waves 600 meters and 300 meters respectively. The lower frequencies of oscillation, for example, from 30,000 to 100,000 correspond to the longer waves from 10,000 meters down to 3,000 meters.

In order that the radiated wave may be detected at the receiving station there must be erected a receiving aerial fitted with tuning appliances to adjust it to resonance with the **natural frequency of the transmitter aerial.** Then, by means of proper oscillation detectors (of which there are various types), these high frequency currents are converted into currents of audiofrequency suitable for response in a receiving telephone.

By interrupting this wave motion to imitate the dots and dashes of the telegraph code, the radiated energy will act inductively at intervals upon the receiver aerial and corresponding currents will flow in the tuning circuits of the receiver.

The action of the transmitter upon the receiver can best be explained by citing a particular case. Assume a transmitter at the sending station of the 500 cycle synchronous spark type, giving 1,000 sparks per second. During each spark discharge one group of radiofrequent oscillations is induced in the transmitter aerial and each group consists of from 25 to 100 complete cycles of current varying in number as the decrement of the aerial circuit. If the receiver aerial is adjusted to electrical resonance with the oscillations of the transmitter, 1,000 groups of radiofrequent oscillations will be induced therein per second and the diaphragm of the receiving telephone will give forth a single sound for each group. The tone of the transmitter spark is therefore faithfully reproduced at the receiving station.

The actual number of groups of oscillations radiated for a dot or a dash in the International code can be fairly well calculated. Assume that a dot requires 1/15 of a second, then it will be composed of 1/15 x 1,000 or 60 + sparks. In other words, sixty groups of oscillations. Assume that a dash requires 4/15 of a second. Then each dash will consist of $4/15 \times 1{,}000$ or approximately 250 sparks or 250 groups of oscillations. No matter how many oscillations a single spark comprises, the effect at the receiving station with the simple rectifying detectors is the production of a single sound from the telephone for each group. (A detailed explanation of the working of oscillation detectors and receiving circuits will be given further on.)

SPECIAL REMARKS

(1) It is important that the student know the values of inductance, capacity, voltage, frequency, power, etc., of a simple low power transmitter of the type used aboard ships.

(2) Take, for example, the Marconi 2 K. W. 500-cycle panel transmitter; the following data cover the principal measurements:

Motor Generator	**Motor—4.2 H.P.; 110 volts; speed 2,000 R.P.M.** **Generator—output 2 K.W.; voltage 380-110; frequency 500 cycles.**
Transformer	**Primary—voltage, 308-110.** **Secondary—voltage, 14,500.**
High Voltage Condenser	**Capacity—total, .012 microfarad** **Capacity—600 meter wave—6 jars in parallel (.012 microfarad).** **Capacity—450 meter wave—6 jars in parallel (.012 microfarad).** **Capacity—300 meter wave—3 jars in parallel (.006 microfarad).**
Spark Dischargers	**Quenched—15 plates; about 9 gaps actually used, depending upon power required.** **Rotary—30 sparking points.** **Spark frequency—either gap properly adjusted—1,000 sparks.**
Oscillation Transformer	**Type—spiral pancake.** **Maximum inductance—primary, about 10,000 centimeters (10 microhenries).** **Maximum inductance—secondary, 30,000 centimeters (30 microhenries).**
Aerial Tuning Inductance	**Type—spiral pancake** { **One, continuously variable.** **Other, plug type of inductance.**
Short Wave Condenser	**4 Leyden jars—.002 microfarad capacity; connected in series.** **Total Capacity—.0005 microfarad.**
Aerial Ammeter	**Thermo type—range 0-20 amperes.**
Aerial	**2, 4, 6, or 8 wires in parallel. Each wire consisting of 7 strands of No. 19 silicon bronze.** **Inductance—fair average, 70,000 centimeters (70 microhenries).** **Capacity—fair average, .001 microfarad.**

QUES.—In order to place a transmitting set of the foregoing type into working order, what adjustments must be undertaken? Give them in the order of their importance.

ANS.—(1) First start the motor generator by pulling over the handle of starting box. Regulate speed carefully by means of the motor field rheostat until the frequency of the alternator slightly exceeds 500 cycles. Then close the telegraph key.

(2) Cut in and out gaps at the quenched gap until the primary wattmeter shows normal power reading.

(3) Listen in on telephone connected to a wavemeter in inductive relation to the radio frequency circuits and adjust generator voltage until the spark note is fairly clear and does not fluctuate.

(4) Place secondary winding of the oscillation transformer in fairly close inductive relation to primary winding.

(5) Select five or six turns of the secondary inductance.

(6) Close key and note reading of the aerial ammeter.

(7) Vary inductance of the aerial tuning inductance until the ammeter gives a maximum reading.

(8) Vary the coupling of the oscillation transformer until maximum antenna current is secured.

(9) Then readjust the spark note by the generator field rheostat.

(10) Do not exceed normal power input. If a clear note cannot be secured except with excessive primary power, cut out one or two gaps and readjust voltage of the generator until the note is clear.

QUES.—What precaution must be taken by the operator in the adjustment of a transmitting set?

ANS.—No part of the high voltage radio frequency circuits should be touched by the operator while the spark is dicharging; a dangerous shock may result. Also, particular care must be taken that no part of the low voltage circuits are close enough to the high voltage radio frequency circuits to permit the high voltage current to discharge directly into them.

QUES.—How, without a head telephone or receiving set, can the spark note of a quenched gap be adjusted for the best pitch?

ANS.—Correct adjustment can be obtained by listening to the note of the brush discharge from the condenser which generally can be heard several feet from the set in a quiet room.

QUES.—Under what conditions is it necessary to insert the short wave condenser in series with the aerial circuit?

ANS.—The short wave condenser must be employed with the average ship's aerial to secure the wave length of 300 meters. In general, the natural wave length of a ship's aerial exceeds 300 meters.

QUES.—What is the function of the safety gap in the foregoing diagram?

ANS.—To protect the secondary winding of the high voltage transformer and the Leyden jars from puncture in event that too many gaps are cut in at the quenched gap.

QUES.—What is the function of the reactance regulator?

ANS.—The reactance regulator may be employed to place the low voltage primary circuit in resonance with the high voltage secondary circuit, but it is generally employed to reduce the primary power. For example, in Marconi 2 K.W. 500 cycle sets, when the condenser capacity is reduced from .012 to .006 microfarad, the primary reactance regulator must be cut in the circuit to prevent arcing at the spark gap, i.e., to prevent overloading the gap.

QUES.—Suppose that when the secondary winding of the oscillation transformer is placed in inductive relation to the primary winding, no reading of the aerial ammeter is obtained, what is the probable cause of this trouble?

ANS.—It may be due to lack of electrical resonance between the open and closed circuits, the ammeter may be at fault, or there may be a complete open circuit.

QUES.—How can a commercial operator determine when the frequency adjustment of the alternator is correct, for instance, at 500 cycles?

ANS.—The frequency of the alternator can be determined by a direct reading frequency meter or by measurement of the speed of the armature per second by means of a speed indicator. For example, if the armature by this measurement revolves at 2,400 revolutions per minute, or 40 per second, and the generator has 30 field poles, then the frequency $=40\times\frac{30}{2}=600$ cycles per second. Since the speed of the generator generally decreases slightly when the telegraph key is closed, it is customary to adjust the frequency of the alternator to approximately 550 cycles.

QUES.—What are the standard wave lengths employed aboard ship in commercial practice?

ANS.—Recent types of transmitting apparatus are designed to radiate waves 300, 450 and 600 meters in length.

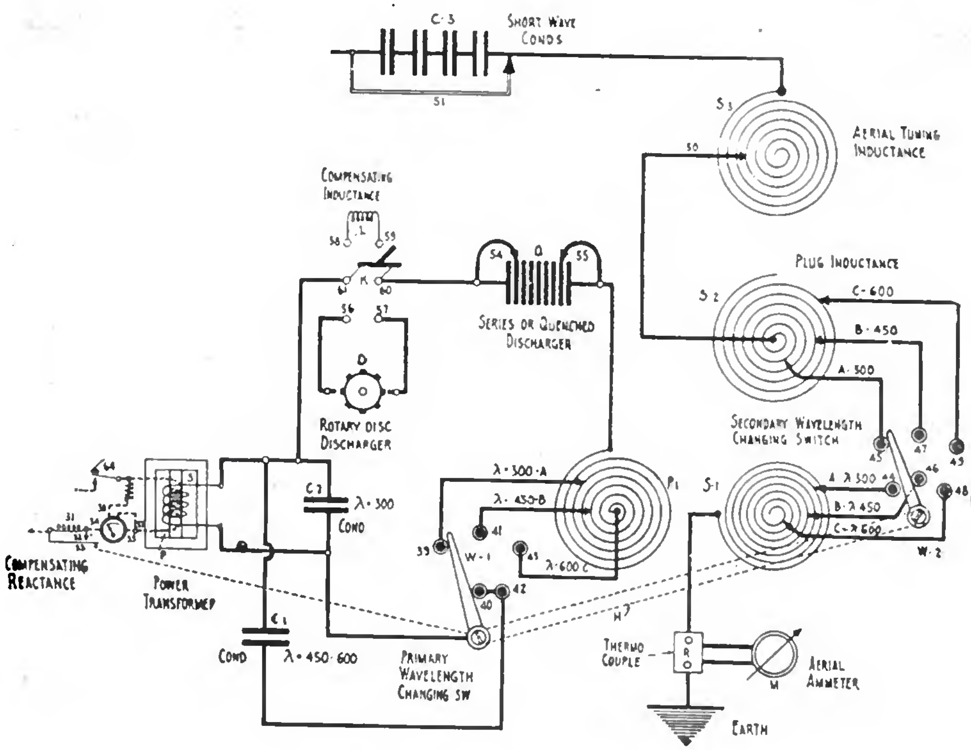


Figure 92

OBJECT OF THE DIAGRAM

To show the functioning of the wave length changing switch supplied with modern wireless transmitters.

PRINCIPLE

The length of the wave radiated by a wireless transmitter is generally changed within the station by means of variable inductances or variable condensers. By providing a special multi-point switch built in proximity to the radio frequency circuits, the required changes of inductance and capacity can be effected instantly.

DESCRIPTION OF THE DRAWING

In figure 92, the **closed oscillation circuit** of the transmitter includes condensers C-1 and C-2, C-2 being used for the 300 meter wave, and C-1 and C-2 in parallel for the 600 meter wave; also, the primary winding of the oscillation transformer P-1, the synchronous rotary spark discharger D, the quenched spark discharger Q, and the spark gap change-over switch K.

The **open or radiating circuit** includes the aerial tuning inductances S-3 and S-2, the former being **continuously variable**, and the latter **variable in steps** by flexible plug contacts; also, the secondary winding S-1, the aerial ammeter M, with the thermo couple R.

The **wave length changing switch** for the primary circuit is indicated at W-1, and for the secondary circuit at W-2. The blades of these switches operate conjointly, and by a mechanical attachment, contacts 32 and 33 which shunt a low frequency reactance coil 31, are opened and closed. When the switch is thrown to the 600 meter wave position reactance coil 31 is cut out of the primary circuit but for the 300 meter wave it is connected in the circuit, to reduce the secondary voltage. The secondary wave length changing switch, W-2, selects the proper values of inductance for the three standard wave lengths of 300, 450, and 600 meters.

OPERATION

To change from one wave length to the other, the transmitting operator throws the handle attached to W-1 and W-2 (not shown) to the wave length desired as shown by the indicator.

To place the rotary spark gap in commission, switch K is thrown downward to make contact with 56 and 57. The quenched spark gap Q is shunted out of the circuit by connecting together flexible contacts 54 and 55.

For use of the quenched discharger, switch K is thrown to contacts 58 and 59. The required number of gaps are cut in the circuit by means of flexible leads 54 and 55.

When switch blade W-1 makes contact with 39, switch blade W-2 simultaneously closes the circuit between 44 and 45. Then, if the jumper around short wave condenser C-3 is removed, the transmitter is connected to **radiate the 300 meter wave.**

For the **450 meter wave,** switch blades W-1 makes contact with points 40 and 41, which not only puts additional inductance in the primary coil P-1, but also connects condensers C-1 and C-2 in parallel. Simultaneously, contacts 32 and 33 shunting the compensating reactance 31 are closed, the set now operating at full power. At the same time contacts 46 and 47 are connected together.

For the 600 meter wave, the primary circuit is completed through 42 and 43, and the secondary circuit through 48 and 49.

The continuously variable inductance S-3 is generally set to include about 3½ or 4 turns for all three standard wave lengths, the additional inductance required for resonance being cut in at L-2. This permits the transmitting operator to compensate for slight losses of energy occasioned by the sagging of the wires (which de-tune the circuit).

SPECIAL REMARKS

(1) The closed oscillation circuit of a transmitter of this type is pre-calibrated by the manufacturer. The connections A, B, and C on the primary inductance are soldered in position permanently.

(2) A small compensating inductance, L, mounted between points 58 and 59 maintains the frequency of the closed circuit constant. The connections to the rotary and quenched gap are of unequal length. Hence, without this inductance, the taps on the primary coil would have to be changed for either gap.

QUES.—How is the apparatus shown in Figure 92 tuned to the standard wave lengths?

ANS.—By selecting the correct values of inductance in the secondary circuits so that by merely shifting the position of the switch blades, maximum antenna current is assured at all wave lengths.

QUES.—What is the relation of the primary and secondary coils in these sets?

ANS.—They remain in a fixed position, being separated no more than two or three inches. Provision is made whereby the coupling can be shifted mechanically during the tuning process, but when completed, the coils remain in a fixed position. The proper coupling for the maximum aerial current is secured by changing the self inductance of the secondary winding.

QUES.—Explain more in detail how the set is tuned?

ANS.—The process is more or less a cut and try method, but from the experience gained by tuning a few sets, the inspector can find the proper positions for the plug contacts of the antenna coils with little difficulty. Since the primary circuit is calibrated to standard wave lengths, a wave meter is not essential for tuning.

The first point to be considered is that we must obtain the maximum antenna current for each wave length. This only can be accomplished by tuning the primary and secondary circuits to resonance and by adjusting the coupling of the oscillation transformer until the aerial ammeter M indicates the maximum reading. Now, if the coupling of P-1 and S-1 had to be changed mechanically for each new wave length, another operation to the throwing of the wave length changing switch would be required. To avoid this, the best coupling for each wave length is found by cutting out turns at the inductance S-1 and inserting a similar amount of inductance at coil S-2 or S-3 until resonance is established.

The correct location of the inductance taps can be facilitated by changing the coupling mechanically to ascertain whether turns must be added or subtracted in the secondary.

QUES.—Explain more in detail how the positions of the taps on the antenna coil are found for a given wave length.

ANS.—The process is as follows: Assume that the set is to be tuned to 600 meters. (1) Throw the wave length changing switch to the 600 meter position which insures, owing to the pre-calibration of the circuit, that the frequency of the primary oscillations corresponds to this wave length. (2) Then place the secondary winding S-1 in inductive relation to the primary winding. (3) Insert a few turns of this coil at point C. (4) Similarly insert two or three turns in the coil S-3 through the plug contact connected to point 49. (5) Turn the handle on the aerial tuning inductance S-1 either to the right or to the left until the ammeter indicates a maximum.

If the reading of the ammeter is maximum with all of the turns of inductance, S-3, cut in or cut out, exact resonance has not been established. In the former case, cut out turns at S-2 or S-1. In the latter case, do the reverse, i.e., add turns at S-1 or S-2. Then find such values at S-1 and S-2 that the maximum antenna current is secured with approximately three or three-and-a-half turns cut in at S-3.

Resonance is now established, but the operator is not assured that the maximum antenna current is secured.

QUES.—How can this be determined?

ANS.—By change of the coupling, i.e., by placing winding P-1 closer to or drawing it away from the secondary winding S-1. If placing winding S-1 closer to P-1 increases the antenna current, it indicates that the coupling previously adopted is not close enough for maximum antenna current. Hence, P-1 is drawn back to its normal position, (with separation of 2 or 3 inches) turns being added at S-1 and a corresponding reduction being made at S-2 until the reading of the ammeter becomes maximum.

QUES.—Should full power be used while the set is being tuned?

ANS.—In a 2 kw. set, for example, no more than 1 kw. should be drawn; since the antenna circuit is not in tune with the closed circuit an excess of current flows in the closed circuit which may over-heat the spark gap. After the correct values of inductance and capacity for the open and closed circuits are secured, the set should then be operated at normal power in order to ascertain if normal value of antenna current has been secured.

QUES.—Approximately what antenna current can be obtained with transmitters of various power?

ANS.—The value varies widely with the power of the transmitter and the constants of the antenna circuit. The average values to be expected from Marconi marine type of transmitters at the wave length of 600 meters follow:

	Antenna Current (Average)		
Power Rating	600 met.	450 met.	300 met.
2 kw. 500 cycle	12 to 17 amp.	9-13	3 to 5
½ kw. 500 cycle	5½ to 8	5-7	2 to 4½
½ kw. 120 cycle	5 to 7		1½ to 3
1 kw. 60 cycle	5 to 7		1½ to 3
2 kw. 240 cycle	5½ to 8		1½ to 3
¼ kw. 500 cycle	3 to 4		1 to 2

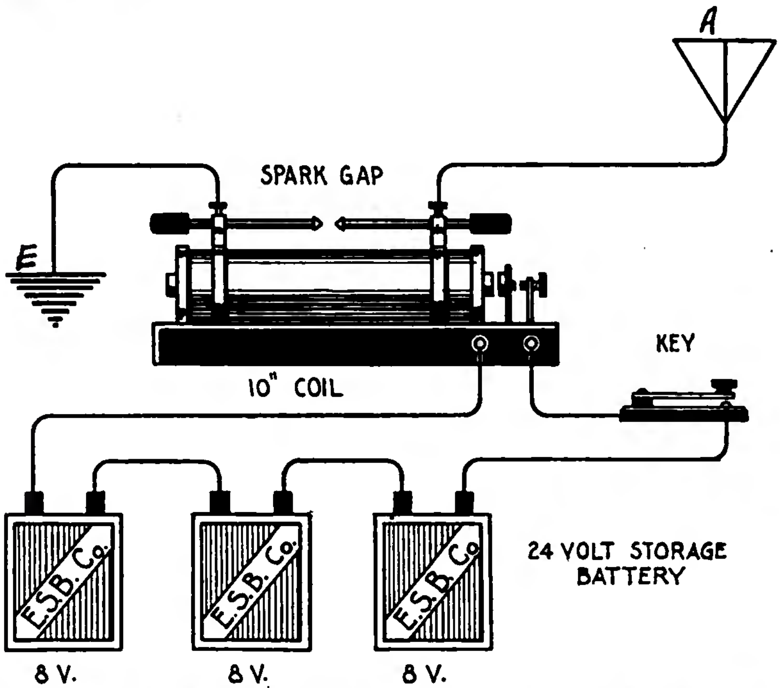


Figure 93—Showing the simplest possible type of wireless telegraph transmitter, popularly known as the "plain aerial" set. An induction coil giving secondary voltages without shunt capacity up to 100,000 volts is connected to a simple spark gap as shown. One electrode of the gap is connected to the earth and the other to the aerial wires. A storage battery of the capacity of 60 to 80 ampere hours and E.M.F. from 16 to 30 volts energizes the primary circuit through a magnetic interrupter mounted at the right-hand end of the base.

When the key is closed, the aerial is intermittently charged to a high potential and a succession of sparks discharge across the gap. Each spark consists of a few cycles of radio-frequency oscillations, the frequency being determined by the distributed inductance and capacity of the aerial, and the resistance of the spark gap. Each group of radio-frequency oscillations radiates a train of electromagnetic waves. If such an oscillator has no localized inductance at the base, the antenna oscillations are rapidly damped out resulting in the radiation of what is termed a "broad" wave. A few turns of localized inductance inserted at the base, however, reduces the damping to a value conforming with Government regulations.

(*To be continued.*)

MILITARY SIGNAL CODES

A Few Timely Observations on Army Practice With Recommendations for Consolidation and Simplification

By LIEUT.-COL. B. O. LENOIR, Signal Corps, U. S. Army

WHEN a man enlists in the Signal Corps, he is confronted with learning all the duties of a soldier—the drill, care of horses, and numerous other duties, and of course the profession of the signalist.

In civil life it requires several years to acquire the skill of the expert telegrapher, even when the mastery is the sole object to be attained. Natural talent is also required, for if it is lacking expertness will never be attained, i.e., the art of sending and receiving 30 to 45 words per minute without thinking about it, and turning out perfect copy without corrections. He who thinks is not an expert. There is no time for thought; fast telegraphing must be done after practice so long and constant that operation is entirely by intuition.

But in the Signal Corps, in addition to numerous duties, the recruit must learn four signal codes, or languages, i.e., the American Morse Code, the International Morse code, the General Service code, and the Semaphore code —quite a Herculean task if it is done properly. It is no wonder that civilian experts who carry on the signal business of 100,000,000 people and the press news of the country balk at the idea of being reduced to recruits in three additional signal languages!

Expertness exists in civil life because there is much practice and a concentration on a single code; similar tactics in the Army will be attended by similar results.

The common law signal language in the United States and Canada is the American Morse code, used by one-quarter million of the most expert signalists on earth, and there seems to be no reason why this common law signal language should not be adopted in the Army for all signaling. Advantage could then be taken of the expert talent that exists in the United States. This code should be an invariable standard for all signalists to follow; for every class of signaling can be done with the American Morse code. There is no reason to depart from it and lose the advantage of the best precedent, besides risking confusion by adopting something different.

Objections have been advanced as to why this can not be done. It is claimed that owing to the spaced letters it cannot be used in the Wig Wag or in the Ardois signal system.

As to the Wig Wag, nothing is more simple than to overcome this objection. In the early nineties, an attempt was made to adopt this code for all purposes. After several years practice it was abandoned on account of the mistake which was made in its adoption, i.e., the space in the spaced letters was shown by a motion to the front with the flag, being the same as at the end of a word; and in addition it was a motion hard to distinguish, owing to the fact that it was made by showing the edge of the flag to the observer.

The original adoption of this code itself showed the remedy; and had it been applied we would now be enjoying the consolidation and simplification which is so much desired. The remedy was this: The letter T was made with a quick motion to the left, which was a short dash, and the letter L was made by a motion to the left, pausing at the lowest point of the flag, which in fact made the long dash for L as it should be.

By applying this principle to the right, the objection of the spaced letters is entirely overcome. There are five spaced letters and the following shows how easily they can be signaled in a manner to show plainly the spaces in the spaced letters:

C, right, right pausing at lowest point of flag, right; equal to .. .
O, right pausing at lowest point of the flag, right; equal to . .
R, right pausing at lowest point of flag, right, right; equal to . ..
Y, right, right pausing at lowest point of flag, right, right; equal to .. ..
Z, right, right, right pausing lowest point of flag, right; equal to ... .

During the six years of adopting, the pause between T and L was very plain, and a mistake on this account was never made. There is every reason to believe the same success will be reached by applying the pause to the right to indicate the space, which space it is in fact, and is actually made by the pause.

The American Morse code can also be applied to the Ardois system of signals in a perfect manner by adding one more red light to the four red lights now in use, making five red lights and four white lights, or a total of nine lights as against eight lights now in use: The red lights would be arranged as follows in the Ardois system to show the spaced letters:

Total red lights	*C*	*O*	*R*	*Y*	*Z*
•	•	•	•	•	•
•	•			•	•
•					•
•			•	•	
•	•	•	•	•	•

It will be observed that the spaces in the spaced letters are actually shown; nothing could be plainer.

There appears no necessity in the Army to learn a foreign signal language to take the place of our American common law Morse signal language.

It has been thought by many that visual signaling, as it is so little used, requires little attention. The very fact that it is little used demands extraordinary attention.

A code much used, as is the American Morse code, requires no extra attention, as its constant use automatically makes efficiency a matter of course. But with a plurality of codes, the less each code can be used; confusion results and more care and attention are required. The efficiency of all kinds of signaling with those who have a gift for the art, is directly proportional to the amount of use given to it; while those with no talent, or with little practice, will never make efficient signalists, for neither will ever learn to read by intuition; nor will those with cares on their minds learn this degree of expertness; it must be learned before cares and responsibilities accrue. Once learned intuitively, however, it is never forgotten.

For the reason that no officer is free from cares and responsibilities, an officer, unless he is an expert before he obtains his commission, cannot be expected to be an expert signalist such as we find among professional signalists. By no means should an officer consider himself as a standard for others to follow in signaling, but he can use his rank and influence in holding men to the work when he studies the necessities that are required.

To be an expert telegrapher requires four or five years of constant and laborious practice; even with natural talent, as much time and talent are required as to pass through any college in the country, or to learn any of the other professions. Signaling must be done constantly to create intuition; there is no time to think or reason; he who has to think or reason is inexpert in the art. For these reasons it is dangerous to depart from the practice of the art as developed since the days of Professor Morse. The constant use of his code has developed a degree of efficiency, that cannot even be imagined by those who are not his ardent disciples. Some of the brightest minds in the country have passed through his school of practice, and his graduates are numbered among all the arts and sciences, professions and business. Some of the largest railroad systems in the counrty are run by them, and other large businesses are operated by those who have served as disciples of Morse. For this reason little attention should be given to the constant demand for changes from those new in the art, who seek a short cut to make efficient signalists; until a man has actually become an expert he should not be heard on the subject of changes.

The ideal signal language for the Army would be the American Morse code; it is as permanent as the English language, and should be no more changed than the English language. The American Morse code should be used in every branch of signaling; it should be the basic signal language, and the exception should be the use of the *European Morse code for communication with the Navy, which is only infrequently required, but this can be automatically provided for by paying the masters of the European code one dollar per month for this mastery—that is, when they are accomplished in both codes.

This arrangement will put the signal system of the Army on a rational basis, and in unison with the grand signal system of our country, instead of creating the European code as our standard. It will bring the Army to the people, or the people to the Army, whichever way one desires to look at it.

Now the question naturally arises, "What will be done with the Semaphore Code?"

The alleged use of this code is to provide for rapid short distance signals. After several years daily practice by 200 men under my command, and a close system of testing and timing, I will say that good readable signals can be made by experts at fifteen words per minute in wig wag and semaphore both. Occasionally, men can reach between twenty and twenty-five words per minute in both codes, but reliable visual signaling cannot be reached beyond, say, fifteen words per minute. At any greater speed there is danger of slur-

*Continental.

ring the signals and running them together; the result is unreliable, especially where hard words, or uncommon words, or code words are used.

Practically the same result can be obtained with the American Morse code, by getting away from an old habit, i.e., considering the two foot flag as the smallest flag that can be used.

Just adjust the Wig Wag medium to the distance: for long distance a large medium; for short distance a small medium. Remember that the longer the distance, the larger the medium and slower the motion must necessarily be; and the shorter the distance the smaller the medium that can be used and the more rapidly the signals can be made.

Long distance Wig Wag is expertness only for the eyesight. Although it impresses the casual observer, for signal efficiency it is a poor standard, as the signals are necessarily slow. For real Wig Wag signal efficiency, use a small medium at a short distance, using only one hand and a combination of the arm motion and the telegraphers wrist motion. He who can read these rapid short distance signals can read signals at any distance that he can see, for the greater the distance the greater the medium used, and necessarily the signals must be slower. Short distance wig wag signals thus made can be made by exceptional men up to twenty-five words per minute.

Applying these principles with 200 men for several years, using a thin, very light disk, of practically no weight, and about twenty inches long, it is found that the Wig Wag is practically as fast as the semaphore, and the necessity for learning a separate language only for rapid short distance signals vanishes, and thus paves the way for one code, i.e, the American Morse code, to be adopted as the basic signal language of America. Thus will the burden of signaling be very materially reduced, and the barrier of four signal languages that at present faces and discourages the signal student, will in a measure disappear. By centering on one code greater efficiency can be expected, and this expectation will most assuredly be realized.

By cultivating rapid short distance with the Wig Wag instead of the semaphore, using a small light medium that can easily and rapidly be operated with one hand, interest in the Army will at the same time also be created in telegraphy, by cultivating an interest in the American Morse code and prepare the learners for further advancement, not only in telegraphy, but indirectly for the radio as before outlined, by giving a small increased monthly compensation.

As Navy signaling has some slight connection with Army signaling, these same principles could be applied in the Navy, the semaphore abolished there, and the European Morse code used in the Navy for rapid short distance signals, and interest in the Navy Radio created direct, thus reducing the telegraphic code in the Navy to one code; while in the Army the European code should be the exception, and learned as previously outlined, the American Morse code being the basic signal language. In neither service does the Semaphore appear essential, but is, on the contrary, confusing.

Thus in the Army it is seen that two signal languages* are necessary, while in the Navy only one is necessary. It should be remembered that in both services the same rapid short distance Wig Wag signals can be used for long distances, by simply increasing the size of the signal medium used.

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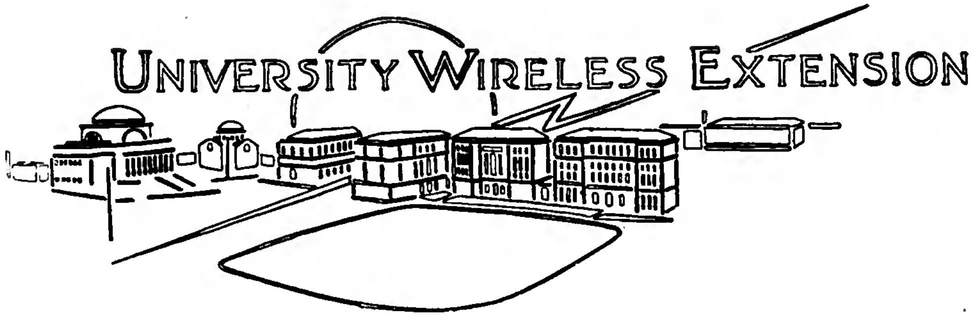
*American and European Morse only, abolishing the semaphore.



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 XIV

(i) **COMPARISON OF CONTROL SYSTEMS.** The choice of modulation control system will depend markedly on the output of the radiophone transmitter and, to a less degree, on the type of installation, i. e., ship or shore station, fixed or portable outfit.

For low-power sets, the placing of the microphone directly into the antenna (as illustrated in Figure 13) is a simple solution and one that is economical of apparatus. It is not, however, economical of energy since the microphone resistance for most efficient operation must be equal to that of the remainder of the radiating system. This condition necessarily involves the loss of half of the available radio frequency energy in the microphone. To some extent this loss may be avoided by the use of one of the circuits shown in Figure 119, whereby the microphone is more fully utilised in that the changes in its resistance vary a number of the electrical constants of the associated circuits and thus produce greater proportionate changes in the antenna current.

For moderate power sets, the difficulties in getting a suitable control system become quite serious. Large numbers of microphones in parallel are bulky and expensive, and tend to cause difficulty in adjustment. Heavy current microphones seldom give the highest quality of articulation and liquid microphones are not easy to build or to shield from disturbance. On shipboard their use is even less desirable than on land. It becomes necessary to use some type of control based on one-way amplifiers (such as the methods of the General Electric Company involving absorption in pliotrons as shown in Figures 163 and 164, and a number of allied methods) or else to use ferromagnetic amplifiers. These last should be so constructed that they are one-way devices so far as possible, in order that there shall be no induction of radio frequency currents in the control or microphone circuit.

For high power sets, direct microphone control is, of course, out of the question. Even the use of the normal vacuum tube amplifier in any of its modifications or modes of use seems of doubtful utility unless some very heavy output bulbs should be constructed in the future. The most feasible methods at present seem to be those involving the control of the outgoing energy by rugged ferromagnetic amplifiers. The control energy for these amplifiers may itself be obtained by the use of vacuum tube or of smaller ferromagnetic amplifiers. In other words, a composite system depending on the use of a rugged final amplifier is desired, its control energy being derived from a more delicate amplifier which can be actuated by the small amount of microphone energy actually available.

It may be here mentioned that the difficulties of the situation are considerably increased when it is desired to control the radiophone transmitter from an ordinary wire telephone line. The power available from an ordinary telephone line is of the order of microwatts. whereas the power derived directly from the transmitter may be 100 or 1,000 times as much. The difference must be made up in the former case by at least one audio frequency amplification.

8. ANTENNAS AND GROUND CONNECTIONS.

(a) **RADIATING SYSTEMS.** For transmission in radio telegraphy, much the same requirements must be met as in the case of a normal sustained wave telegraph station. That is, a high capacity antenna of low ohmic resistance

	WAVE LENGTH		
	1,600 m.	3,200 m.	6,400 m.
Ohmic Resistance of Antenna...	0.3	0.2	0.1
Ground Resistance.............	1.0	2.0	4.0
Radiation Resistance	1.0	0.25	0.06
Loading Coil Resistance........	0.3	1.2	4.8
Total Resistance...............	2.6	3.65	8.96
Antenna Current...............	19.6	16.6	10.6
Radiated Power (watts)........	385.	69.	7.
Radiation Efficiency (in per cent.)	39.	6.9	0.7

is desired. The radiation resistance should be the chief portion of the total antenna resistance else the efficiency of radiation may be very low. This can be well illustrated by the following numerical example:

Suppose an antenna to have an effective height of 40 meters (130 feet), and that 1 kilowatt is available for the antenna circuit. Suppose further that the antenna is used successively at wave-lengths of 1,600, 3,200, and 6,400 meters. In the table below are given values of the probable ohmic resistance of the antenna, its ground resistance, and its radiation resistance at each of the wave-lengths. These are calculated on the basis that the ohmic resistance increases as the frequency increases (i. e., as the wave-length diminishes), that the ground resistance diminishes almost inversely proportionately to the wave-length, and that the radiation resistance is inversely proportional to the *square* of the wave-length. The antenna current is then calculated from the total resistance, and the radiated energy and radiation efficiency in per cent. The resistance of antenna loading coils is omitted for simplicity; and this omission does not affect the nature of the results.

It is clear enough, everything else remaining the same, that the shortest wave-length (nearest to the antenna fundamental) would be by far the most suitable so far as radiation efficiency is concerned. However, the absorption of the electromagnetic waves in passing over the intervening country may partially or entirely nullify this difference, and thus it may occur that by day and for overland transmission the best wave would not be the 1,600 meter wave but possibly the 3,200 meter wave. For the case mentioned, with the relatively small antenna power available, the transmission could hardly be over a great enough distance to make the longest wave given the most desirable. In other words, in every case of day transmission, there will be some wave-length for which best results are obtained because a diminution of wave-length below this most favorable value, while it would increase the radiation efficiency, would more than correspondingly diminish the freedom from absorption in the intervening space.

In constructing antennas for radio telephony, all the usual precautions as to antenna insulation, ground resistance, freedom from neighboring energy-absorbing conductors and guy wires are observed. In addition, it should be remembered that it will be sometimes necessary to use a suitable coupling between the antenna and the radio frequency generator in order that the resistance which is thus, in effect, introduced into the generator circuit shall have the most favorable value for full generator output.

A "fly-wheel effect" similar to the "inertia effect" mentioned under "Causes of Distortion in Radio Telephony" may occur in the antenna circuit. If the persistency of the antenna system is very great, i. e., if the damping is very small, the wave trains in the antenna will tend to persist at full intensity and the difficulty in getting complete modulation may become excessive. As regards this feature, which is most prominent at long waves, there is a conflict between good antenna design in the usually accepted sense as indicated above, and the design indicated to avoid the fly-wheel effect. In general, however, the compromise will be satisfactory if the fly-wheel effect is practically disregarded, except for long waves and very persistent antennas.

(b) **RECEIVING SYSTEMS.** The same general considerations as hold for transmitting antennas also hold for receiving antennas except that smaller antennas will in general be used. This is because of the diminished expense, because of the large static charges which readily accumulate on large antennas, and because it is easy enough to amplify the signals received on a small antenna to satisfactory values. Of course, the fly-wheel effect mentioned previously may again occur in the tuning of sharply resonant radio frequency circuits, though the Author has not experienced much trouble on that score using waves of moderate length. The present tendency seems toward the use of small antennas with sensitive receiving sets and high amplification of some sort. It seems that the ratio of signal strength to stray intensity remains reasonably constant as the size of the antenna is diminished, at least when crystal detectors or detectors of the audion type are used. For the oscillating audion, Mr. Armstrong has pointed out that this is not necessarily the case, since the oscillating audion favors weak signals compared to heavy strays to a greater extent than does the plain audion. So that, unless the beat method is used for reception, radio telephonic reception may just as well be carried on on small antennas as on large.

9. RECEPTION PHENOMENA.

(a) DETECTOR AND AMPLIFIER TYPES. Almost all detectors have been used for radio telephony, and indeed all but the coherer type can be used. At the present time such detectors as the crystal rectifier, the audion, and the dynatron have proven to be practically usable and satisfactory. The detectors and amplifiers used in radio telephony should have a linear characteristic like that mentioned in connection with Figure 6. Otherwise there will be speech distortion of the types described in the discussion to which reference has been made. Both detectors and emplifiers should be of such sort that they are easily adjusted to maximum sensitiveness, retain this sensitiveness indefinitely, do not require frequent renewal, and are inexpensive. These requirements have not yet been entirely met.

(b) BEAT RECEPTION. Beat reception is possible in radio telephony, and there may be used for this purpose either the normal detector with an external oscillator circuit coupled to the receiving system to produce the beats or the so-called "self-excited heterodyne" where the same vacuum tube is used at once as an oscillator, detector, and amplifier. Generally speaking, this latter arrangement, while convenient in manipulation and economical of equipment, does not utilise to the full the various properties of the bulb and is less stable and certain of adjustment than the former.

It need hardly be said that for beat reception in radio telephony extreme constancy of frequency at the transmitting end is essential. This will be evident when it is considered that radiophone reception under these conditions requires either zero beats per second (that is, equality of frequency of the transmitter and of the local oscillator at the receiver) or a beat frequency above audibility (that is, a greater difference between the transmitter frequency and the local oscillator frequency than say 10,000 cycles per second). As a matter of fact, only the first of these expedients is practically usable since the detuning of the antenna and its associated circuits in the receiver for the second case would make the reception very inefficient except on extremely short waves where a difference of frequency of 10,000 or more cycles per second is only a small percentage of the main transmitter frequency. However, it must be admitted that zero beat frequency is usually not very easy to obtain or hold as a receiver adjustment and even slight variations in transmitter or receiver oscillation frequency will then cause a drummy quality to appear in the speech and seriously impair its intelligibility.

With radiophone transmitters employing alternators, or alternators and frequency changers, very perfect speed regulation will therefore be required if beat reception is to be used. For example, working at 6,000 meters wave-length (50,000 cycles per second), a much greater speed variation than one part in 10,000 would be objectionable; and if frequency multipliers were employed in conjunction with the alternator to get the 50,000 cycles per second, even greater accuracy would be necessary. When bulb radiophone transmitters are used, the filament currents and reactions on the oscillator must be kept quite constant else there will be changes in the emitted frequency even in this case, and beat reception will not be feasible.

(c) **SELECTIVITY IN RECEPTION.** There is a fairly sharp conflict between the requirement of loud signals and extreme selectivity. The first of these generally requires sensitive detectors and powerful amplifiers used with close coupling to the antenna system, while the second tends in the opposite directions. Nor does beat reception solve this problem as will be evident below. All that can be said is that a rational compromise must be effected in every case, this to be determined by the operating conditions in the neighborhood of the receiving station. Thus the amount of interference in the vicinity of the receiver is an extremely important factor in determining the amount of power required at the transmitter to cover the desired distance. This is a factor which is often overlooked in the design of stations.

There is also, particularly at long waves, a conflict between the extreme antenna persistance necessary for adequate selectivity in reception and the undesired fly-wheel effect which has been previously mentioned. This, again, must be met by compromise.

(d) **INTERFERENCE WITH RADIOPHONE RECEPTION.** Interference from spark stations disturbs radiophone reception less than might be expected, partly because the dots and dashes constitute a more or less intermittent disturbances through which portions of the words can be heard and partly because of the resulting "assistance of context" effect. Sustained wave station interference is, however, very serious since this causes a continuous musical note by the beats with the incoming radiophone frequency and this continuous musical note cannot be tuned out either by ordinary or beat reception being a physically present phenomenon caused by two frequencies *external* to the receiving station. In the neighborhood of a large arc radio telegraphic station, this may become a very grave matter particularly if compensation waves are used by the arc station in transmission. In this latter case, there will generally be produced a long series of overtones of both the sending and the compensation waves, and there is very likely to be continuous beat interference. The Author is very much of the opinion that radiation at non-useful frequencies should not be permitted since the growth of the radio art will be much hampered thereby. Furthermore, provision should be made in all sustained wave stations to avoid the production of these series of overtones, (which, it may be mentioned, are frequently not harmonics but fall at non-integral multiples of the main and useful frequency).

(e) **TELEPHONE RECEIVERS.** It might be expected that there would be no great difference between the various telephone receivers used in radio sets, so far as speech reception were concerned, but this is far from being the case. In addition to marked differences in intrinsic sensitiveness, the receivers show differences as to the extent to which they distort speech and the relative extent to which they respond to the sudden shocks caused by heavy strays. Generally speaking, the receivers with diaphragms of moderate thickness give good articulation, moderate sensitiveness, no inordinate response or "singing" when stray impulses are received, and are robust. More sensitive receivers with very light diaphragms tend to give "tinny" speech and more than proportionate response to impulses.

A number of other types of receivers besides the usual electromagnetic type have been suggested. Thus Messrs. Fessenden, and, later, Ort and Rieger have built electrostatic receivers. These are nothing more than a condenser one or both sets of plates of which are movable. The electrostatic forces developed as the difference of potential between the plates changes will cause minute movements of the plates and consequent sound. Sometimes an auxiliary potential is kept constantly on the plates and they are under considerable tension, this being found to increase the sensitiveness greatly. Such an arrangement, though it approaches the usual receiver in sensitiveness, is not particularly convenient and has not found favor in the commercial radio field.

Mr. Fessenden has further developed and used a receiver based on alternating current repulsion between two coils of wire each carrying the same current, or a current of nearly the same frequency. The construction of the device was simple. Two flat spirals of thin wire were placed parallel and near to each other, and the incoming current passed through both, or else through one of them with a locally generated radio frequency current passing through the other. While the device was operative, it did not find favor in the radio field, and is not used in practice at present.

(f) **RECEIVING APPARATUS.** The first receiver we shall consider is that shown in Figure 187. It is the usual audion used as a detector. Incoming radio frequency energy causes radio frequency potential differences at the terminals of the secondary tuning condenser C_1. Consequently alternating current tends to flow in the grid-to-filament circuit, C_1C_2GF. However, since the grid-to-filament has unidirectional conductivity only, the grid gradually accumulates a larger and larger negative charge, which charge cannot escape through L_1 to the filament because of the grid condenser C_2. In consequence of the increasingly negative potential of the grid, the

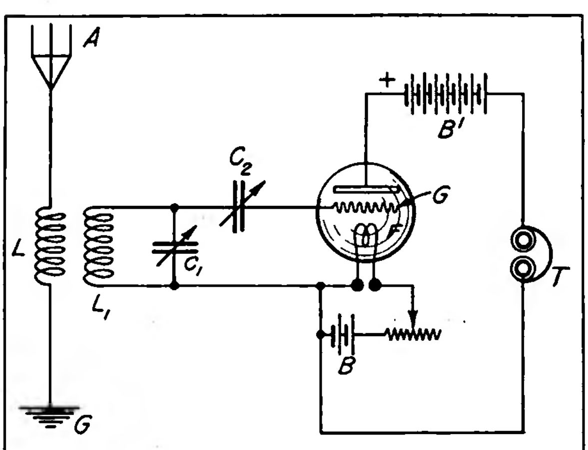


Figure 187—Normal audion receiver

current in the plate circuit diminishes. If the signals cease, the grid leakage (through the condenser C_2, through the glass supports of the grid, and because of any residual positive ionisation due to gas molecules in the space between the grid and filament) will speedily bring the grid potential back to normal and the plate current will then increase to its usual value. As a result of this action, variations in the incoming radio frequency currents, such as occur in radio telephony, will be approximately followed by changes in the plate current of the audion. A supplementary resistance may be shunted across the grid condenser so as to increase grid leakage and improve the fidelity of reproducton of speech in the plate circuit. This will generally diminish the audion sensitiveness. The resistance used in practice for this purpose are pencil lines, graphite rods, or liquids (e. g., xylol), and have values ranging from a few thousand ohms to several megohms.

As explained in connection with Figure 69, Mr. E. H. Armstrong has devised a number of methods of using the audion as a regenerative relay by coupling the plate and grid circuits. Such an arrangement adapted for telephonic reception and giving radio frequency amplification is represented in Figure 188. As will be seen, the grid circuit $L'C_1L_1$ is coupled to the plate circuit by means of the inductive coupling $L'L''$. Armstrong has found in bulbs used by him (high vacuum bulbs) that the regenerative amplificaton obtained was fifty-fold in energy or about 7 times in audibility (as audibility is usually defined, namely, as directly proportional to the current through the telephone receivers). It will be noted that the telephone T is shunted by the condenser C', the purpose of which is to permit the passage of the radio frequency current while forcing the audio frequency currents of the signal to pass through the receivers.

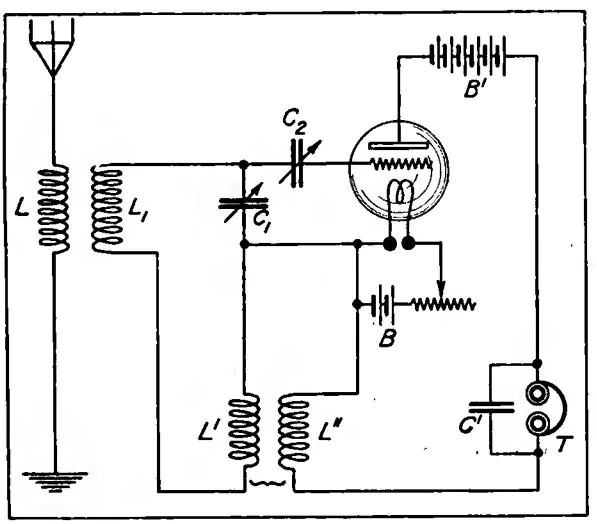


Figure 188—*Armstrong regenerative circuit for radio frequency amplification*

An improved arrangement, also due to Armstrong, is shown in Figure 189. Here, in addition to the regenerative coupling between the plate and grid circuits, we have tuning of the plate circuit by means of the inductance L_2 and the condenser C''. As before, the receivers T and the plate battery B' are shunted by the by-pass condenser C'. Another interesting modification is given in Figure 190. Here the coupling is secured by means of the large inductance L' and the capacity C_1. The details of this circuit together with the detailed explanations of the various circuits here outlined and similar circuits can be obtained in the "Proceedings of The Institute of Radio Engineers," for September, 1915. It need only be mentioned here that it is recommended that the inductances in the plate and grid circuits be large and the capacities small.

For the sake of completeness, we include here as Figure 191 the de Forest ultraudion circuit which has previously been explained in connection with Figure 76. The modified ultraudion circuit having grid and plate circuit coupling by means of the so-called "tickler coils" is shown and explained in connection with Figure 77.

The actual appearance of a de Forest assembled audion and ultraudion receiving set is indicated in Figure 192. The tubular audion is mounted at the left with its carbon sector potentiometer (for obtaining a continuously variable plate potential) to the right of the supporting socket. The bridging condenser and the stopping condenser (C' and C_2 respectively of Figure 191) are controlled by the switches below the bulb. The three top-row knobs control an antenna loading coil, a secondary loading coil, and a coupling between the primary (antenna) circuit and the secondary circuit. The two lower knobs control an antenna tuning condenser and the secondary circuit tuning condenser. It will be seen that a special switch is used in connection with the loading coils so as to avoid dead ends when using only a portion of each coil.

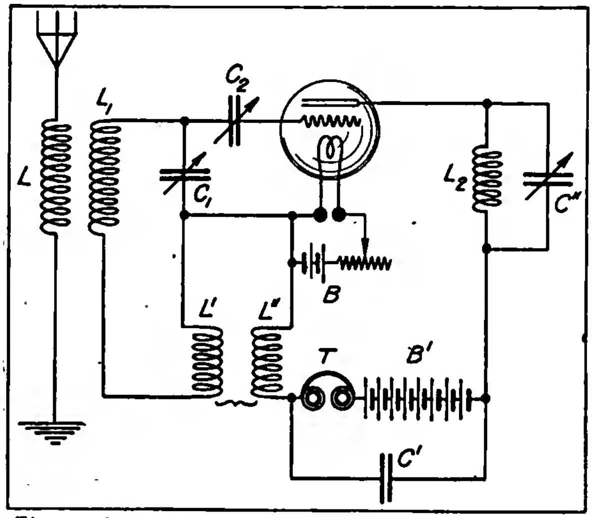


Figure 189—Armstrong regenerative circuit for radio frequency amplification with plate circuit tuning

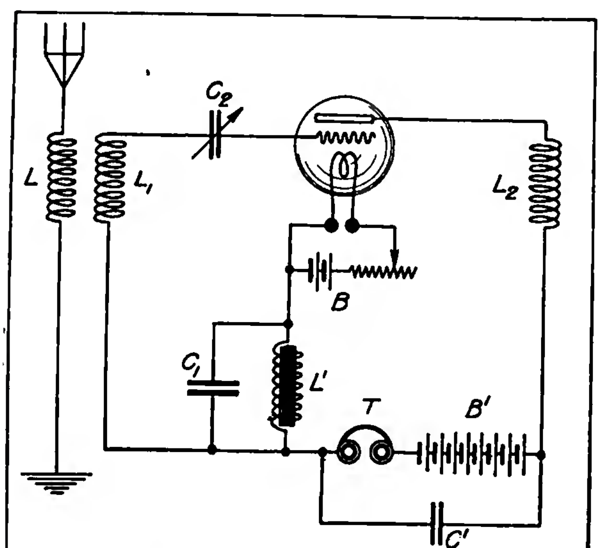


Figure 190—Armstrong regenerative circuit for radio frequency amplification

The general appearance of the de Forest audion and three stage amplifier is shown in Figure 193. The lowest bulb is the detector, the remainder are audio frequency amplifiers. Each has its own filament current rheostat and its own cell plate battery variable in steps of 3 volts. The telephone can be plugged in at any stage as desired.

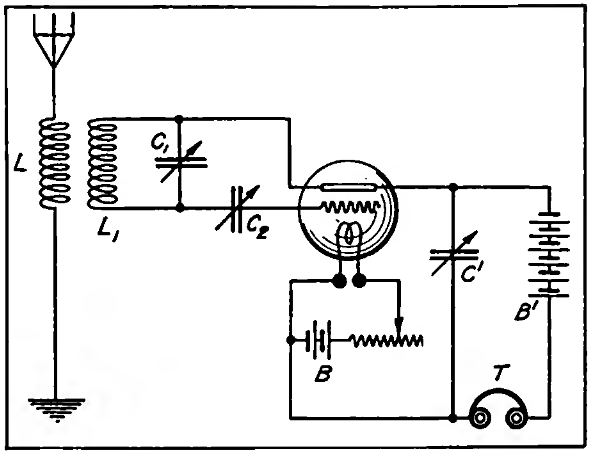


Figure 191—*de Forest ultraudion receiver*

In Figure 194 is represented a general type of circuit devised by Dr. Meissner of the Telefunken Company. It differs from the preceding in the method of obtaining plate circuit outputs. Instead of inserting the telephone receivers into the plate circuit, the large inductance L_2 is placed in this circuit, and the alternating potential differences appearing at its terminals cause currents to flow in the tuned circuit L_3C_5 which is coupled to L_2 by the condensers C_3 and C_4. The right hand bulb serves as a detector and amplifier, and finally delivers audio frequency currents to the telephone T. Another form of receiver of the Telefunken Company, devised by Count von Arco and Dr. Meissner is represented in Figure 195. It will be seen that this differs from Mr. Armstrong's circuit of Figure 189 only in the mode in which the plate circuit output is delivered to the receivers.


Figure 192—*de Forest Company receiver,* 1914

The receiving set used with the Marconi Company's radiophone trans-

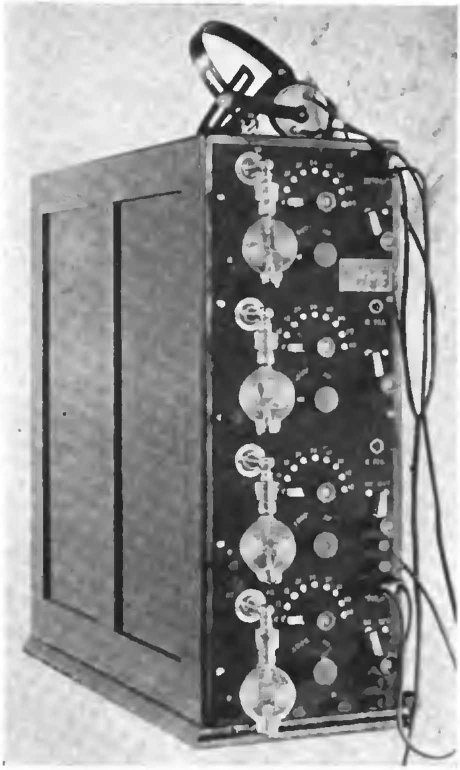


Figure 193—de Forest audion and three stage amplifier

mitter shown in Figure 141 and described in conjunction therewith is indicated in Figure 196. The grid circuit is coupled directly to the antenna circuit through a portion of the antenna inductance L and the inductance L'. The grid circuit is also coupled regeneratively to the plate circuit through the coupling between L' and L''. The plate circuit is tuned by means of the condenser C'. The plate battery B has a voltage of 200 and the resistances R_1 and R_2, which limit the plate current, are each 2,000 ohms. The battery and its associated resistances are shunted by the condenser C'' which passes the amplified radio frequency current. The filament of the bulb is lit by the 6 volt battery B', and grounded through the potentiometer resistance R'. The output of the plate circuit is drawn from the condenser C' across which is placed the usual crystal detector, auxiliary potential, and telephone receiver combination. In other words, the system shown consists of a regenerative radio frequency amplifier combined with an ordinary crystal rectifying circuit for utilising the amplifier output.

Passing to the work of the Western Electric Company, we consider first some

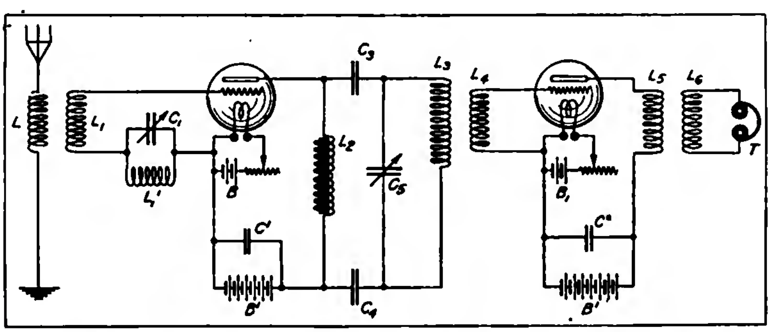


Figure 194—Telefunken Company-Meissner receiving system

of the tubes developed by the engineers of that company and their method of construction. One type of tube, due to Mr. H. J. van der Bijl, is shown in Figure 197. Herein the objects are to keep the planes of the grid and

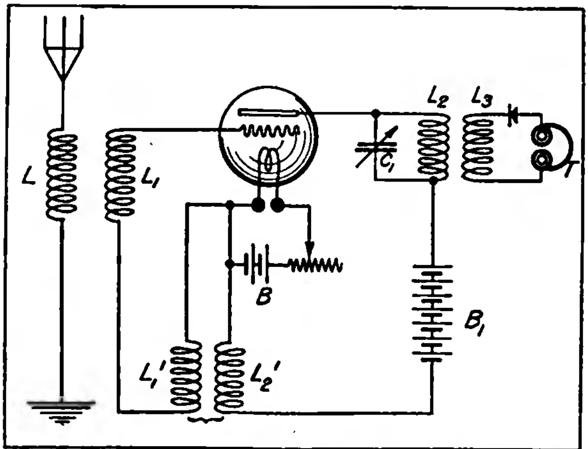


Figure 195—*Telefunken Company-Arco-and-Meissner receiving system*

filament close together (for high amplification) and to avoid undue tensions on the filament. As will be seen from the lower portion of the Figure, the filament is threaded to and fro on the flat mica support, passing alternately from one side of the mica to the other. The grid and its supporting frame are mounted close to the mica, and are preferably arranged as shown in the lower portion of the Figure,

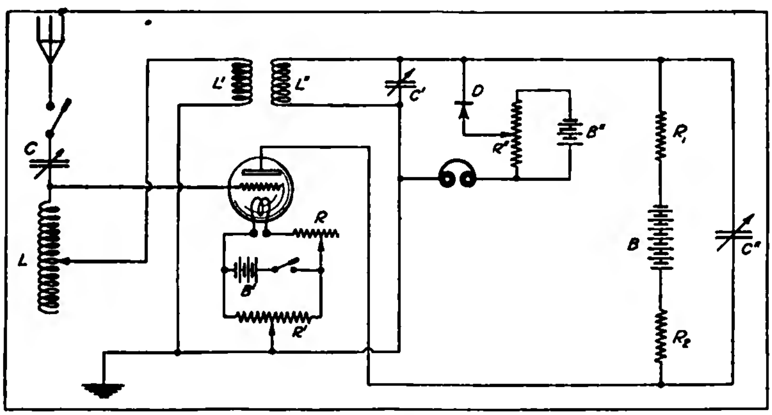


Figure 196—*Marconi Company radiophone receiver*

that is, with grid wires not crossing at the portions of the mica where the small vertical portions of the filament are exposed on that side. In another form of tube, due to Mr. A. McL. Nicolson, and represented in Figure 198, it is attempted to secure "efficient control" by twining the grid wire around the filament, separating them only by a non-conducting or dielectric film. Nickelous oxid is recommended for the purpose. In the form shown in Figure 198, the grid wires 1 are coated with nickelous oxid, and around them are twined the filament wires 2. The plates 3 are situated as usual.

A type of Western Electric Company amplifier or "repeater" tube is shown in Figure 199. This type is due to Messrs. A. McL. Nicolson and E. C. Hull. The distinctive feature thereof is the twisted platinum filament 2, which is coated with metallic oxids. It is made by dipping a platinum ribbon having a width of say 0.3 mm. (0.012 inch) and a thickness of 0.05 mm. (0.002 inch) in chromic or nitric acid, washing it in water, and then in a strong solution of ammonia. After this thorough cleansing, it is heated to incandescence to see if it has any defects. It may then be dipped in a trough filled with dilute strontium hydroxid and thereafter dried at 100° C (212° F.) by a current of

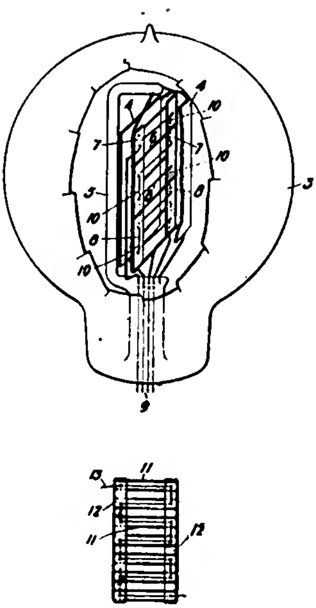


Figure 197—*Western Electric Company-van der Bijl amplifier tube,* 1915

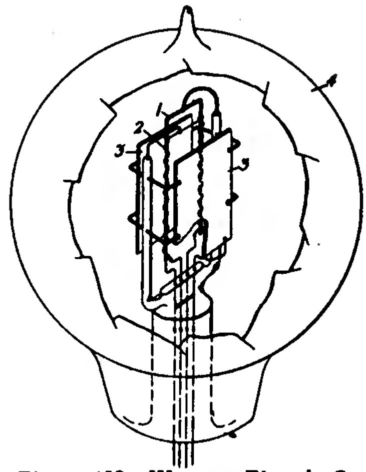


Figure 198—*Western Electric Company-Nicolson amplifier tube,* 1914

1.4 amperes. After four such coatings, the filament is heated to incandescence for a few seconds to harden the oxid film. It is next coated with barium resinate melted at a temperature of 600° C. (1,100° F.), and given four coats thereof as before except that it is heated for a few seconds to incandescence after each coat or two. The entire process thus far mentioned is then repeated, thus giving four sets of four coats of the oxid or resinate in all. The filament is then kept at incandescence for about 2 hours at 800° C. (1,470° F.) to ignite the resinate. The resulting film of strontium and barium oxids on the filament is smooth and tough and gives high electron emission at comparatively low temperatures thus tending to give a long filament life in use. Tubes of this sort, but with a grid and plate at each side of the filament, are widely used by the Company.

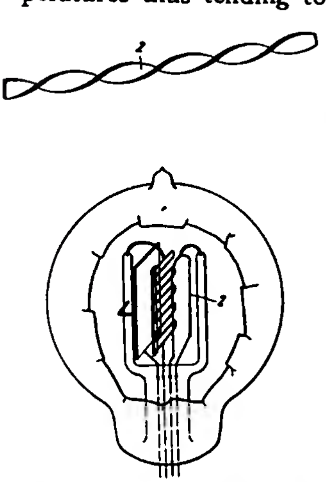


Figure 199—*Western Electric Company-Nicolson-and-Hull amplifier tube,* 1914

One type of receiver used by the Western Electric Company consists of a number of steps. The antenna circuit is coupled to a radio frequency regenerative amplifier, much like that shown in Figure 188 in most respects except that the output is obtained by coupling in the plate circuit to a fairly large impedance as in Figure 194. The next circuit is a detector circuit, also provided with regenerative coupling. The output of this step passes into a two-step audio frequency amplifier with inductive coupling between the steps. The final output is inductively coupled to a balanced receiver for reducing the relative intensity of strays, and devised on somewhat the same general lines as that shown in Figure 9 except that three-electrode tubes are used.

The General Electric Company has constructed a number of different types of pliotron amplifier tubes,

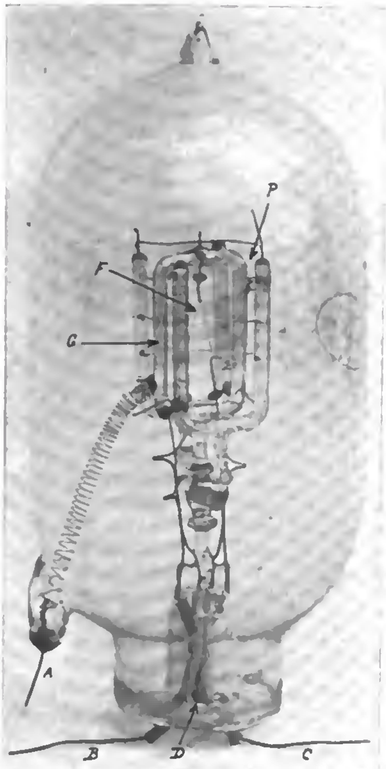


Figure 200—General Electric Company-White small pliotron amplifier

one type of which intended for relatively small outputs is shown in Figure 200. The grid *G* is made of very fine wire wound on a glass frame. Inside the grid is the "V" or "W" shaped filament *F*. The plate *P* is not a solid plate of metal, but consists of a zig-zag wire supported on wire supports placed appropriately in two "U" shaped glass frames. The filament leads are *B* and *C*, the plate terminal *D*, and the grid terminal *A*. The whole structure is carefully built and exhausted to an extremely high vacuum at which "pure electron" effects are obtained. Under these conditions it has been found possible to obtain extremely high audio and radio frequency amplifications without using regenerative circuits in connection with the bulb, that is, without any other coupling between grid and plate circuits than the small capacitive coupling which necessarily exists within the bulb.

Mr. Alexanderson has shown several methods whereby a number of such tubes may be used in cascade, each giving radio frequency amplification. It is claimed that the selectivity of the resulting system is high, rising in geometric proportion to the number of steps.

This is the fourteenth of a series of articles on "Radio Telephony," by Dr. Alfred N. Goldsmith. In the fifteenth and concluding article, to be published in the March issue, Dr. Goldsmith discusses strays, range in radio telephony, radiophone traffic and its regulation and duplex operation. He also gives examples of imaginary radiotelephone conversations.

Tuning and Wave-Length Changing of Wireless Transmitters

IN the early days of radio development in the United States, it was customary to tune a ship's transmitter to the natural wave-length of the antenna regardless of its length; also, the majority of transmitters were very closely coupled, causing the antenna to radiate two waves. While this was not a desirable condition in the majority of cases, in certain instances it was of real benefit, because if the operator receiving experienced interference on one of the waves radiated by a given transmitter he could retune his equipment to the other wave and thereby receive signals. It is interesting to note that although considerable interference was caused by this double wave emission, it was often found that the decrement of the longer wave was far within the limit of the present-day Government restrictions.

At the time when the United States Government signed the articles of the London Convention, all ships were retuned and adjusted to the standard wave-lengths of 300 and 600 meters. It was somewhat difficult in some installations to reduce the natural wave-length of the antenna by means of the short wave condenser to the smaller value (300 meters) and in extreme cases it became necessary to erect a separate aerial for radiating energy at this wave-length.

A Digest of Electrical Progress

Unprecedented Demand for Power Station, Railway and Industrial Equipment—the Feature of the Manufacture of Apparatus During 1917—A Voltage Stabilizer Designed to Overcome the Fluctuations of the Line Voltage Where Electric Lights and Motors are Fed from the Same Source of Power—Practical Uses for the Kenotron Rectifier.

Developments in the Electrical Industry During 1917

THE expansion in the manufacture of electrical apparatus during the year past has been unprecedented. Due to the demands of war, laboratories of the various electrical manufacturing concerns throughout the United States have been placed under unusual pressure, and for obvious reasons, the nature of many practical inventions of unusual merit cannot, for the present, be disclosed. But it is certain that when the curtain is drawn aside after the war apparatus or machinery of great usefulness will be available for commercial enterprise.

When, in the fullness of time, the complete story of the developments in electrical industry for 1917 is told, it will constitute a record of which the entire electrical fraternity may well be proud; but at present, for reasons which will be appreciated by every American engineer, many items of interest must of necessity be omitted from any review covering the accomplishments of the industry.

So says John Liston in a recent issue of the General Electric Review.

The writer says that the feature of over-shadowing importance was the enormous increase in the volume of production of standard apparatus to meet unprecedented demands for power station, railway and industrial equipment. For certain types of apparatus which had long been in general use, this increase actually represented advances of several hundred per cent as compared with the maximum output of preceding years. Among the power apparatus of unusual proportions designed by the General Electric Company is mentioned a 35,000 kw. Turbo-generator, a 20,000 kv-a. 6,600 volt 60-cycle alternator, and a 50,000 kv-a. 60-cycle transformer for increasing a current of 12,200 volts to 24,400 volts. The latter instrument had a full load efficiency of 99.4 per cent.

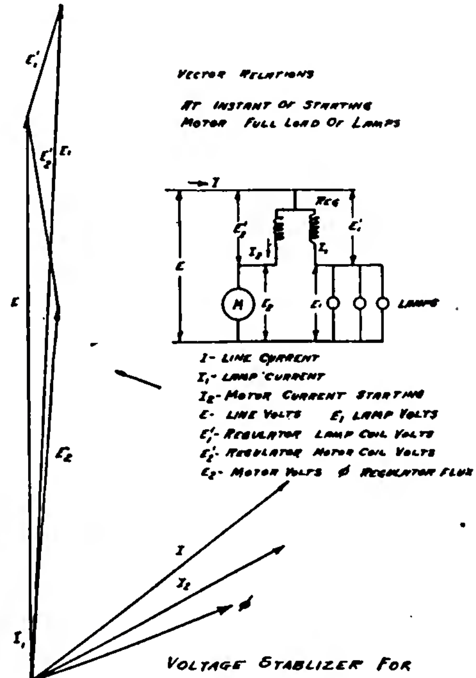
An interesting device known as a voltage stabilizer for alternating current circuits is described. This device was designed to overcome the fluctuations of the line voltage where electric lights and motors are fed from the same source of power.

The stabilizer is essentially a highly reactive transformer having a primary through which the motor current flows and a secondary which is connected in series with the lamp load and boosts by an amount proportional to the voltage drop caused while starting. A photograph is shown in figure 1, and the theory of its operation is disclosed in figure 2.

A description follows:

It consists of a laminated core into which an adjustable airgap has been interposed. On the middle leg of the core structure are interwound the motor and lamp coils. When starting, the rush of current through the motor coil excites the magnetic circuit of the stabilizer and induces a voltage in the lamp coil which is substantially in phase with the lamp voltage. This action is

Figure 1—Voltage stabiliser for alternating-current circuit.



VOLTAGE STABLIZER FOR A.C. CIRCUITS.

Figure 2.

shown in the diagram (Figure 2) where E is the voltage added vectorially by the lamp coil in order to maintain E_1, the lamp voltage, at a constant value. If, however, a transformer or reactance is inserted permanently in series with the motor its terminal voltage is appreciably lowered and this might be detrimental, since in some cases full load could not be delivered. In the stabilizer this effect is overcome in two ways: First, by designing so that at normal full load running current the flux density in the iron core is low—this means a correspondingly low voltage drop; Second, by inserting an air gap in the iron core the apparatus is made highly reactive and most of the drop over the motor coil is in quadrature with the line voltage, except for copper and core loss. These losses can and must be kept low in order to make the apparatus efficient.

Special notice is given to the work of the research laboratory and its development of a portable X-ray outfit that should prove of great service to our army. This equipment consists of a single cylinder, air-cooled gasolene engine, with direct connection to a 1 kw. direct current generator provided with slip rings so that current at a frequency of 47 cycles is applied; the carbureter of the engine is controlled through a solenoid and the necessary changes in speed are effected by means of a simple resistance unit located at the head of the operating table when the outfit is being used.

Due to the rectification characteristic of the Coolidge X-ray tube, no separate rectifier is required. The entire equipment, including the operating table, can be rapidly assembled or taken apart for transportation, the complete set having a net weight of 850 pounds.

The kenotron rectifier, which in reality is an enlarged form of Fleming's vacuum valve tube, has found two practical usages during the year. The first of these was in connection with the process of precipitation by means of high vol-

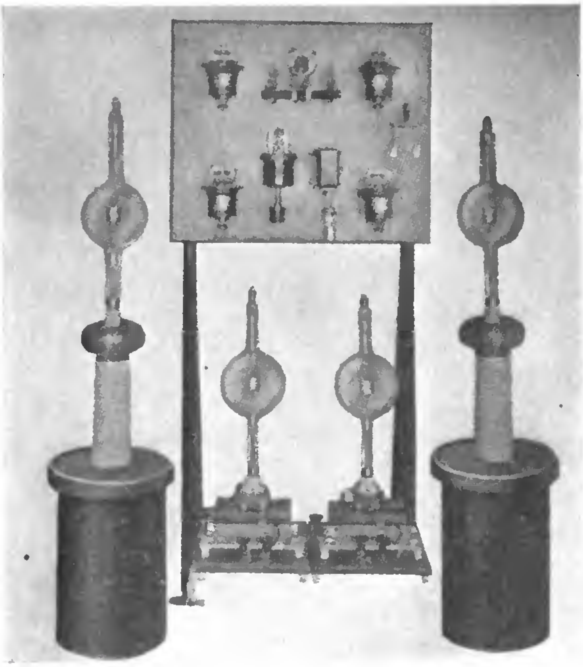


Figure 3—Switchboard Panel with protective devices for use on kenotron precipitation outfits, with filament transformers for kenotron.

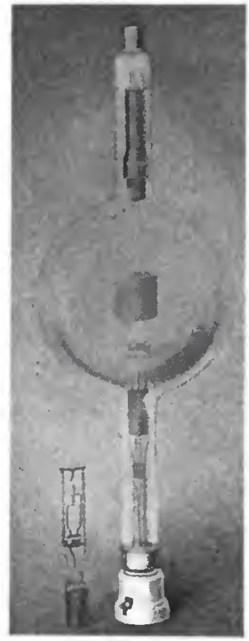


Figure 4—High-voltage kenotron.

tage direct current for the reclamation of usable materials in gases or smoke, or the abatement of the nuisance caused by the emission of noxious gases or smoke from flues or stacks. Direct current of high voltage is necessary for this work and heretofore it has been obtained by a mechanical rectifier which included several undesirable features which the kenotron rectifier eliminates. In addition, the mechanical rectifier imposed an undesirable strain upon the high voltage transformer.

The kenotron rectifier is noiseless in operation and the rectification is nearly perfect, with maximum voltage fluctuations of less than fifteen per cent delivering direct current of 100,000 volts. The complete switchboard fitted with kenotron precipitation outfit is shown in the diagram, figure 3, and a high voltage kenotron in figure 4. It should be remembered that the operation of the kenotron rectifier is perfect on voltages up to 100,000 volts, and as such it gives perfect rectification.

The kenotron found another application in the development of a cable testing set for supplying direct current of potential up to 60,000 volts.

The tungar valve rectifier, introduced to the trade some months ago, has found use in an astonishing number of ways. These rectifiers are applied in charging, starting, and lighting batteries on automobiles, motor-boats, motorcycles, in private and public garages, in groups as high as ten batteries, many public garages having from three to five rectifiers in service. They have also been utilized for charging the batteries required for the operation of clocks, telephones, fire alarms, etc. and for track and motor batteries on railway signaling systems. Tungar rectifiers are now built in sizes from .1 ampere and 7.5 volts up to 15 amperes and 108 volts, with many intermediate sizes and voltages.

Static condensers for correction of the power factor on commercial power lines have been developed to a point of great satisfaction. These condensers consist of groups of condenser sections, each made up of layers of tinfoil assembled in oil in metal containers. The sections are individually fused and in addition, an oil switch is provided for connecting to or disconnecting from the line.

It was found that when condenser sections were connected directly across the line no improvement in power factor was secured, but that by inserting a small reactance in series with the condenser the use of practically the entire capacity of the condenser sections for power factor correction was possible.

As compared with the synchronous condenser, the static condenser shows exceedingly high efficiencies, the losses being less than one per cent of the total kv-a. regardless of capacity.

This condenser, of course, weighs less and occupies less space for a given capacity than a synchronous condenser, and since it possesses no moving parts, it requires practically no attention.

A number of mechanical and electrical devices, which mark distinct progress in the electrical art, are described in detail.

The Production of Nitrate by the Electric Arc

THE production of nitrogen from air by the electric arc is a process which has been carried on for a number of years. The principal nitrate works are situated in the southeastern part of Norway in the Telemark river district. Approximately 60,000 horsepower is employed.

One of the best known systems by which nitrates are obtained is known as the Birkeland-Eyde process. In this process, nitrous gases are separated from the air by the formation of an arc between the points of electrodes, which are placed close to each other in a strong magnetic field. In a recent issue of the Electrical Review the process of generation is described as follows:

> The electric arc that has been formed moves on account of this powerful magnetic field with great velocity perpendicularly to the lines of force, so that the arc is lengthened and finally broken. As the length of the arc increases the resistance becomes greater and the tension increases, until it becomes so great that a new arc starts from the points of the electrodes. In order to regulate the current an inductive resistance is used in series with the arc. With alternating current all the arcs are formed in opposite directions and appear to the eye to be circular disks. This flame provides a very effective means for the oxidation of the nitrogen of the air. The flame in the furnaces burns with a steadiness that is really astonishing.
>
> The electrodes are thick copper tubing, through which water passes for cooling purposes. The furnace chamber in which the flame burns is circular, of only a few centimeters in width, and about three meters in vertical diameter. The furnaces are lined with fire-clay brick, through an opening in which the air is admitted to the flame. The nitrous gases formed in the flame escape through a channel made along the casing of the furnace, which like the flame chamber is lined with firebrick.
>
> Each furnace is furnished with an induction coil by means of which the power is regulated as required. The induction coil serves, moreover, to keep the flame in the furnace steady and even while working. It is claimed that with this furnace there was obtained such steady working that it burns for weeks without any regulation worth mentioning. The maintenance of the furnace and its repairs are simple, as the most exposed portions, the electrodes, need be changed only every third or fourth week, and then but a small part of them. The firebrick masonry is changed every fourth to sixth month.
>
> The temperature in the flames exceeds 3000 degrees centigrade.

The temperature of the escaping gases may vary between 800 and 1000 degrees. The furnaces are made of cast steel and iron, the middle of the furnace being in the form of a circular flame chamber. The electrodes are led radially into this flame chamber. By aid of centrifugal fans the air is brought into each furnace through pipes from the basement. Furnaces have been built consuming energy from a few horsepower up to 5000 horsepower.

The furnace just described has been improved upon by Dr. Schoenherr, and an electrical engineer named Hessberger, of the Badische Company.

The Schoenherr furnace in its present form consists of a slender vertical column of iron plates 7 meters in height, in each of which is developed a long slender arc in the axis of a narrow iron tube through which a current of air is forced. The inner tube is the reaction chamber, the others form channels for the entrance of the air current and its exit after coming in contact with the flame. In this manner, the heat of the outgoing gas comes in contact with the ingoing current.

At the lower end is the main electrode which is movable in a vertical direction, as it must be raised from time to time when the end is worn away by the arc. The reaction tube serves as the second electrode. By means of a lever the space between the electrode and tube can be bridged over and the arc formed. The air current, forced by a powerful aspirator, enters the lower part of the furnace and passes through the various channels. The entry into the reaction chamber is through a number of small tangential openings arranged in several horizontal rows in the sides. The current passes in this way around the chamber and the arc is driven up in the midst of the rapidly moving current of air.

The final process by which the nitrogen gases are cooled and absorbed is of interest. When the air in the flame chamber has been acted upon by the electric current, the nitrous gases generated thereby pass out through pipes into steam boilers where their temperature is reduced.

Air compressors, which supply air at considerable pressure, pump acid and lye into the various chemical departments. The gases pass from the steam boilers through an iron pipe into the cooling house, where the cooling which is begun in the steam boilers is completed.

The coolers consist of a great number of aluminum tubes, over which cold water runs, while the hot gases pass through them. The temperature of the gas is thus considerably reduced.

The next step is to pass the gases from the cooling chambers into the oxidation tanks. These are vertical iron cylinders lined with acid-proof stone. In these the cooled gases have a sufficient period of repose in which time the complete oxidation of the nitrogen oxide may occur. The necessary amount of oxygen is present in ample quantity in the air which accompanies the gases from the furnaces.

The process from this point on is described as follows:

From the oxidation tanks the gases are forced by blast engines into the absorption towers. Broken quartz which is affected neither by nitric gases nor by nitric acid, is used in the towers. To assist the passage of the gases on their way from the furnaces there are centrifugal aluminum fans on each row of towers. The gases enter at the base of the first tower, go up through the quartz packing and thence by a large earthenware pipe enter the top of another tower, and so on, until the air, relieved of all nitrous gases, leaves the last tower.

Water trickles through the granite towers and by absorbing the nitric oxides is gradually converted into a weak acid. The absorbing liquid enters the top of the tower and is distributed in jets by a series of earthenware pipes, so that the permeating gases enter into intimate contact with the liquid. Nitric acid is thus formed in the granite towers. In the iron towers a weak solution of caustic soda is used which on absorption of the gas is converted into a solution of nitrate of soda.

Further application of this process is bound to follow hydro-electric developments throughout the various countries.

Vacuum Valve Rectifiers for Charging Storage Batteries

THE rectifying properties of the Fleming valve have been employed for a number of years in connection with the receiving apparatus of a wireless telegraph system, but little use has been made of rectification in connection with low frequency currents. The General Electric Company has recently placed on the market, however, a simple vacuum valve rectifier, known as the Tungar, which is applicable to charging storage batteries from alternating current. It consists of a hot cathode and anode, the bulb being supplied with argon gas. In variation to the usual form used in radio, the anode in this valve is made of graphite.

In operation the filament of the rectifier is connected to an ordinary lamp socket, the two remaining connections of the complete rectifier to the storage battery under charge. When the tungsten filament is lit to incandescence there is a purplish glow between the cathode and the anode, and as usual in devices of this kind, a current of electricity can pass from the anode to the cathode, but not in the opposite direction. A rectified current therefore flows through the storage battery.

With these rectifiers it is possible to charge small storage batteries such as are employed in miners' lamps, inspectors' lamps, dentists' lamps, exit lights, electric piano players, burglar alarms, railroad signals, motor cycles, etc.

The Tungar rectifier is made in three sizes, and all are of the half-wave type with different amperage and voltage capacities. The 2-ampere unit, operated on 115 volts, 60 cycles, will charge three storage cells at 2 amperes, six cells at about 1 ampere, and eight cells at about 0.75 ampere.

The 6-ampere, 7.5-15 volt unit will charge either three or six cells of lead battery at 6 amperes when operated on 115-volt, 60-cycle circuit.

The 6-ampere, 7.5-75 volt unit will charge three to thirty cells of lead battery at from 1 to 6 amperes.

In addition to providing direct current in localities where alternating current only is available, the rectifier may be used for charging the storage battery of an automobile during the idle periods of the winter. In other words, the loss in charge due to the slight use of the automobile during the winter months can be compensated for during the night hours by permitting a small charge to pass through the battery.

The operation of the device is simplicity itself. The charging is accomplished by connecting the two leads from the rectifier to the storage battery; the red lead on the rectifier connects to the positive pole of the battery and the other to the negative pole. The lamp plug is then screwed into the nearest lamp socket and the switch turned on. Continuous charging is assured so long as the filament is lit to incandescence.

The cabinet in which the Tungar rectifier is mounted includes an ammeter, switch and current regulating handle, located on the front of the case.

Novel Buzzer Practice Set for Government Schools

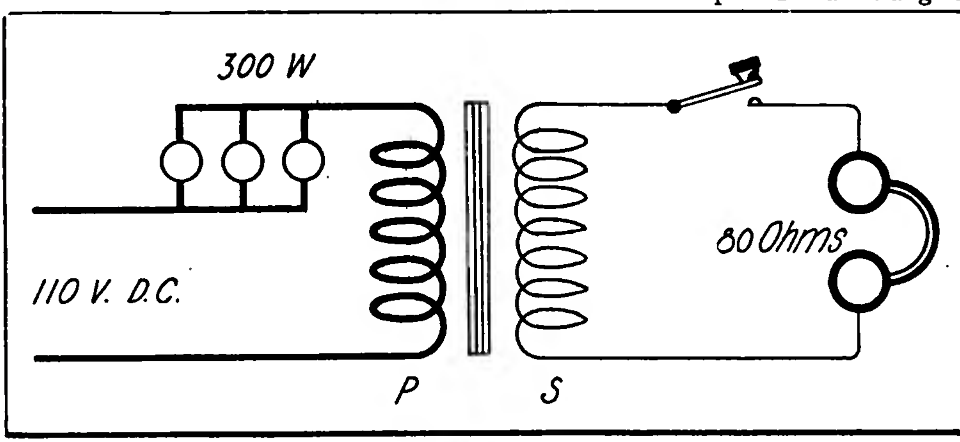
Paul G. Watson.

The accompanying diagram shows the connections of the apparatus used for code practice in the radio school for drafted men in West Chester.

The source of current is 110-volt direct current mains. The bank of lights consists of three or four 100 watt carbon bulbs or their equivalent in smaller bulbs.

For efficient operation, an iron core must be used. The core for this coil consists of a tightly drawn bundle of No. 22 Norway iron wires, the bundle being about 9/16 inch in diameter. It is slipped inside of the primary tube, leaving ½ inch projection beyond the ends of the coil windings.

The coil is then placed in a rectangular case similar to a spark coil box and covered with insulating compound.



Novel buzzer practice set

The induction coil consists of two layers of No. 18 D. C. covered magnet wire, wound for a distance of 7½ or 8 inches on a fiber tube with an inside diameter of ¾ inches and an outside diameter of 1 inch. The terminals of the primary are brought to binding posts on the case of the coil and are marked "Primary."

The secondary winding is put on after the primary has been covered heavily with insulating varnish and several layers of empire cloth have been added. It consists of about ¾ lbs. of No. 26 D. C. C. magnet wire wound evenly over the empire cloth in several layers. The terminals of this winding are taken to binding posts on the coil case and are marked "Secondary."

After the insulating compound is hardened the primary is connected in series with the bank of lamps. The telephones are shunted across the secondary with the key in series. When the current is turned on and the key depressed a note similar to the pitch of NAA is produced in the receiver. One of the advantages of this system is that when the key is pressed no "click" is heard, but just a steady "buzz."

Do not have the telephone circuit closed when the power is turned on as the surge is strong enough to burn out the telephones. The telephones are of the ordinary 80 ohm telephone type and the key is a standard line telegraph key.

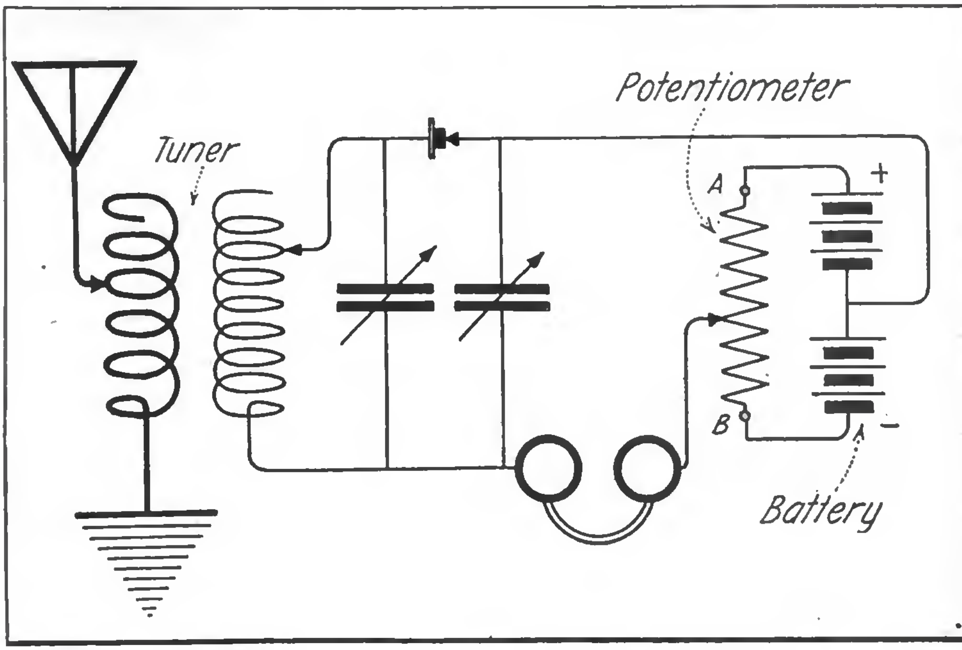


Figure 1—Current reverser, complete circuit

A Current Reverser for Crystal Detectors

MANY amateurs have been accustomed to install an elaborate current reversing switch for changing the direction of current through crystalline detectors, but they have neglected to employ a much simpler system, the circuits of which have been used in commercial wireless systems for a number of years. Either a positive or negative potential can be supplied to one side of the crystal detector by simply changing the position of the sliding contact on the potentiometer as will presently be shown.

In the accompanying diagrams, figures 1 and 2 are shown; first, the complete circuit, and, second, the construction of the potentiometer. In addition, it will be noted from figure 1, that the battery must be twice the size of that ordinarily applied in connection with crystalline detectors. In this diagram, a negative potential can be applied to the right-hand terminal of the telephone by sliding the contact to the top of the potentiometer (A), and a positive potential by sliding it to the bottom of the potentiometer (B).

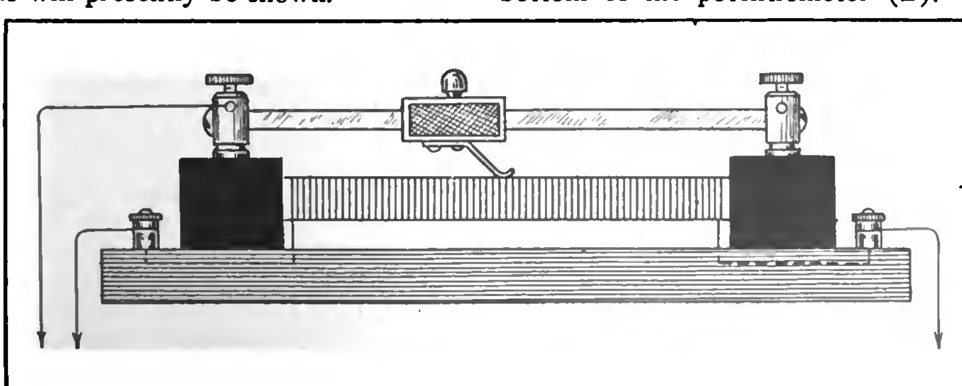


Figure 2—Construction of the potentiometer

A Remarkable High Tension Insulator

THE accompanying illustrations show a remarkable high tension insulator which several power companies have tested under oil, 200,000 volts being an average value for puncture strength of these discs. The puncture of some occurred at 300,000 volts. The insulators have stood high frequency flashover tests for one hour.

Instead of the usual rigid malleable iron caps and solid pins, two spider shaped caps are used, with eight legs fastened into the upper and lower sides of the insulator at a depth of 1 inch. The flexibility of the legs prevents expansion and contraction strains on the porcelain, absorbs shocks and distributes the tensile strain uniformly. No cement is used. The spider legs are anchored into recessed holes in the porcelain by means of a special alloy similar to that used in die casting. This alloy as applied does not shrink away from the porcelain and has a very low coefficient of expansion. The insulator will stand plunging from boiling to ice water without injury.

High tension insulator tested under oil up to 300,000 volts

Single unit of the high tension insulator

The construction described gives the disc an ultimate strength of 8,000 to 10,000 lbs. Electrical properties have been proven not to be affected in the least up to the full breaking strain, and the electrical and mechanical strains occur at entirely different parts of the porcelain.

The diameter of the unit is 11 inches, and the distance between units assembled is 6½ inches. The dry flashover tests of one unit at normal frequency showed 97,000 volts; with two in series the pressure was 184,000 volts, while three in series withstood 253,000 volts. In the wet flashover test (precipitation 1 inch in 5 min.) 50,000 volts was used and with two in series 92,000 volts; four in series withstood 185,000 volts, and with five in series the pressure was 220,000 volts.

It is stated that the high frequency oscillator test gave a first arc-over value with one disc of 120,000 volts, and with five units in series 500,000 volts. In testing insulators each unit is mechanically tested to a strain of 5,000 or 6,000 pounds, then it is tested electrically to flashover for ten minutes on a 60-cycle transformer with a high frequency oscillator for 250,000 volts. As soon as this is finished the disc is tested on high frequency, as it is better to find the weaknesses before putting the insulators on the line than afterward.

This insulator, once it is put up, will not have to be taken down due to any di-electric or mechanical weakness. The di-electric thickness of this disc is 2¼ inches, against one-third this amount for single piece units in use in the post. The stress on the porcelain under all operating conditions is correspondingly lower than on thinner types.

It has been proven that insulating materials gradually fail under stresses which cause corona. The critical stress varies with the specific inductive capacity of the material. For porcelain, the safe potential gradient is about 40,000 volts per inch thickness. It is held that the disc, as proven by tests, both on normal and high frequency, avoids corona up to 90,000 and even 110,000 volts, whereas a disc ¾ inch thick is under corona at 30,000 volts. Some experimenters claim to have observed it at much lower voltages.

This disc will insulate permanently, because of its safe di-electric stresses; the perfectly balanced field is also very important in securing the full value of the insulating material and enabling the insulator to resist high frequency and other line conditions caused by lightning and switching. In the cap and pin type the area of contact with cement outside is six or seven times that in the pin hole, causing a greatly concentrated stress on the porcelain nearest the pin hole.

Construction of a Buzzer Telegraph

WHILE the buzzer telegraph is not new, I think that a description of one will prove of interest to amateur wireless operators at this time. Many are apt to forego code practice during the war because it lacks the interest of actually communicating. The buzzer offers a simple, cheap and efficient method of communicating and at the same time obtaining practice.

The most prominent features of the device are the distance that can be covered and the simplicity and cheapness of the apparatus. It may be used either as a permanent or portable outfit, depending on how it is mounted. As most experimenters have all the materials needed, the cost will be next to nothing.

The following articles are needed:

1. A call buzzer.
2. A cheap receiver or phone.
3. A telegraph key.
4. Two or three dry cells.
5. A line connecting the two points or stations.
6. A ground connection.

The buzzer may be of the type used for adjusting mineral detectors or as a door call. A telephone receiver, "pony" receiver, or the 'phones from your wireless set can be used. The batteries may be dry cells or a 4-6 volt storage battery.

If you live in town you will possibly have to erect a line on 2 by 4's or through trees. The line does not need to be insulated. It may be of iron wire. In the country, the top wire of the barbed wire fence can be used. See that the line is continuous. An extensive ground connection is not required, a small pipe or rod driven into the earth a few feet serves excellently.

Connect the buzzer, key and batteries in series. Solder a flexible wire to the upright contact post of the interrupter, connect one terminal of the 'phone to this and the other to the line. Connect the ground wire to the binding post on the buzzer which leads to the coil of wire.

The U. S. Army Signal Corps has sent over 150 miles with the buzzer. A fellow "fiend" in a nearby town told me that he and a friend had a line a mile long and that when using a six-volt storage battery to work the buzzer they had to put a resistance in series with the line so that the signals in the receivers would not hurt their ears!

I have an outfit similar to the one I have described and have sent eleven miles over a country telephone line with it. I used one wire and a ground. Ordinarily, I use it to communicate with a friend about one mile away over a barbed wire fence. The signals come in very strong.

HAROLD C. VANCE,
Washington.

EDITORIAL NOTE.—The use of a shunt resistance is recommended, rather than a series resistance, to reduce the strength of signals.

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

A Short Wave Regenerative Receiver

I SHOULD like to present to the readers of your excellent magazine the complete drawings of a short wave regenerative receiving set which I have designed and used with excellent results. The general plan, including the placing of the various parts of the complete apparatus is shown in figure 1, a fundamental wiring diagram in figure 2, a sketch showing how the coupling between the primary and secondary windings is adjusted, in figure 3, and the over-all dimensions and general outside appearance of the cabinet, in figure 4. Although primarily designed for reception at the wave-length of 200 meters, it was found that response could be obtained in this circuit at wave-lengths up to 800 meters.

It will be noticed first, that the primary and secondary winding of the receiving tuner, two variable condensers and two variometers are mounted on the cabinet, to the left of figure 1, and the vacuum valve with the filament rheostat and switch for the high voltage batteries to the right. The reader's attention is called to the fact that the position of the filament rheostat has been left out of this drawing, but it is to be mounted on the front of the panel as shown in the right-hand part of figure 4.

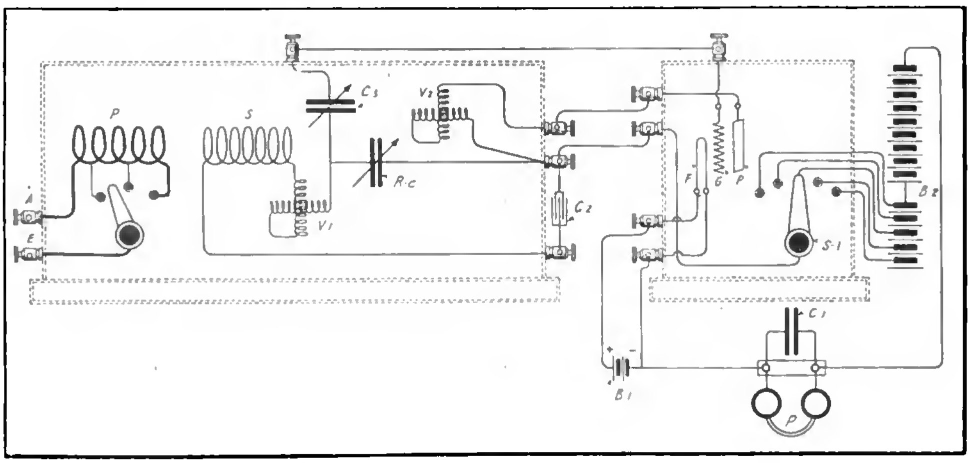


Figure 1—First prize article

Beginning with the panel, it can be made of black fibre and should have dimensions of 18 inches by 8 inches. The cabinet for the vacuum valve can be of any size consistent with the dimensions of the tube and, of course, it should have sufficient space to hold the high voltage battery (30 to 50 small cells).

The primary winding of the receiving tuner P (figure 1) is wound on a tube 3 inches in diameter by 1½ inches in length, containing thirty turns of No. 26 wire. The secondary winding is 2½ inches in diameter and 1½ inches in length, wound with 25 turns of No. 32 wire. No provision is made for variation of the inductance in this

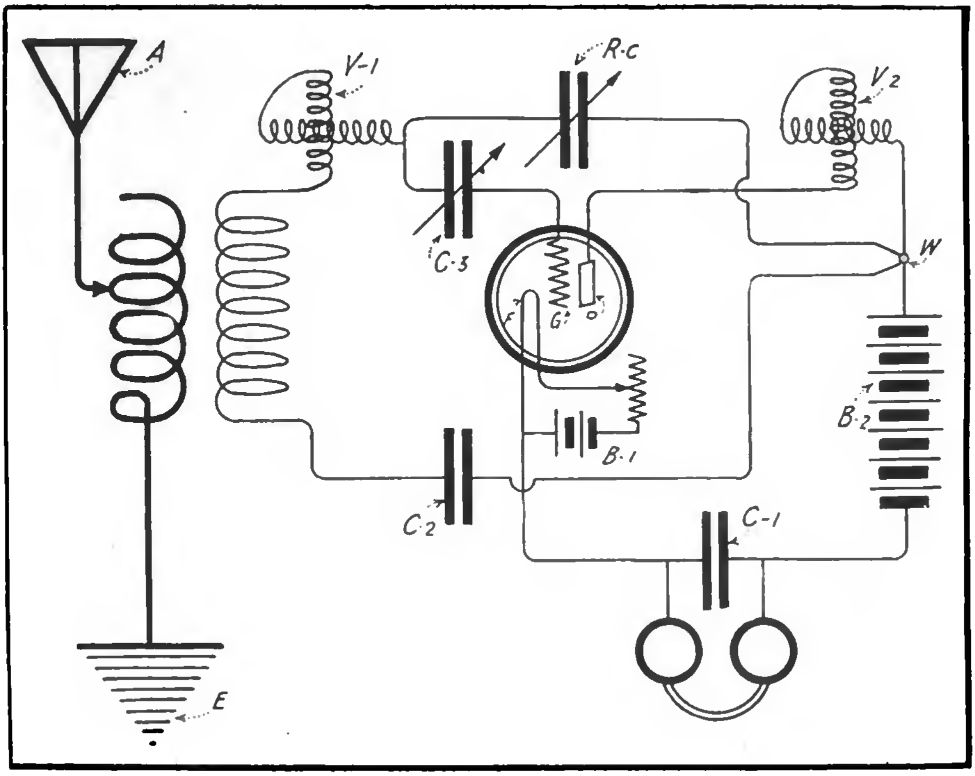


Figure 2—First prize article

winding as the necessary changes of frequency in the closed circuit are made by the variometer, V-1, and the grid condenser, C-3.

Each of the variometers, V-1 and V-2, in figure 1 have twenty-five turns of No. 28 B & S wire on each coil. The two variable condensers, R_c and C-3, should be of small capacity; in fact, they need not contain more than from three to five plates, each of the usual small size condenser. These can easily be made, or purchased from a wireless supply house.

After the reader has thoroughly noted the general outlay of figure 1, he should study the fundamental diagram of Figure 2 in which it will be observed that the grid circuit of the vacuum valve is tuned by the variometer, V-1, and the wing circuit by the variometer, V-2. One secondary terminal of the receiving tuner goes through variometer, V-1, through the grid condenser, C-3 to the grid G, and the other connection goes through the condenser, C-2, to the wing circuit at point W. By this connection the wing and grid circuits are electrostatically coupled through the telephone condenser, C-1, and an additional coupling is afforded by what is termed the "regenerative condenser," R_c, shown at the top of the drawing.

Further reference should be made

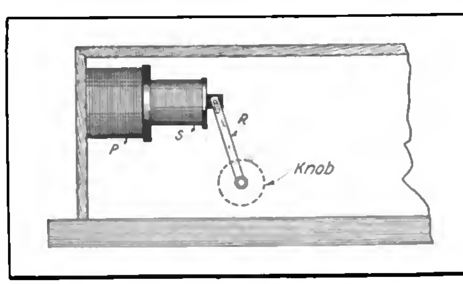


Figure 3—First prize article

to figure 4, in which the positions of the knobs controlling the variable condensers and variometers are clearly shown. Owing to the extreme sensitiveness of a circuit of this kind, it is better to fit these knobs with long fibre handles from 6 inches to 8 inches in length so that the circuits can be tuned without changing the resonance adjustment by the capacity of the body of the manipulator.

Figure 3 shows how the primary and secondary coupling is varied by a knob. This is accomplished by a rod, R, which is attached to the secondary winding. The secondary coil slides on a rod in the usual manner.

In the adjustment of this apparatus it is best to first set the regenerative condenser, R_c, at zero and then tune the secondary and wing circuits with variometers V-1 and V-2. After resonance is established amplification is obtained by careful adjustment of the condenser R_c. Condenser C-2 can be made of two or three sheets of tin foil 2 inches by 2 inches, separated by thin sheets of micanite 2½ inches by 2½ inches.

Surprising results are in store for the amateur who has never tried a circuit of this kind. Extreme selectivity is obtainable which is, of course, due to the regenerative feature of the apparatus which makes the circuit act much similar to an oscillation circuit of very small damping. The adjustments of the variable condensers or variometers for a given station are invariably exceedingly sharp. In fact, a movement of about 1/30th of an inch of the control knobs often will completely eliminate the signals.

The experimenter should take into consideration that it requires a certain amount of experience to get the best results from an apparatus of this kind, and in consequence, he should not be dissatisfied if the results at first trial are not to his liking.

Howard White, *California.*

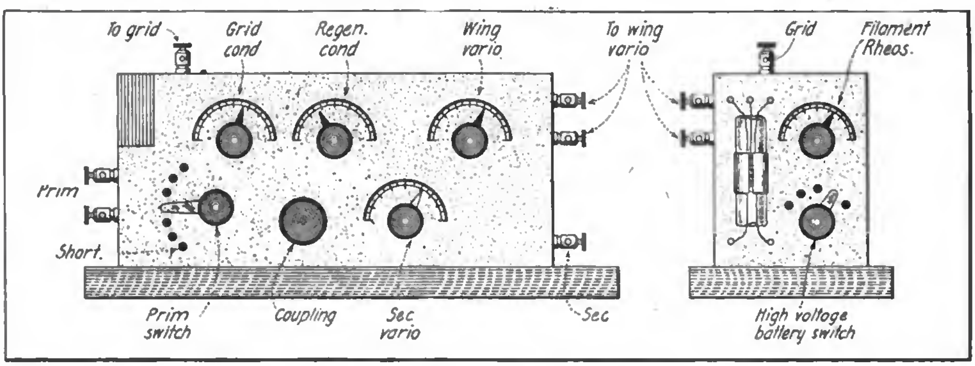


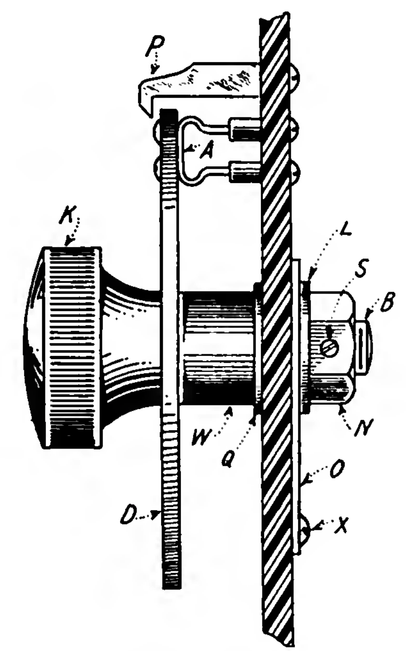
Figure 4—First prize article.

SECOND PRIZE, FIVE DOLLARS—A Simple Dead-End Switch

FROM time to time dead-end switches have been described in the various magazines, all of which will work in theory but in actual practice either fail to work at all or are so impractical as to necessitate their removal. I know, for I have tried some of them.

A practical dead-end switch must be of the type easily constructed because of the limited tool kit which the amateur possesses. Also, it must be rugged, easily repaired, and inexpensive. The one I am about to describe includes all these desirable features.

The knob, K (figure 1) is 1¼ inches in diameter and of composition. It is procurable at any radio supply house for 20 cents. The dial, D, is of bakelite or hard fibre 1/16th of an inch thick and 3 inches in diameter. The pointer, P, is shown at the top of the dial, but may be placed at either side and a scale scratched into the dial and filled in with a paste made of powdered chalk and glycerine. In assembling the rotating unit see that the washer, W, has both faces parallel and perpendicular to the hole. The washer may be a length of tubing with the hole threaded to fit the 2-inch machine screw B, or it may be an ordinary nut. Q and L are washers. Nut N is of brass and as thick as possible. On one face a hole is drilled as far as the center and



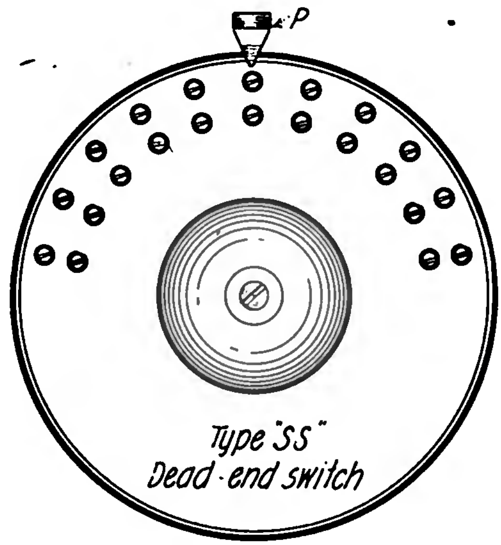
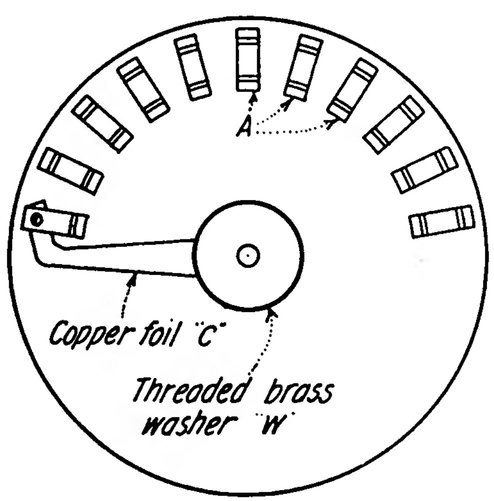


Figure 1 *Second prize article* *Figure 2*

tapped to fit the machine screw S which is employed to lock the nut onto the bolt B so that it *cannot* come off unless the owner unscrews S. No connections are taken from the nut, but are soldered to the brass plate O which is kept from turning by a screw X. The drawings (figures 2 and 3) explain the method of mounting the blades, A, which are of fairly heavy



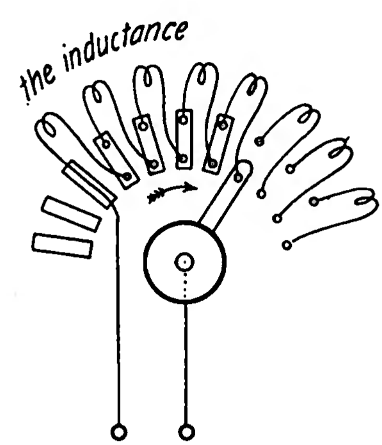


Figure 3 *Second prize article* *Figure 4*

spring brass or phosphor bronze and bent as shown in the end view. Each blade is fastened to the dial by two small machine screws (about 6/32 of an inch).

As raw material is rapidly advancing in price for the experimenter and decreasing in quality and amount, it is advisable to buy at once, even though the switch is not to be used for the duration of the war. A wiring diagram for the switch is shown in figure 4.

Francis R. Pray,
Massachusetts.

THIRD PRIZE, THREE DOLLARS

A Multi Detector

Of all the receiving detectors I have employed in practice I find the one shown in the drawing (figure 1) to be superior to any. It is to be noted in this diagram that the crystals are mounted with cups 1, 2, 3, 4, which, in turn, are mounted on a strip of 1/8 inch brass bent to shape as shown. An upright brass post, A, is mounted on the base; a square rod, B, carries a slider, C, which has a movement on rod, B, of about 2 inches. Mounted on slider C is a piece of elastic metal, D, which carries the contact point, E. Contact point E can also be slid back and forth on the strip, D, as shown at point F. Connection can be made to one terminal of the detector at binding post S and to the other terminal at binding post S-1.

The process of adjustment of this detector is self-evident from the drawing. Crystals of different kinds can be mounted in cups 1, 2, 3, 4, or crystals of various degrees of sensitiveness of the same kind. If crystal No. 1, for instance, becomes inoperative for any reason whatsoever, the operator needs only to pull on the handle, H, and place the contact point, E, on the surface of another crystal. Again, the pressure on the crystal can be adjusted by the knob, K, the rod to which it is attached being threaded.

If the crystal becomes "clogged" by induction from the local transmitter, it is only necessary to take hold of the handle H, raise the contact point E off the crystal and let it return to its original position. Usually, the necessary readjustment is secured immediately.

E. T. Jones, *Louisiana.*

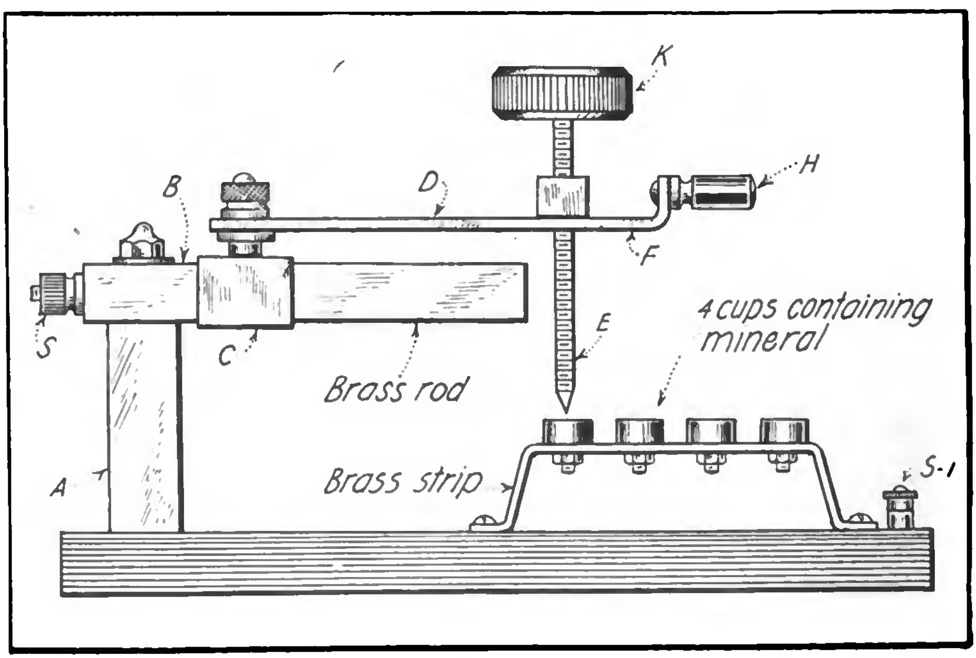


Figure 1—Third prize article

The Monthly Service Bulletin
of the
NATIONAL AMATEUR WIRELESS ASSOCIATION

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

J. ANDREW WHITE, Acting President GUGLIELMO MARCONI, President ALONZO FOGAL, JR., Secretary

Headquarters, 25 Elm St., New York

WHEN a letter addressed to an old-time amateur friend fails to elicit a reply, the possibility suggests itself that he is serving either in the U. S. Navy or with the expeditionary forces in France.

Almost daily, Association officials come in contact with former amateurs who must now be addressed as Radio Gunner Smith, Ensign Jones, Lieutenant Brown, Captain Hicks, and even Major Dobbs. That the majority of these men are highly qualified for the appointments they have obtained is due to the fact that many are college graduates who have had several years of practical experience in radio, or those whose contact with the art in a commercial and amateur way has well fitted them for their undertaking.

Although, so far as actual wireless experiments are concerned, the experimenter is prevented from carrying out a self-educating program at home, he still may secure the necessary practical experience by enrolling in a nearby radio school. Among such schools are those given permission by the naval authorities to operate apparatus with certain minor restrictions which do not hinder gaining a practical education. Numerous vacancies for expert wireless men exist in both Army and Navy. Young men who will shortly come to draft age should not fail to grasp the opportunities thus placed before them.

Full particulars regarding enlistment in either the Army or Navy can be secured from the nearest recruiting office. Skilled men are the requirement of the hour and experience has demonstrated that the recruit who advances most rapidly is the one who has had some practical experience in a wireless telegraph school.

Schools have been established by the U. S. Navy at New York and San Francisco for the purpose of furnishing both radio and general electricians from the enlisted personnel of the Navy. The pay of landsmen for electrician is $17.60 per month while under instruction, and in addition he is furnished with a complete outfit including a uniform, board and lodging, textbooks, tools, and materials with which to work. The length of the course is about eight months.

* * *

JUST now the atmosphere is far from being congested with a mixture of radiograms. Never were the seas so quiet; only essential business is being dispatched, and it is limited in quantity. Radio stations throughout the world are on the alert these days to intercept distress signals or other urgent messages. There are always several vessels within range to effect a rescue, and a call for help never fails to bring response from a land station or coast patrol boat. Through the employment of supersensitive receiving detectors the range of wireless transmitters has been greatly increased, and a call for assistance may now be heard thousands of miles even during the daylight hours.

* * *

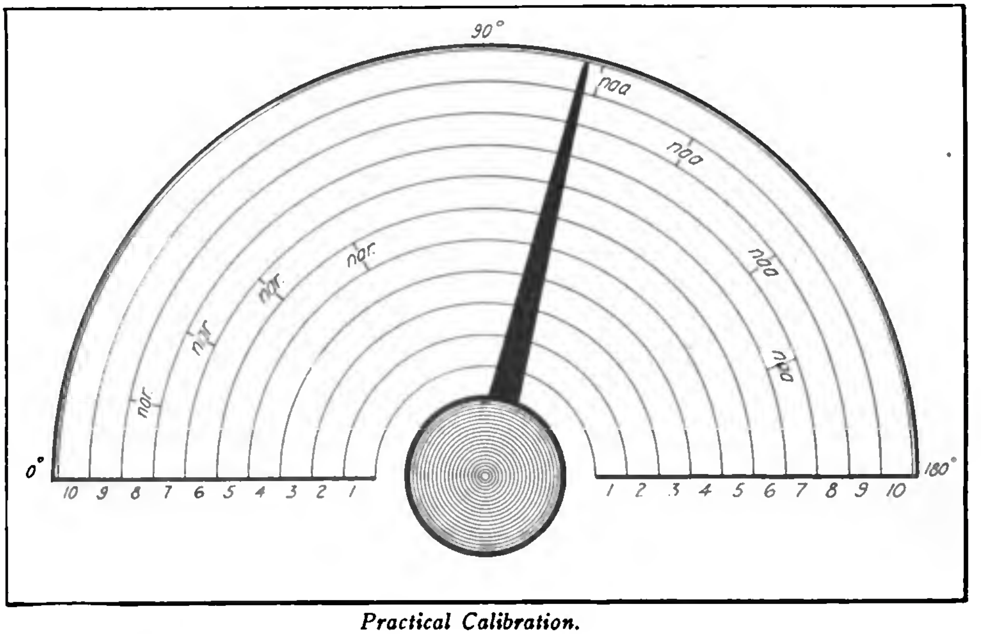
"WHAT constitutes a wireless telegraph equipment?" asks the over-zealous but still patriotic amateur. "Can't I purchase a detector or variable condenser, or construct a high voltage transformer without permission from the Government authorities?"

Positively, No. All or any parts of an apparatus which is eventually to be used in a wireless system come under the embargo, and cannot be constructed, bought, or sold until the end of the war. Should the experimenter desire to construct a piece of apparatus which *might* be used in a wireless system, but is intended strictly for another purpose, the necessary permission may be had by addressing the Communication Superintendent of the nearest Naval District.

The President's order must be strictly observed.

Practical Calibration of the Receiving Tuner

AMATEUR experimenters could work their apparatus with greater ease if they would calibrate the condenser connected across the secondary the point of resonance will be found upon the variable condenser at a different angle of displacement of the plates.



Practical Calibration.

winding of the receiving tuner as per the accompanying drawing. It is well understood that owing to the different amounts of inductance that may be connected in the secondary circuit for a given wave length, different values of capacity must be employed for determining resonance. Hence, for each new value of the secondary inductance,

In the diagram, semi-circles 1, 2, 3, 4, 5 6, etc., represent the taps of the secondary inductance, and the notations NAR, NAA, represent the different points on which a station radiating a given wave length is heard with different values of secondary inductance. I highly recommend this plan to experimenters.

E. T. Jones, *Louisiana.*

The Wireless Man's BOOKSHELF

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$$T = \frac{E \times 10^8}{N \times \Phi \times 4.4}.$$

where $\Phi = A \times B$

A = the area of the cross-section of the iron core

B = the lines of force per square inch

E = the primary E.M.F.

N = the frequency of the current

Φ = the total lines of force.

It is suggested that you allow approximately 30,000 lines of force per square inch in this transformer.

J. A. R., New York City, inquires:

Ques.—(1) Please calculate for me the total magnetic lines of force in a toroidal coil of the following dimensions: The main circumference of the coil is 32 inches. It is wound on 64 turns of wire which pass 10 amperes of current. The cross-sectional area of the toroidal is 2 sq. inches and the permeability of the iron is 3,000 perms per inch cube.

Ans.—(1) The total lines of force

$$= \frac{N \times I \times A \times \mu}{l}$$

Where N = the total turns
I = the exciting current in amperes
A = cross-sectional area of right angles to the flux
l = the length of the magnetic circuit in inches
μ = the perms per inch cube

Hence, the total lines of force

$$= \frac{64 \times 10 \times 4 \times 3.000}{32} = 240,000 \text{ lines.}$$

* * *

J. B. R., Chicago, Ill.:

In a single phase rotary converter maximum alternating current voltage is equal to the normal continuous current voltage. It can be shown mathematically that the effective value of an alternating current is .707 of its maximum value. Hence, if 110 volts are supplied to the motor terminals of a converter, 110 × 70.7 or 77.7 volts will be supplied by the generator assuming no armature losses. Owing to the resistance of the armature conductors, the normal A.C. voltage will be somewhat less—about 70 or 71 volts.

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

Ques.—(1) In the practical operation of a receiving tuner, how does the operator determine the most efficient coupling of the receiving transformer? How can his attention be drawn by a transmitting station operating on a wave length different from that to which his receiving apparatus is tuned?

Ans.—(1) Obviously, the most efficient degree of coupling at the receiver is the one giving the loudest signal. If the receiving detector is adjusted to its maximum sensibility, the loudest signals are secured by merely changing the coupling and readjusting the inductance and capacity in the primary and secondary circuits of the receiving system.

Replying to the second part of your query, it is assumed that the receiving station when not actually taking signals from a transmitter, has its tuning transformer so closely coupled that a number of different wave lengths will be heard simultaneously. Or, on the other hand, if the transmitting operator has some knowledge of the approximate adjustment of the receiving tuner, he might change the wave length of his transmitter to that value and thus attract the attention of the receiving operator.

* * *

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

Isothermal lines are those drawn on the map joining all points having the same temperature. These lines are practically parallel on the ocean, but not so on land, due to changes in topography and therefore the change in the slant of the sun's rays.

Isothermal, Isotheral, and Isochimental lines refer to **mean general, mean summer,** and **mean winter temperature.**

* * *

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On the basis that the atomic weight of hydrogen is unity, the atomic weight of aluminum is 27.4, of copper 63.18, and of silver 107.7. Whether or not this data is sufficient to carry on your calculations, we cannot say, for you have not stated your problem fully.

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

Ques.—(1) Does it make any difference in which direction a motor generator revolves?

Ans.—(1) It makes no difference in so far as the generation of alternating current is concerned, but in some machines the brushes of the motor are such that better contact with the commutator is secured with the motor revolving in a certain direction.

Ques.—(2) What is the best way of reversing the direction of a compound wound motor?

Ans.—(2) The precaution should be taken to reverse the flow of current through the armature only, the connections of the two field windings to the outside line remaining as before.

Ques.—(3) Is it necessary to use protective condensers on a motor generator the wires to which are enclosed in conduit?

Ans.—(3) If the conduit is thoroughly connected to earth, in general, the desired protection will be secured, but it is customary on commercial wireless telegraph transmitters to use protective condensers in addition to the metallic covering. Lead-covered wire is employed in marine installations for connecting up the low voltage circuits.

Ques.—(4) How can a buzzer be employed to make audible undamped oscillations in an ordinary receiving apparatus?

Ans.—(4) The method generally used follows: Excite a wave meter in the usual way by a buzzer and place it in inductive relation to the antenna system. If the buzzer vibrates at a very high frequency, very little sound interference will be secured in the telephone, and the incoming oscillations will be varied at an audio frequency.

Ques.—(5) Which do you consider the better method: to connect a crystal rectifier to the output circuit of a vacuum valve, or to connect a crystal rectifier in the secondary circuit which is coupled to the antenna, attaching the vacuum valve to the local circuit of the rectifier?

Ans.—(5) Either connection may be used, but reports indicate that the best results are obtained by first rectifying the oscillations through the crystal. It is then customary to shunt an audio frequency transformer around the stopping condenser, the secondary terminals of which are connected to the filament and grid of a vacuum valve. A small battery should be connected in series with the grid circuit to obtain the best operating characteristics of the valve.

* * *

A. L. R., Richmond, Va., asks:

Ques.—(1) Please recommend a publication which gives a simple explanation of the principles of electrical engineering, principally the operation and fundamental circuits of dynamos and motors.

Ans.—(1) Dynamos and motor are treated in an elementary way in the book, "Practical Wireless Telegraphy." The book entitled, "Electrical Engineering" by Rosenburg, Gee and Kinzbrunner, will be of some assistance to you. Copies can be purchased from Wireless Press, Inc., 25 Elm Street, New York City.

Ques.—(2) Can the magnets of a telephone receiver be remagnetized?

Ans.—(2) They can be remagnetized by the usual process and increased sensitiveness will be obtained if the telephones have had "rough" treatment.

* * *

P. B. D., Radio Operator, U. S. S. Roosevelt, writes as follows:

"I should be interested to know whether other operators have noticed a phenomenon which seems to me to be more than a chance. I have often observed, while working during the winter months in the North Pacific and Bering Sea in particular, that a decided change of weather such as from stormy to calm, and vice versa, invariably is accompanied by good receiving weather, i.e., no static or atmospherics.

"I have never seen this fact mentioned in radio literature and would like to know whether I am alone in my observation."

We have no comments to offer on this statement, but would be interested to hear if any of our readers have made similar observations.

* * *

J. A. R., San Francisco, Cal.:

The diameter of No. 12 wire in the S.W.G. gauge is .104" or 2.64 centimeters, and at a frequency of 1,000,000 cycles per second its resistance is .0328 ohm per meter. The diameter of No. 44 S.W.G. wire is .0032" or .0081 centimeters.

* * *

L. A. R., Seattle, Wash.:

The capacity of two concentric metal cylinders can be found by the following formula:

$$K = S \frac{L}{2 \log_e \frac{R}{r}}$$

Where K = the capacity in electrostatic units (divided by 900,000 to convert to microfarads).

R, r = the radii of the external and internal cylinders respectively in centimeters.

L = the length in centimeters of part of the cylinders overlapping.

S = the specific inductive capacity of the di-electric (unity for air).

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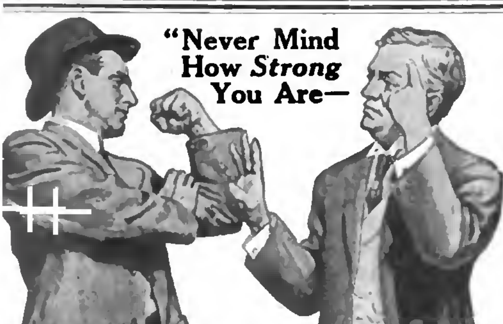

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