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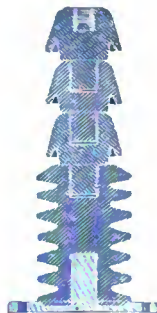
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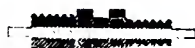
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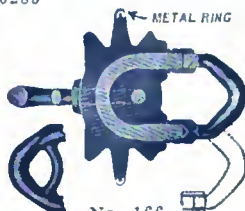
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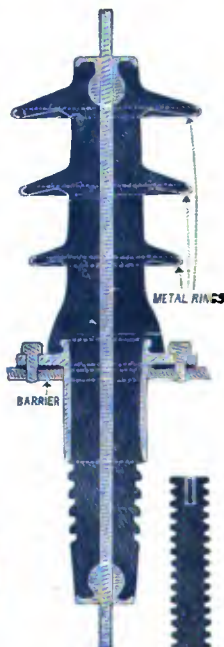
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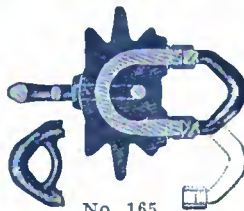
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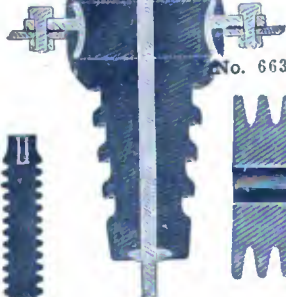
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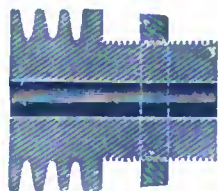
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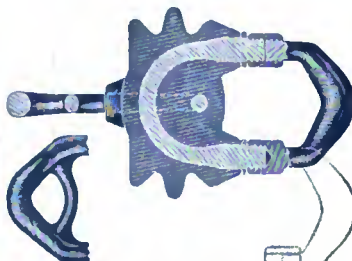
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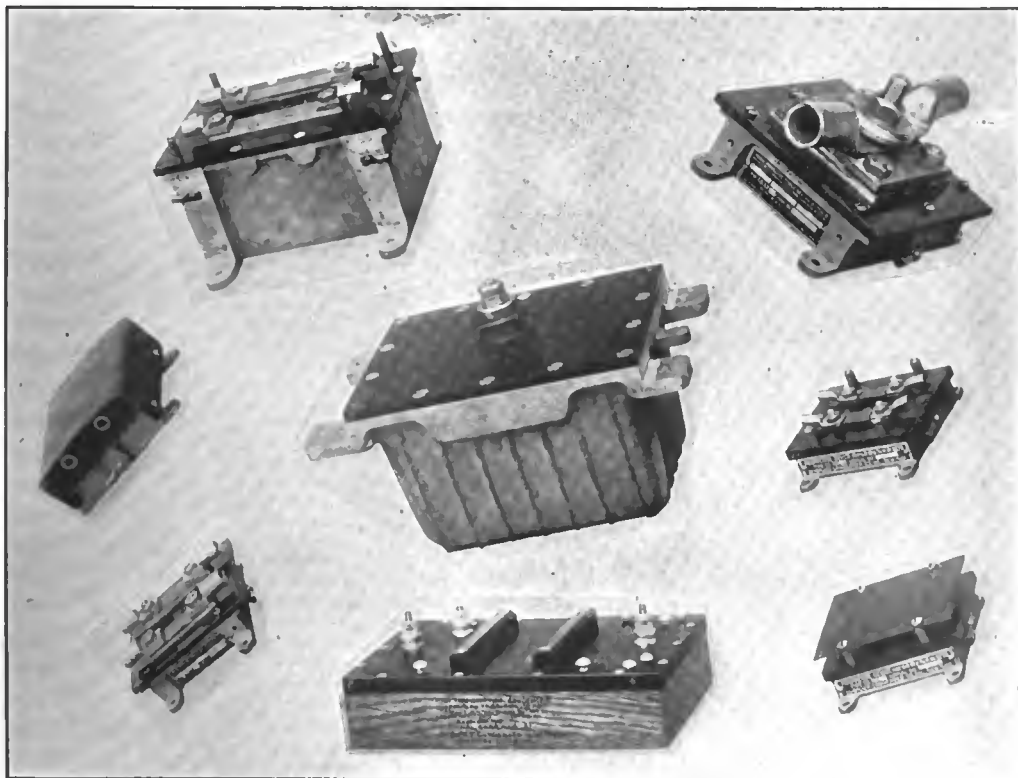
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WIRELESS STATION IN A FRENCH TRENCH



*This view of a French wireless equipment in the second line of trenches is representative of the conditions awaiting American wireless men. The photograph clearly indicates the use of horizontal aerials suspended by pulleys for quick lowering. It is also worthy of note that the antenna is suspended but a few feet above the natural surface of the ground*



# THE WIRELESS AGE

## WORLD WIDE WIRELESS

### Marconi an Advocate of Allied Scientific Board

A VERY big suggestion to America and its allies has been made by Marconi, wizard of wireless and senator of Italy. Edward Marshall, a noted correspondent, to whom the inventor recently made the suggestion while in Rome, characterizes Marconi "one of the great doers of the world, as well as a great and startlingly developed thinker, and in this war, which so very largely is a war of science, he is a greater power than very many people know."

"One of the things which has been evident from the start of the great war," Marconi said, "has been and is the fact that the allies have not co-operated with complete effectiveness.

"I hope and I believe that the entrance of the United States will mean the start of real co-operation.

"Let the United States Naval Consulting Board become the model for an international committee of inventors and executives, which will mobilize the scientific thought and practical achievement of all our brains and hands in the service of the great cause of humanity!

"The great disinterestedness of the United States is what must most appeal to a fair European mind about the course which you have taken in entering the war.

"The American democracy is the greatest in the world. It has the vast material wealth necessary to the conduct of the greatest campaign ever made by any nation since the start of the world's history; that we know it has ideals and fights for them alone I have already indicated; it has developed an inventive genius which has given to humanity many of its greatest scientific and mechanical treasures, including steamship, telegraph, telephone, aeroplane, many of the engines of destruction which are utilized by both sides in this war."

Marconi was told how Edison was asked if he would head a committee for the accomplishment of this in case the government appointed one, and how he said he would, although at that time he was overburdened by the tasks which for a long period followed the great fire which almost wholly wiped out his works at Orange.

Marconi listened closely.

"We must have a similar board, at once, for all the allies," he declared emphatically.

"It would be a wonderful thing if it, also, might be under Mr. Edison's chairmanship. Surely it should have a real American as chairman.

"Thus, although its headquarters probably of necessity would be on this side of the ocean, it would be saved from some of the grave dangers of red-

tapeism which are so likely to surround European efforts at international co-operative organization."

"Would you co-operate fully with a board of that kind?" he was asked.

"I should be glad to," said Marconi.

"Would you serve as member of it?"

"I should be proud to," said Marconi. "Especially should I be proud to if at the head of the great board was Mr. Edison, the most honored son of wonderful America, and loved citizen of all the decent world.

"Now when the allies are confronted by the desperate necessity for real co-operation, the most intelligent model for its development in the scientific aspects of the war is found in the United States."

Of course it will be necessary to select a meeting place somewhere in Europe, for that could be near to the actual battle line, while an American city could not be, and because in Europe there are many allies, while the United States is one.

"Each contributing nation would need to appoint delegates with power and to furnish them with means unstintedly for carrying on new work, as well as with full facilities for learning everything that has been done by every friendly nation, and, as far as possible, the achievements and the failures of the enemy.

"What service such a board might render! Consider, for example, the splendid British tanks. They were infinitely valuable from the start, but it was months before any one of Britain's allies knew anything about them. Indeed that they should have known was quite impossible because of the lack of any medium through which they could be safely and intelligently informed. There have been other episodes as striking.

"Wireless has done much, but is capable of doing more. Too many good minds cannot be trained on it; it is worth the greatest mental effort and experimental industry. These, all, are problems of the sea, and there are many more which do not come into my mind.

"There are as many upon land. There wireless plays a large part, too, and might play an infinitely larger one."

### Holland Has Long-Range Station

JAVA and Holland are now in communication by wireless over a distance of 10,000 miles. A. P. A. Kissing, business man of Batavia, is authority for the statement that the de Groot station at Bandoeng, Java, is transmitting 5,000 words daily to Scheveningen, a seaside resort of The Hague.

Owing to differences between the British and Dutch Governments, regarding alleged exports from Holland to Germany, the British refused to pass cablegrams to the Dutch East Indies, and Java and Holland were left disconnected.

Thereupon the matter was submitted to de Groot, already famous for his experiments in wireless telegraphy. He built a high-power station at Bandoeng, near Batavia, 2,800 feet above sea level, and soon got into touch with Holland.

### Hun Humor In Wireless Defiance

COMMANDERS and crews of the American destroyers operating in European waters are talking about a grim piece of Hun humor. Nearly every night the commander of one of the destroyers receives by wireless a message reading:

"My position is (so many) degrees north and (so many) degrees west.



Come and get me. I'm waiting for you." The message is always signed "Hans Rose."

Rose is the German who took a submarine into Newport two years ago. According to the story passed around by the men engaged in the thrilling and hazardous task of seeking submarines, the captain to whom is directed the nightly messages of the German sub-sea craft, sank two. The commanders of both were intimate friends of Rose. He has sworn vengeance.

It is disquieting for the American commander, but he has no fears. Twice, it is stated, he has swiftly guided his craft to the location described by his enemy, but has found nothing. Still the mysterious wireless dispatch comes every night, no matter where the destroyer may be. Others catch it, and thus the weird story is told wherever the hornets of the sea are seen.

### France and America To Perfect Overseas Communication

THE Navy Department is erecting a high-power radio station in France at a cost of \$2,250,000, which will be ready for operation in August next. The French government will take it off our hands after the war is over. It will be used in connection with the great station fast nearing completion at Annapolis, which will be greater than the one at Arlington, Va. The present French stations are not powerful enough for communication across the Atlantic Ocean, being of about the same power as the station at Arlington. All of the equipment and structural parts are being made in this country for the foreign station. A station is also being built in Porto Rico. The British are establishing a high-powered station in the Azores, which will be valuable as a relay station. At present about 30,000 words a day are possible by wireless, and the new station at Annapolis will add 50,000 words per day. The greater part of the communication at the present time is by cable. If the cables are cut, it is estimated that the Annapolis station and Sayville and Tuckerton would probably be able to take care of all absolutely necessary military business. There is but little necessity for the use of the Pacific coast stations at this time, as practically all of the naval operations are on the Atlantic coast.

### Victor Makes Records

ONE of the many problems of the War Department at the present time is that of securing a sufficient number of competent wireless operators, and arrangements have just recently been made whereby the Victor Talking Machine Co. in co-operation with the Marconi Institute will issue a special set of records to be used for purposes of instruction.

These instruction records were primarily prepared as a part of the courses offered to radio students by the Marconi Institute of New York.

Owing to the unusual demand for skilled telegraphists in the United States Army and Navy, the institute quickly realized that it would be almost impossible to provide training facilities rapidly enough to meet conditions brought about by the war. To meet this emergency this series of lessons on Victor records was prepared in order that students might have the much more frequent opportunities and all the facilities for study which can so readily be afforded by the Victrola, either at home or in camp.

Those who have experimented at all with wireless know that it is rather more difficult to receive correctly than it is to send. The sending operator at least knows what it is that he wishes to say, and it is easy to understand how valuable these Victor records will be to the student.

In the ordinary way it is necessary to have two people at work before the student can get any practice. There must be someone to send as well as

someone to receive, and this difficulty is at once obviated by the use of the records.

Another even more valuable feature of the records is that they afford the student ample practice in receiving under all sorts of "interference." The operation of several wireless instruments in the same area produces a confusion which is known as interference, and which greatly increases the difficulty of receiving correctly. By means of the records the most serious "interference" conditions can be so arranged that the student, through practice, may readily become expert under the most adverse conditions.

### The Cipher Message Which Foretold Lusitania's Doom

THE cipher message which proved that Berlin directed the sinking of the Lusitania is made public for the first time in the World's Work. John R. Rathon, editor of the Providence Journal, which exposed numerous German plots in this country during the last three years, in an article giving in detail the methods he used to unearth the work of the German agents, quotes this message from his files, and explains how it was decoded. The message, in cipher, reads as follows:—

From—Berlin foreign office.

To—Botschaft, Washington:

669 (44-W)—Welt nineteen-fifteen warne 175 29 1 stop 175 1 2 stop durch 622 2 4 stop 19 7 18 stop LIX 11 3 4 5 6.

This cipher message came through from Nauen, Germany, to Sayville, Long Island, at 2 o'clock in the morning of April 29, 1915, and was caught by the operator at a wireless station maintained by the Providence Journal. It was especially interesting because it followed none of the codes which they had previously observed. It was evidently important, because four attempts were made to put it through before the German station succeeded in overcoming the unfavorable static conditions which prevailed that morning. Every attempt to decipher it failed, until somebody with a line on the internal activities of the German embassy remembered that during that morning Prince Hatzfeldt, of the embassy staff, had been looking for a New York World almanac. The first two words of the message "Welt (German for 'world') 1915" supplied the clue. Following the other numbers in the message as representing page, line, and word in the World Almanac for 1915, the Journal men decoded the message as follows:—

"Warn Lusitania passenger (s) through press not voyage across the Atlantic."

Two days later the German embassy printed the now historic advertisement in the New York papers warning travelers not to cross the Atlantic, and a week later, on May 7th, the Lusitania was sunk by a German submarine.

A dramatic touch of suggestion of death in the message lies in the fact that the word not in it is taken from the first sentence of an obituary of the late Joseph Pulitzer, former owner of the World, which publishes the "Almanac." And another grim bit of irony in it is that the last four words were taken from an advertisement of a well known marine motor headed "The Seal of Safety at Sea."

Two words of the message are spelled out in German. They are "warne," which in English is "warn," and "durch," which means "through." The word "Botschaft" is German for "Embassy."

### Italy's Wireless Link With U. S. Established

DIRECT radio communication between an Italian government station in Rome and the Arlington station of the United States Navy here has been successfully established and daily use is being made for communications passing between the two governments.



The daily statements of the Italian war office will be received by radio from Rome and issued here for publication in the United States.

### **English Marconi Maintains Dividends**

**M**ARCONI Wireless Telegraph Co., Ltd. (of London) has declared a dividend of 7 per cent. on the preferred stock and a 5 per cent. Interim dividend on the Ordinary Stock. This is on account of the working for the last year.

Further dividends will probably be declared after the full results for the working of the year 1917 are ascertained.

These are the same dividends as were declared in 1917.

### **Numerous Short-Wave Sets in German Trenches**

**T**HE application of wireless telegraphy and telephony in the present war has undergone marked changes, owing to the unforeseen peculiarities of trench warfare. It was formerly assumed that wireless methods of communication would be unsuitable in such circumstances, owing to the ease with which such messages can be intercepted by the enemy. The tendency has, therefore, been to rely mainly on telephone connection, notwithstanding the ease with which this connection can be ruptured by bombardment. The destructive effect of modern artillery has made the ordinary method of laying wires along the surface of the ground or attaching them to trees of limited utility. Even buried wires are apt to be destroyed at an inconvenient moment by explosive shells, and therefore the depth at which such wires are buried has become continuously greater and the methods of protection more elaborate. The Germans have sought to get over this difficulty by laying a regular network of interconnected lines, according to L'Industrie Électrique, so that in the event of several being damaged there is still a path for the current. Even this precaution, however, may fail in a modern bombardment, and the Germans now appear to be relying to a much greater extent on wireless communication. The article gives particulars which are said to apply to the latest German practice, according to which it would appear that the antennas are mounted four meters above the surface, are about one hundred meters long, and emit waves of three hundred to six hundred meters. On the Eastern front about one hundred and ten wireless detachments are said to be employed.

### **International Strafing a Wireless Possibility**

**W**HY did the German foreign minister, Kuehlmann, speak with annoyance of the Bolshevist use of the wireless in sowing broadcast the propaganda of Lenine and Trotzky?

On his return from Poland Ernest P. Bicknell of the American Red Cross described a peculiar international co-operation in the use of the wireless. Each nation, he said, takes its turn in sending messages, a certain period of the night being set aside for each. All the nations, whether holding with the entente allies or with the central powers, keep out of the air during the periods allotted to others. Mr. Bicknell declared that this was a portentous arrangement, though at the time he did not indicate in what way he thought it might demonstrate its great possibilities.

There seems to be little doubt that the Bolshevist government and perhaps other governments have been flashing to the German wireless stations facts, proposals and suggestions not at all acceptable to Potsdam.

# Radio Science

## A Novel Ammeter

**A** DISTINCT departure from the common methods of constructing current-indicating instruments is the vacuum ammeter shown in figure 1 developed by Marconi's Wireless Telegraphy Company, Ltd., of England. The instrument is particularly suitable for employment as a current gauge to indicate conditions of resonance in wireless telegraph circuits.

The meter possesses a notable degree of sensitiveness. In fact, when it is placed in the circuit of a wave-meter and the inductance coil of the wave-meter is held two feet from the primary winding of the oscillation transformer in a  $1\frac{1}{2}$  K.W. Marconi set, a practically full scale deflection is obtained. A direct advantage of this method in measuring the wave-length of a spark gap circuit is the elimination of the interference due to the noise of the spark which is especially troublesome when a crystalline rectifier and head telephone are used for determining the point of resonance.

The meter is now supplied as a low reading voltmeter or ammeter, or as a shunted ammeter having a normal resistance of about twelve ohms. A special high resistance type has resistance of thirty ohms. The gauges so far manufactured have maximum reading of .11 ampere and .035 ampere and 1.44 and 1.25 volts respectively. The lower limit of the scale in the first instrument is .02 ampere and in the second .007 ampere.

The particular instrument shown in the accompanying drawing is designed to read volts or amperes. The operation of the device follows: Under the tension of the spring, the pointer of the instrument rests in the zero position, but as the filament is heated by current passing through it, the filament elongates and the pointer takes up a new position. The angular displacement of the pointer is a measure of the current. To further protect the apparatus from damage, dust and corrosion, the air is exhausted from the bulb—the device is provided with an Edison screw socket so that the meter can be placed in the conventional type of lamp base.

The meter will soon be available for ranges from 50 to 500 amperes and may be said to constitute a distinct and valuable addition to the line of radio frequency measuring instruments.

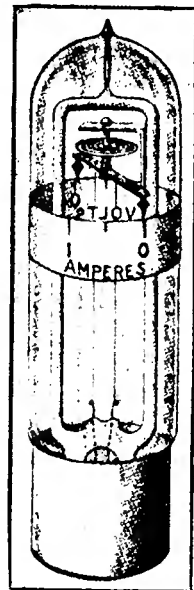


Figure 1—Vacuum ammeter

## High Voltage Condenser for Radio Transmitters

**T**HE most cumbersome part of a wireless telegraph transmitter is the high voltage condenser which not only takes up much space in the operating cabin, but, if of the oil type, is subject to break-down and is very inconvenient to handle.

William Dubilier of New York City has brought forward a type of high voltage condenser which is believed to have sufficient di-electric strength under the strain of the impressed voltage of the average wireless transmitter to absolutely prevent break-down. Another important feature of the condenser is that it is equally applicable to high and low voltages and therefore may be used in radio-frequency circuits of a wireless telegraph transmitter or for measurements in an experimental laboratory.

It will be noted from figures 2 and 3 that the complete condenser unit consists of six sections connected in series; each section consisting of a number of metallic plates separated by thin insulating material such as mica, the individual units comprising a plate condenser being insulated from one another by special insulating separators, as shown at 7 in figure 2. It is to be noted also that the con-

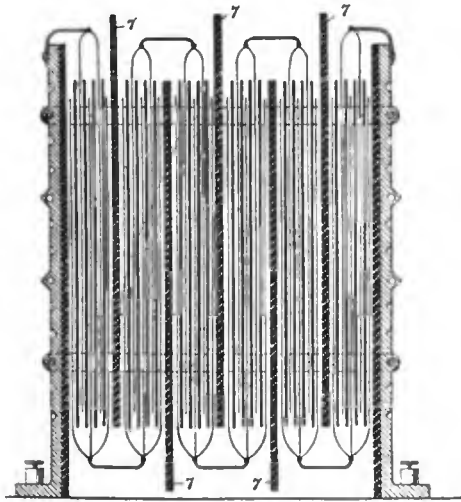


Figure 2

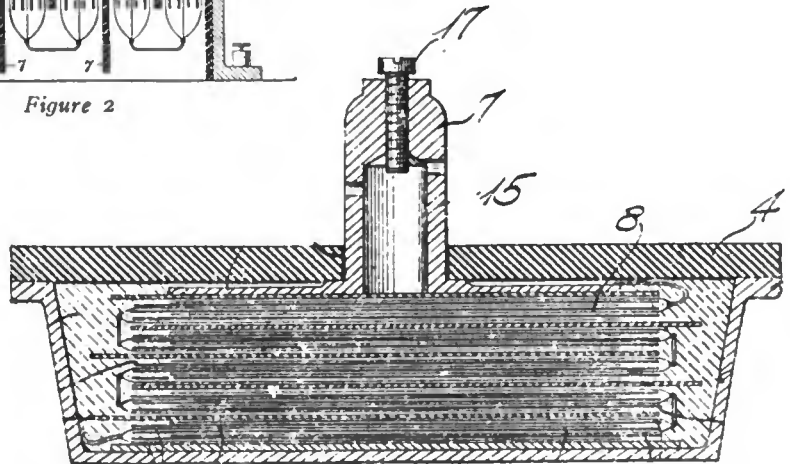


Figure 3

Figures 2 and 3—Two views of Dubilier high voltage condenser

ducting surface of the condensers are placed far enough from the top to prevent the current discharging over the ends.

The inventor points out that the leakage of energy due to brush discharge at high potentials constitutes one of the greatest losses in the ordinary high voltage condenser, and to overcome this, he mounts several condensers in a single

unit; for example, in one type ten sections are connected in series and if the outer terminals are subjected to a potential of 15,000 volts, the potential difference across each section is only 1,500 volts and, as is well known, the brush discharge at this potential is practically nil.

Another loss of energy in the ordinary high voltage condenser is that of leakage due to dampness or moisture accumulating on the surface. The inventor overcomes this by sealing the entire condenser unit in a container and filling it with a melted insulating compound. While the compound is still hot, the condenser tank is connected to a vacuum pump and all air bubbles withdrawn. This may be said to constitute an important feature of construction because in this way air pockets are entirely eliminated and the break-down which usually occurs at these places is prevented.

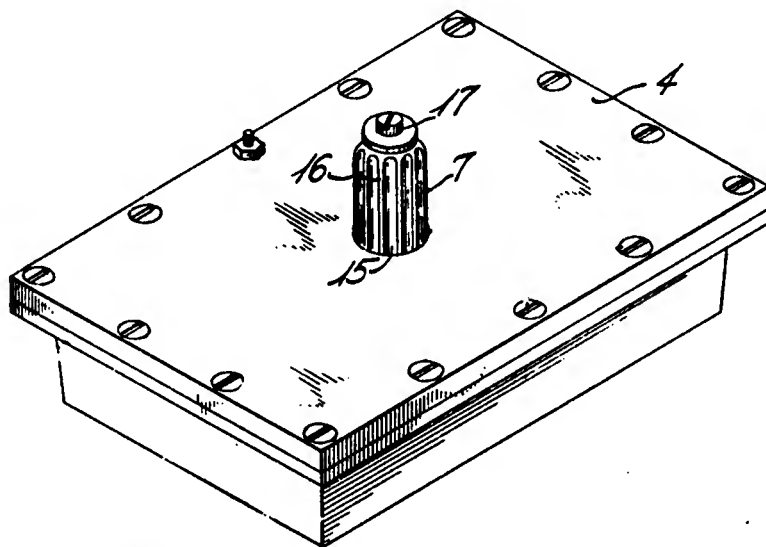


Figure 4—Single unit condenser for high potentials

Although the capacity of several condenser units connected in series in this way is considerably less than that of a single condenser, the required capacity for a given radio transmitter can be obtained by connecting several of such condensers in parallel. Although this condenser requires more plates than the usual type for high voltage purposes, the heat losses are much reduced and the conduction is better, because the power taken by each plate is relatively much less. Since the losses due to brush discharge in any condenser will be proportional to the square of the voltage, it is easily seen that the losses in this condenser will be but a very small percentage of what they would be if the entire line potential were applied to any two adjacent plates. Insulating or di-electric materials other than mica may be employed, but they must be homogeneous and able to withstand the tension and heat which attend high potential currents.

A condenser built in this manner mounted in a single unit is shown in the perspective in figure 4. It is admirably adapted for high potentials with no danger of injury and eliminates the heavy losses heretofore experienced. At the same time, owing to its compactness (due to the thinness of the di-electric) its adaptability for low potentials is maintained to the fullest extent.



**A Receiver for Undamped Oscillations**

**R**OY A. WEAGANT, chief engineer of the American Marconi Company, is credited with the novel system for the reception of damped and undamped oscillations shown in the accompanying diagram, figure 5, in which the antenna circuit and the receiving apparatus are represented by the usual elements. The secondary system comprises the condenser C-5, a loading coil 4, and the secondary

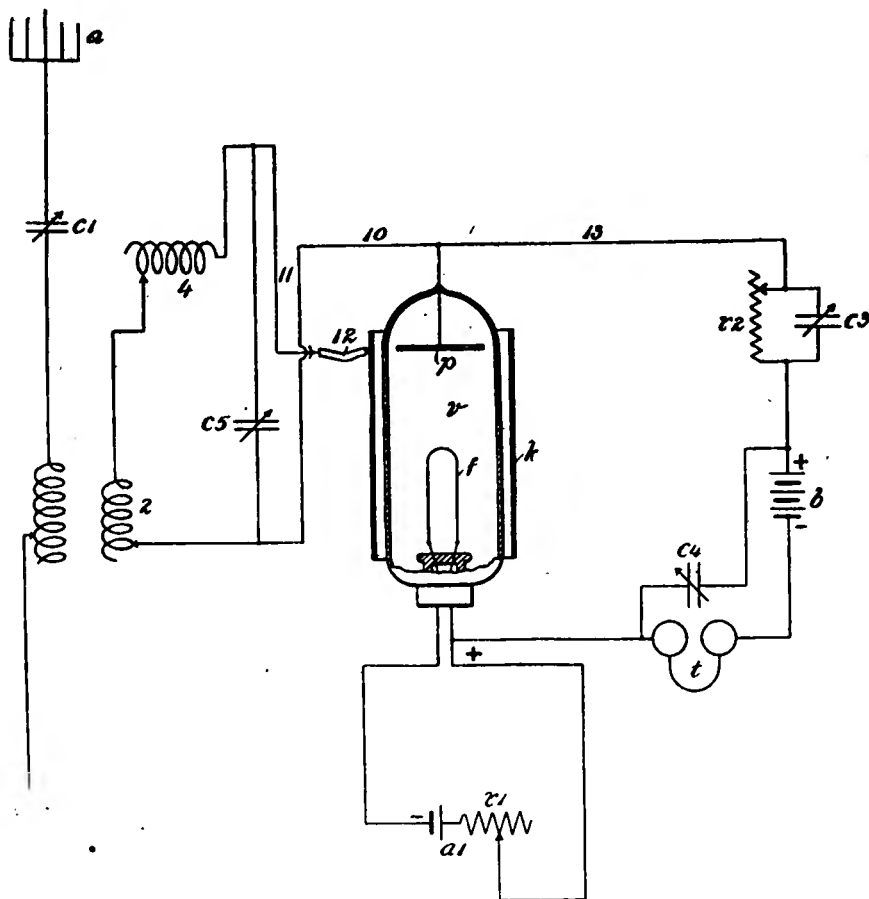


Figure 5—Valve receiver circuit for reception of damped and undamped oscillations

inductance 2. The oscillation valve comprises the plate P, the metallic envelope K, and the filament F. Another feature of this circuit is the plate circuit resistance, R-2, and the shunt condenser, C-3.

The inventor states that by means of this combination of capacity and shunt resistance, he is enabled to adjust the voltage of the plate battery to a value higher than would be possible without its use. A very critical adjustment of the valve is thus obtained, so that the effect of very minute disturbances impressed thereon causes a much greater flow of current through the head telephones. In other words, amplification is secured. It is to be noted from the diagram, that the secondary terminals of the receiving tuner are connected to the metallic envelope K and to the plate P. Correct adjustment of plate battery B, the temperature of

the filament through rheostat C-1, and the capacity of condensers C-3, C-4, and C-5 will cause the valve to oscillate at an audio or radio frequency. Thus, it may be employed as a receiver of undamped oscillations for the production of beat currents. The resistance R-2 in the circuit shown is variable, and must be of the order of the normal resistance of the circuit between the electrodes F and P.

### Open Circuit Oscillators In Receiving Tuners

A RECEIVING system employing so-called open circuit coils has recently been described among the patent issues. One method of connection is shown in figure 6, where the antenna circuit is represented at A, 4, G, the open coils at 5 and 6, and the crystal rectifier at D shunted by the head telephone T. The coils 5 and 6 are wound so that the potentials of their extreme ends will be opposite, as shown.

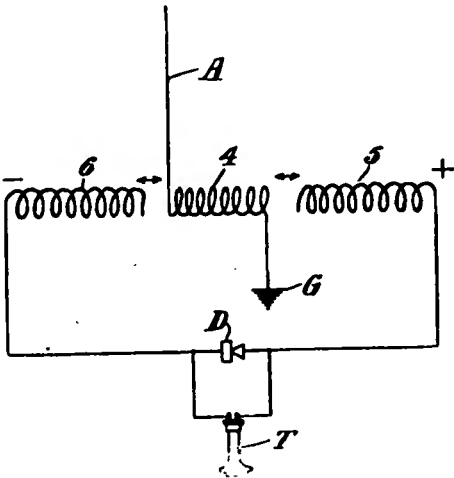


Figure 6—One method of connecting open circuit coils in a receiving system

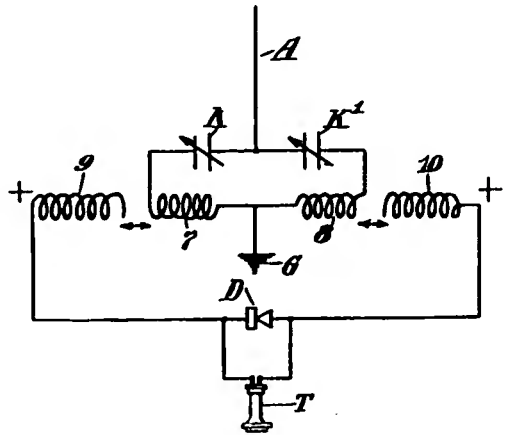


Figure 7—Another method constituting the well-known interference preventer

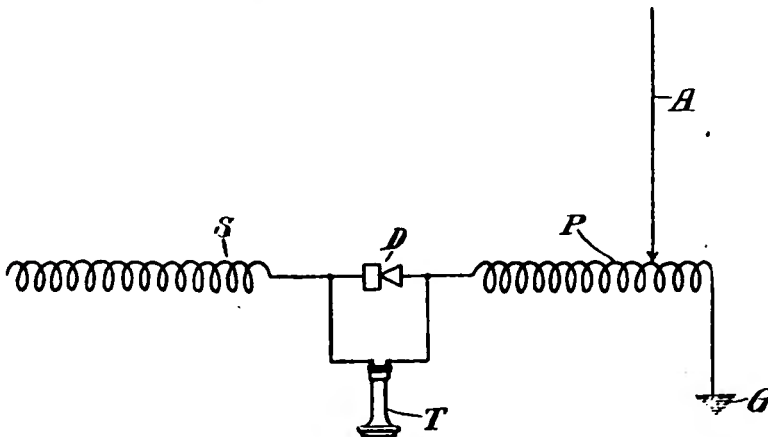


Figure 8—Receiving tuner using a crystal detector

In the practical operation of this system, the operator adjusts the coupling between the antenna coil 4 and the detector coils 5 and 6. Obviously, coils 5 and 6 oscillate by virtue of the distributed capacity between turns.

In the diagram of figure 7, coils 5 and 6 of the first diagram are represented by 9 and 10, being connected to primaries 7 and 8, respectively. This arrangement constitutes the circuits of the well-known interference preventer. Thus, one side of the system may be detuned and signals received on the opposite side, but waves of high decrement are assumed to effect both sides equally.

It is to be noted in the diagram of figure 6, that coils 9 and 10 are connected in opposition.

Another system of reception is shown in figure 8. Here, a long coil P is attached to the antenna connection A and the earth connection G. A crystal detector D is connected between coils P and S which have similar dimensions. Radio frequency oscillations induced in the receiving aerial A cause the circuit G, P, S, to oscillate at a similar frequency, the currents being rectified by the crystal D.

The use of open circuit coils in radio receivers has been previously described in this department.

### An Inclosed Arc of Novel Characteristics

**A**N inclosed arc device possessing an unusually low voltage drop, as shown in figure 9, is the invention of John Clough. The device consists of a low expansion glass envelope (1), such as a sodium-magnesium, boro-silicate glass; the cath-

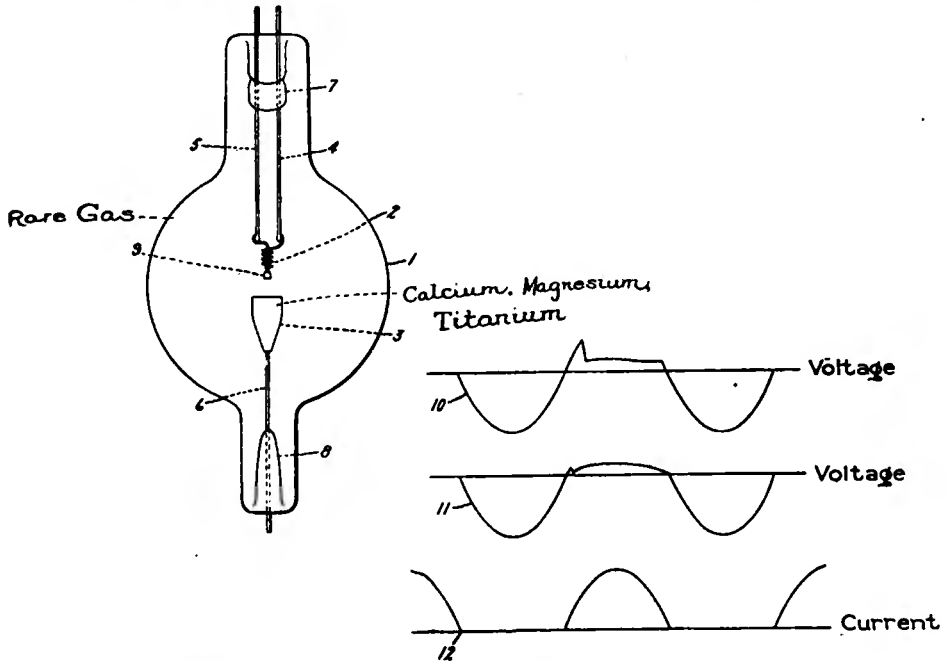


Figure 9—Inclosed arc possessing unusual low voltage drop

ode (2), consists of a highly refractory material such as tungsten, tantalum or carbon. The anode (3) is made up of metallic calcium, magnesium, titanium or other metal highly reactive chemically to gases other than the inert so-called rare or monatomic gases. The filament supply wires are designated at (4) and (5), the anode conductor at (6) which are sealed in the stems. The cathode is preferably provided with a tip (9) having a somewhat greater diameter than the adjoining sections.

In former arcs of this type, the anode was made of refractory metal such as tungsten, carbon, or tantalum; but it has been discovered that if it is constituted in part or entirely of a highly chemically reactive metal such, for example, as cal-

cium, magnesium or titanium, the gaseous atmosphere surrounding the arc consists of a monatomic gas such as argon, neon, xenon, krypton, or helium. A voltage drop in the arc of a hitherto unattainably low value is obtained. When arc devices such as this are operated in series with an external resistance or load, part of the impressed voltage is consumed in the arc itself. This ordinarily is termed the arc drop, the value of which is approximately twenty volts when the anode consists of tungsten. But in an arc constructed after Clough's design, wherein the anode consists wholly or in part of calcium or highly chemically reactive material, the arc voltage may be as low as 4 to 5 volts. In fact, the inventor declares that when argon was introduced into an arc constructed in accordance with his specifications, an 8 ampere arc was produced with the cathode at bright incandescence at a voltage drop of 10.4 volts. After three hours with the calcium anode the voltage drop had decreased to 7.8 volts. With the twenty ampere arc an initial arc drop of 6.9 volts was observed, which in three hours of operation had decreased to 4.5 volts. In a neon atmosphere of about  $\frac{1}{4}$  atmospheric pressure purified by the usual chemical methods, a 10-ampere arc was found initially to have a voltage drop of about 5.8 volts. The chemical effect of the calcium anode reduced the voltage drop to about 12.5 volts in forty minutes.

A remarkably low voltage is required to start the arc of figure 9. A 15-ampere arc, for example, may be formed with a potential as low as 14 volts, provided the temperature of the cathode is 2,500 degrees Centigrade.

In the former type of arc, the voltage must rise to value about double that required to maintain the arc, before it will start and current be transmitted, but as soon as an arc is formed the voltage quickly drops to a lower value and then remains nearly steady until near the end of the half wave when the arc again goes out as the voltage approaches a zero value. But in the improved device, the voltage at the beginning of the wave during which an arc is operating does not rise to a value higher than the operating voltage of the arc. This the inventor believes to be strictly new to the art.

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## Progress In Wave-Changing Devices

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.

The modern transmitters of the Marconi Wireless Telegraph Company of America are designed to radiate three standard waves of 300, 450 and 600 meters. This apparatus is constructed so that these wave-lengths can be instantly changed by merely throwing a switch. The convenience of an apparatus of this type cannot be over-estimated. A great deal of interference heretofore experienced has now been done away with.





# Military Preparedness

## Signal Officers' Training Course<sup>\*</sup>

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

TENTH ARTICLE

By MAJOR J. ANDREW WHITE

*Chief Signal Officer, Junior American Guard*

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### The Camp Telephone

This telephone, which supersedes the field telephone, was developed by the Signal Corps for use in connection with camp telephone systems and small arms target range system, and may be installed in tents and structures, or considered a portable instrument for use in the field for testing lines or other purposes.

It is of local battery type. The battery employed is one unit of tungsten type A. Figures 1 and 2 illustrate this telephone, it being shown dismantled in figure 2 to facilitate identification of parts in connection with the preparation of requisitions for renewals.

The first lot of these instruments was equipped with 2-bar magnetos and due to its limitations the instrument could not be used for long-distance work. The new model of this instrument will be equipped with a 3-bar magneto, employing a special high grade steel for permanent magnets, and while in other features there may be a slight deviation from the following description it is believed that figures 1 and 2 can be used in preparing requisitions, it being merely necessary to state "For Camp Telephone, 3-bar magneto type."

The instrument is made as compact as practicable and is contained in an oak case  $4\frac{1}{4}$  by 7 by 10 inches high. The top consists of a metal hinged cover with circuit diagram on inside, held rigid when closed by a spring snap which can be released by depressing a button. The bottom of case is covered by a flanged piece

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

of metal, the flange projecting approximately one-half inch up sides of case. Through one side of the case are six three-eighth inch holes which are covered on the outside by a close mesh metal screen held in place by a metal frame. These apertures allow the ringer to be distinctly heard. The case is equipped with a substantial, adjustable carrying strap, each end of which is fastened to case by means of hinged metal rings.

A small 2-bar magneto generator, small ringer, induction coil, aluminum chamber for the single unit of tungsten type A dry battery, hard rubber block upon which are mounted line binding posts, plug connections for the hand-set used with the instrument, hook switch and hook operating it and auxiliary battery binding posts are all mounted on a common base which may be readily removed

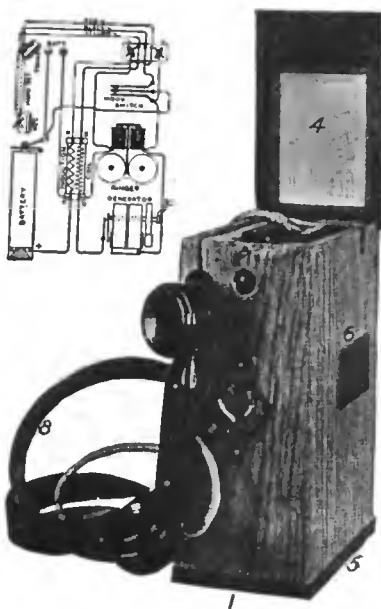


FIG. 1.—THE CAMP TELEPHONE AND ITS CIRCUITS

Key to reference numbers:—1, case; 2, hinged cover; 3, circuit diagram frame; 4, circuit diagram; 5, metal base for case; 6, wire netting frame; 7, wire netting; 8, carrying strap; 9, fitting and ring for carrying strap

from case after removing magneto generator crank, metal housing for it and three screws which extend through the case.

The instrument may be operated with cover closed, which is highly advantageous in inclement weather. To accomplish this there is a suitable opening for leading out the 3-conductor cord to receiver and transmitter, the two latter being mounted in the form of a unit, termed a hand-set. This hand-set consists of a transmitter and receiver mounted on a metal piece and is so designed that when the transmitter is normally placed to the mouth, the receiver is automatically adjusted to the ear.

The hook of the hook switch is so designed that it protrudes through case. When it is desired to transport the instrument or to remove the base upon which is mounted all the parts of the instrument, it is merely necessary to depress the hook and push it toward the base. By this arrangement the hook is not only held in the down position, thereby opening the battery circuit, but it is also protected.

The aluminum chamber for housing the single unit of tungsten type A battery is equipped with a spring catch so located that when upper hinged piece is depressed to proper position the battery compresses a helical spring, thereby insuring continual contact. The base is equipped with two screw binding posts which may be used to connect leads to an outside battery in the event of there being no tungsten type A batteries available.

An aluminum frame, which is supported on the base previously mentioned,

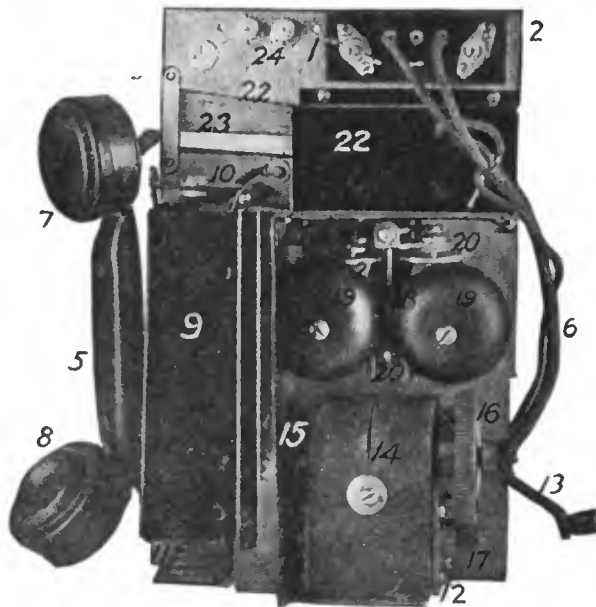


FIG. 2.—CAMP TELEPHONE, DISMANTLED

*Key to reference numbers:—1, base; 2 connecting block with binding posts; 3, binding post; 4, socket for hand-set cord; 5, hand-set; 6, hand-set cord; 7, hand-set receiver; 8, hand-set transmitter; 9, battery case; 10, battery-spring catch; 11, battery spring and support; 12, magneto; 13, magneto crank handle; 14, permanent magnet for magneto; 15, contact spring; 16, magneto gear; 17, magneto pinion; 18, ringer; 19, gong; 20, hammer and armature for ringer; 21, ringer coils; 22, case for hook switch; 23, switch hook; 24, binding posts for external battery*

forms a compartment for the hand-set when instrument is being transported. When the instrument is installed for a temporary period, unless in actual operation, the proper place for the hand-set is hanging on the hook of hook switch, there being a ring on the hand-set for this purpose.

A small screw driver which will fit practically all screws used in the construction of the instrument is supported by the metal frame and is furnished with each instrument. The instrument complete weighs approximately 11 pounds.

### The Service Buzzer

The buzzer is strictly a portable instrument and is issued to troops in the field for use in connection with all kinds of communication. It may be used as a telephone or for sending Morse or Continental Code signals, and for that reason it is specially adapted for field use.

When it becomes impracticable to transmit messages telephonically, due to the line becoming impaired or for other reasons, the usual telegraphic signals can be transmitted and are received in distance telephone receivers in the form of a

high-pitched hum, somewhat similar to radiotelegraphic signals. These signals have been exchanged between two of these instruments after the wire line had been severed, both the ends, however, being slightly grounded.

The service buzzer, which is the latest approved instrument of this type of apparatus, replaces the field buzzer, the cavalry buzzer and the field artillery telephone and hereafter is the standard issue.

A circuit of high E. M. F. is obtained by means of two coils of wire wound on a soft iron core in connection with the telephone. This method may be termed mutual induction and is employed in the service buzzer. A high E. M. F. can be obtained by means of one coil of wire wound on a soft iron core, the latter method being termed self-induction. In order that operation of the service buzzer may be clearly understood, the theory of the field buzzer will first be explained.

The principle upon which the original *field buzzer* operates depends upon the effects of self-induction, i. e., the comparatively high self-induced voltage developed at the terminals of an electromagnet (coil with iron core) when the current through the circuit is suddenly interrupted. The interruptions are automatically produced by a circuit breaker, which is described later. During the interval of time required for the current to reach its maximum value, the field of force expands in direct proportion to the current strength until it also reaches maximum value. The current strength being kept constant, the magnetic field is of constant value. Any variation in current strength produces a corresponding variation in the strength of the magnetic field; therefore, when the circuit is broken and the current rapidly falls to zero the field of force also collapses and disappears. The energy furnished by the current and stored up in the magnetic field is thus returned to the circuit and tends to sustain the original current, as is noticed by a bright spark appearing at the point of break.

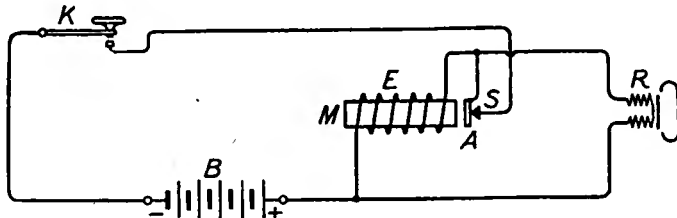


Figure 3—Simplified circuit of field buzzer

On "make," then, the whirls spring out from and cut the wire, inducing therein a current opposed in direction to inducing current. On "break" the whirls collapse, again cutting the wire and inducing therein a current having same direction as inducing current. The phenomena resulting from such cutting of a wire by magnetic lines of force is called self-induction.

When the circuit contains a coil, the effects of self-induction are much greater. If the coil contains an iron core the effects of self-induction are still more pronounced.

To make clear the action of the buzzer, let us consider the diagram, figure 3: *B* is a battery of five dry cells; *K* is a key for making and breaking the circuit; *E* an electromagnet; *R* a telephone receiver.

When the key is closed there is a rush of current which reaches its maximum strength almost instantly. Simultaneously there is built up a magnetic field of force around the electromagnet. Now, if the key be opened, a pronounced click, of momentary duration, is heard in the receiver, which is caused by a self-induced current of high E. M. F. produced by the collapse of the magnetic field around the coil. This induced current would spark across the break at the key if there were not an alternate complete circuit through the receiver.

The more rapidly the circuit is made and broken by closing and opening the key, the greater the rapidity with which clicks in telephone follow one another,



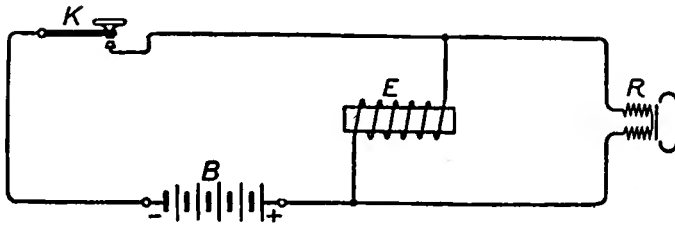


Figure 4—Field buzzer simplified circuit with interrupter

until, if the interruptions recur sufficiently often, the sounds in the receiver appear to be almost continuous.

If we introduce an automatic interrupter into the circuit (fig. 4), a loud buzzing sound is heard in the receiver whenever the key is closed, and the dot and dash of the Morse alphabet are thereby produced by making short and long contacts with key.

The action of the interrupter or circuit breaker is as follows:

When the circuit is made by closing the key *K*, the current flows through coils of the electromagnet *E*, magnetizing the iron core *M*, which, in turn, attracts armature *A*. As soon as the armature is withdrawn from contact *S* the circuit is broken; as a result, the core becomes demagnetized and armature *A* springs back against *S*, thus again closing the circuit. The action continues so long as key *K* is kept closed.

If instead of the interrupter we substitute therefor a transmitter (fig. 5), then when the key is closed current flows from + side of the battery through the coil to the lower disk (stationary) of transmitter, through loosely packed carbon granules to upper disk (movable), which is attached to the diaphragm, to key, to — side of battery.

Except when this circuit is first made, there is no evidence of self-induction in the circuit until the transmitter is spoken into, then the sound waves of the voice striking the diaphragm cause it to vibrate. The carbon granules between the carbon disks are thus subjected to varying pressure; this causes a variable resistance in the circuit, and the resulting current is a pulsating one (uniform in direction, but varying in strength). The effect of the varying current passing through the circuit is to increase and decrease the field of force built up around the wire. This changing field of force in turn produces the effects of self-induction, and these effects are particularly noticeable in coil *E*.

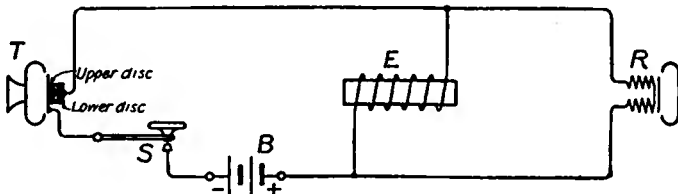


Figure 5—Simplified circuit of field buzzer with transmitter

The inductive property of the coil is thus employed to augment the comparatively weak primary current to one of high E. M. F., which intensifies the vibration of the receiver diaphragm, these vibrations being received by the ear as articulate speech.

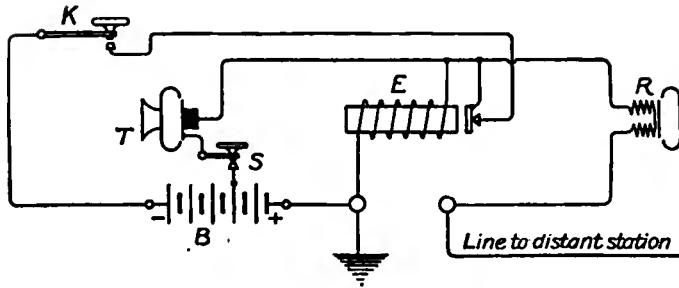


Figure 6—Simplified circuit of field buzzer with transmitter and interrupter

The sounds thus produced are not as loud as those produced by the interrupter, even though the same number of cells are used, for the reason that in the latter case the current is completely interrupted (circuit broken), whereas, in the case of the talking circuit, current is always flowing but is varied in strength; therefore the resulting field of force never reduces to zero, the cutting of the wire is consequently less, and the effects of self-induction are diminished.

If we now combine the two circuits described in one diagram we have the simplified buzzer diagram which is shown in fig. 6.

An examination of this figure shows that the only change made is the introduction of two terminal binding posts, one of which is connected to the line, the other to the ground: If a similar instrument is connected at the distant stations, the currents traversing the home receiver also pass through the distant receiver.

The utilization of existing telegraph lines as a part of or the whole of a circuit for buzzer and telephone working, at the same time not interfering with the use of a wire for Morse working, may be effected by using condensers interposed between the line and the buzzer. See fig. 7.

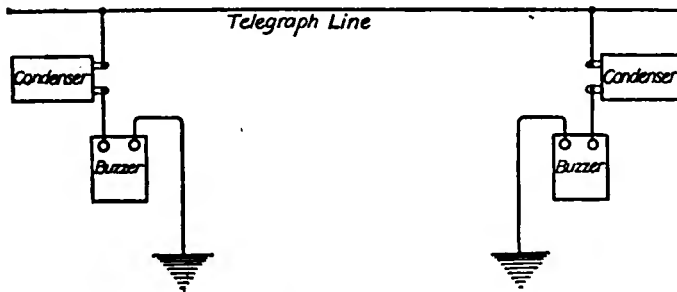


Figure 7—Buzzers connected to a telegraph line

The pulsations of the ordinary Morse sending are comparatively slow. The condensers, therefore, act as a very large resistance, and no appreciable effect will be noticed in the telegraph line.

The very rapid pulsations produced by the buzzer or transmitter, however, will permit of transmission from one buzzer to the other with little diminution of sound.

Figure 8 shows the circuits of the service buzzer. It will be noted that with the field buzzer if a line of low insulation resistance is utilized a heavy drain on the battery will ensue, due to the battery being connected to the line, while with the service buzzer under like conditions a heavy drain will not exist, due to the battery being connected in a local circuit which does not physically connect with the line. It will also be noted that a condenser which can be cut out by means of a short-circuiting switch is contained in the instrument and connected in series with the

line. This condenser is for use when it is desired to use an existing telegraph line. (See fig. 7.) Two units of tungsten type A dry battery are used with the service buzzer for furnishing the necessary primary current, both being in circuit when sending telegraphic signals, and one only being in transmitter circuit for telephone communication.

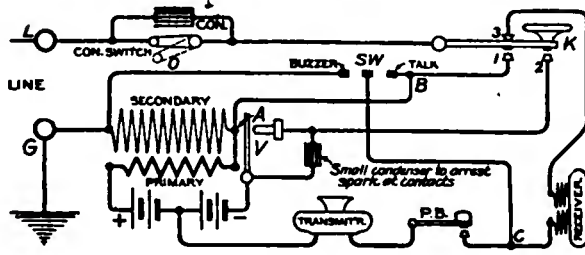
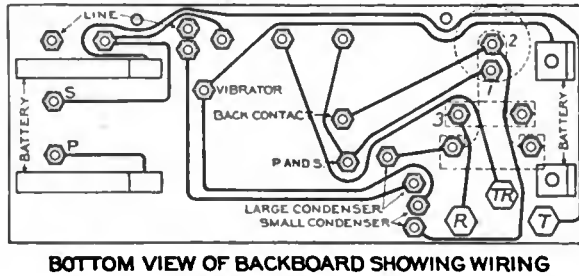


Figure 8—Service buzzer circuits

The circuits of the service buzzer may be classed as follows:

- Primary sending circuit—telegraph.
- Secondary sending circuit—telegraph.
- Receiving circuit—telegraph.
- Primary sending circuit—telephone.
- Secondary sending circuit—telephone.
- Receiving circuit—telephone.

These circuits may be traced as follows, reference being made to figure 8:

**Primary Sending Circuit—Telegraph**

*S. P. D. T.* knife switch marked "Sw" must be closed on side marked "buzzer." Upon depressing key *K*, circuit is as follows: Positive end of battery, through primary induction coil, to *A* to *B*, contact 1 of key, lever of key, contact 2, vibrator, to negative end of battery.

**Secondary Sending Circuit—Telegraph**

*S. P. D. T.* knife switch marked "Sw" is closed on side marked "buzzer." An A. C. current of high E. M. F. is induced in the secondary winding of the induction coil by interrupted current in the primary and its path is as follows: *G*, earth or one side of line (if metallic circuit is used); "receiving circuit, telegraph" of distant buzzer, other side of line, *L*, contact 1 of key (key is depressed), *B*, *A*, other side of secondary winding of induction coil.

**Receiving Circuit—Telegraph**

*S. P. D. T.* knife switch marked "Sw" is closed on side marked "buzzer." A. C. current of high E. M. F. reaches *L* from distant instrument by one side of

line, contact 3 of key (key raised), receiver, *C*, switch marked "*Sw*" *G*, other side of line to distant instrument.

### Primary Sending Circuit—Telephone

*S. P. D. T.* knife switch marked "*Sw*" is closed on side marked "talk"; from positive end of battery through primary winding of induction coil, to *A*, to *B*, through blade of switch marked "*Sw*" to *C*, through push-button switch marked "*PB*," through transmitter to negative side of one unit of the tungsten type *A* battery.

### Secondary Sending Circuit—Telephone

*S. P. D. T.* knife switch marked "*Sw*" is closed on side marked "talk." When sound waves fall upon the diaphragm of the transmitter, an alternating current of high *E. M. F.* is induced in secondary winding of the induction coil. Starting with secondary of induction coil, to *G*, to earth or one side of line (if metallic circuit be used), through "receiving-circuit-telephone" of distant instrument, returning on other side of line, to *L*, through contact 3 of key marked "*K*" (key raised), to receiver, to *C*, to switch marked "*Sw*," through blade of this switch to *B*, to *A*, to other side of secondary winding of induction coil.



Figure 9—Service buzzer

### Receiving Circuit—Telephone

*S. P. D. T.* knife switch marked "*Sw*" is closed on side marked "talk." An alternating current of high *E. M. F.* induced in the secondary winding of induction coil in distant instrument reaches the buzzer over outside line, to *L*, thence to contact 3 of key marked "*K*," to receiver, to *C*, to switch marked "*Sw*," through blade of this switch to *B*, to *A*, through secondary winding of induction coil to *G*, to earth or line (if metallic circuit be used), to distant buzzer.

When an existing telegraph line is utilized, the switch marked "*con sw*" should be thrown to the "*O*" position in order that the condenser "*Con*" will be placed in the circuit.

The service buzzer is shown in accompanying figures 9 and 10, it being shown dismantled in figure 10 to facilitate preparation of requisitions for renewal parts.

The instrument is contained in an aluminum case fitted with a hinged cover, both of which are covered externally with a russet-colored, smooth-finished leather which is neatly sewed and riveted in place. The overall outside dimensions of the case are approximately  $3\frac{1}{4}$  by  $5\frac{1}{4}$  by  $7\frac{1}{2}$  inches. The two units of tungsten type *A* battery are contained in a chamber located in the bottom and are accessible without opening the main cover, there being an additional small hinged cover in one end of case which is fastened securely, when closed, by a substantial spring clip, and by a flap of leather.

The instrument may be operated with both covers closed, which is highly advantageous in inclement weather. To accomplish this there is a suitable opening for leading out the cords to the receiver and transmitter, and in main cover, directly over the sending key, is a round aperture which is made moisture-proof by means of a covering of extremely flexible pigskin. The sending key can be readily operated through this flexible pigskin.

The sending key, induction coil, condensers, plug jack, transfer switch, vibra-

tor, and binding posts for transmitter and receiver cords are mounted upon a common base of hard rubber. Wiring to the component parts is routed in the under side of this base, which is mounted in the front of the case above the battery chamber previously mentioned. In the rear of the instrument is a compartment of leather for containing the transmitter, receiver, and cord for connecting them. At one end of this chamber, neatly mounted on a hard rubber strip, is a socket wrench for adjusting the nuts which secure the transmitter and receiver terminals, also two screw drivers—one large and one small—which are so constructed that the shanks may be inserted in the end of socket wrench, thereby using the socket wrench as a handle.

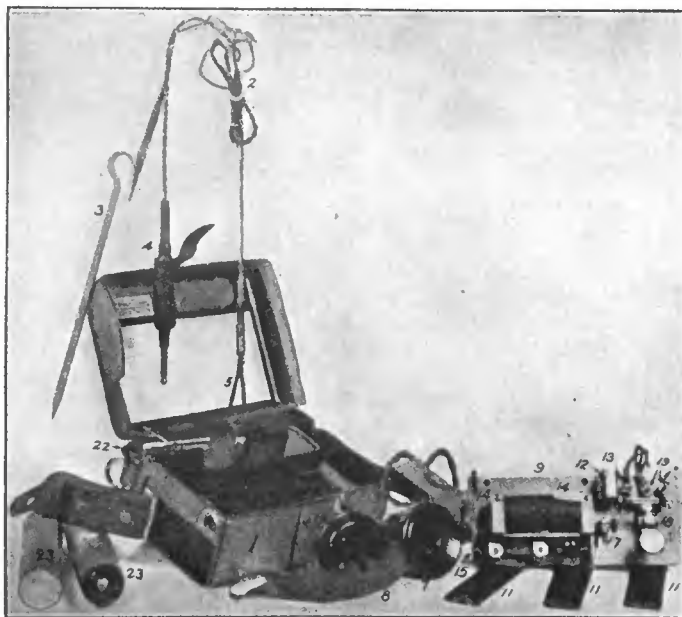


FIG. 10.—SERVICE BUZZER, DISMANTLED

Key to reference numbers:—1, case; 2, main cord with terminals; 3, ground rod, type D; 4, plug; 5, connector, type A; 6, transmitter; 7, receiver; 8, head band; 9, base; 10, induction coil; 11, condensers; 12, condenser connecting blocks; 13, short-circuit switch; 14, holding clip; 15, jack plug; 16, transfer switch; 17, vibrator; 18, sending key; 19, binding post; 20, large screw driver; 21, small screw driver; 22, handle for screw drivers and wrench; 23, tungsten battery, type A

Invariably there is furnished with this instrument a two-conductor cord, approximately 5 feet long, one end of which is equipped with a substantial plug similar to those used in connection with telephone switchboards. At other end one of the conductors is equipped with a Williams test clamp for connection to line, the other conductor being equipped with a Signal Corps type D ground rod. The Williams test clamp is so constructed that to attach it to the line, it is merely necessary to compress the two principal parts, releasing them when the line has been inserted in space provided. One side of this clamp is equipped with an 11-point stud securely threaded to test clamp. These points make excellent contact on line, regardless of whether the line be insulated or not. By this means a quick connection can be made to buzzer wire or field wire which is insulated, and when the clamp is removed the abrasion to insulation is negligible. There is an opening in the case of the buzzer through which the plug is inserted when connection is desired, and when plug is so inserted it makes a positive connection by means of a substantial jack mounted on the base as previously indicated.



# Wartime Wireless Instruction

## A Practical Course for Radio Operators

### ARTICLE XI

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By Elmer E. Bucher

*Instructing Engineer, Marconi School of Instruction*

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**EDITOR'S NOTE**—This is the eleventh 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.

## SPARK DISCHARGERS

(1) The efficiency of a radio transmitter for the production of damped oscillations depends largely upon the design of the spark discharger. Hence, it is important that it be constructed in accordance with certain fundamental principles.

(2) The functions of the spark gap are:

- (1) to keep the closed oscillation circuit idle until the condenser is fully charged;
- (2) to discharge the energy stored up in the condenser in the form of radio frequency oscillations;
- (3) to quench the oscillations in the closed oscillation circuit or, in other words, to restore the gap to its non-conducting state after the energy of the condenser has been most effectively transferred to the aerial circuit.

(3) Previous to the discharge of the condenser, the resistance of the spark gap is infinite, but as the air surrounding the electrodes is burnt by the spark discharge, the resistance falls rapidly. The charge in the condenser, however, is soon emptied and as the oscillating current decreases, the resistance increases until the voltage of the primary circuit becomes so low that the spark can no longer bridge the gap. The primary oscillations then cease.

(4) It is due to the lag in the cooling of the gap electrodes and the dissipation of the burnt gases that the current oscillates in the primary circuit. If there were no lag in the cooling, i.e., if the burnt gases surrounding the electrodes were immediately removed the non-conducting state of the gap would be restored after the first half cycle of the radio frequency current. The lag in cooling, however, permits the current to oscillate through a number of cycles before the oscillations cease.

(5) The most efficient spark gap is one designed to remain conductive until the energy of the condenser circuit is transferred to the aerial wires. When the energy of the closed circuit has been transferred to the antenna, the non-conducting state of the gap should be restored immediately.

(6) Retransference of energy from the aerial wires to the closed circuit is thus prevented. Greater efficiency results thereby, because the antenna oscillates at its own natural frequency and damping.

(7) If the non-conducting state of the gap is not restored at this moment, there will be an interchange of energy between the open and closed oscillation circuits, which causes the antenna to oscillate at two frequencies resulting in the radiation of two waves. Double wave emission obviously causes unnecessary interference.

(8) Speaking generally, a spark gap designed to transfer the energy from the spark gap circuit to the antenna circuit in one or two cycles and to become non-conductive at such a time that no retransference of energy from the antenna circuit can take place is said to quench the primary oscillations. Such a transmitter will radiate a single wave.

(9) Quenching of the primary oscillations may be obtained in several ways:

- (a) by breaking up the spark discharge into several short gaps no more than .01 of an inch in length;
- (b) by cooling the gap by rotating the electrodes;
- (c) by applying a blast of air directly to the spark discharge;
- (d) by correct design of the generator and transformer or both to prevent arcing at the spark gap;
- (e) by reduction of the coupling at the oscillation transformer.

In some systems all of these means are employed simultaneously and in others only in part.

(10) Correct design of the alternator and transformer assists greatly the quenching of the primary oscillations. It must be remembered that the transformer secondary is practically on short circuit when the spark discharges across the gap. Hence, unless the source of energy possesses a certain amount of magnetic leakage either in the dynamo, in the transformer, or in the primary or secondary reactance coils, or the possibility of short circuit is prevented by the insertion of resistance, the quenching will not be reliable. In this case, the spark discharge will be followed by a certain amount of transformer arc which will prevent quenching unless very loose couplings are employed between the primary and secondary of the oscillation transformer.

(11) The application of an air blast, careful adjustment of the length of the gap, and reduction of the coupling will quench the primary oscillations and give single wave emission with any type of gap. But with gaps designed especially to obtain these results, quenching is secured with very close couplings at the oscillation transformer and increased efficiency is thus obtained.

(12) Quenching of the primary oscillations is secured with the following types of spark gaps:

- (a) The non-synchronous rotary spark discharger.
- (b) The synchronous rotary discharger.
- (c) The multi-plate or series discharger.

(13) In addition to quenching, the non-synchronous rotary gap affords a spark note of musical pitch from a low frequency charging current such as 60 cycles.

(14) In addition to providing a uniform spark discharge the synchronous spark gap discharges the condenser once for each alternation of the charging current, thus giving a more uniform note than the non-synchronous gap. The multi-plate gap gives synchronous discharges if the alternating voltage is properly adjusted, and very effective quenching even when the open and closed oscillation circuits are closely coupled. The plain or simple spark discharger comprising two simple electrodes is now employed only in event of emergency. Quenching effects can be obtained from the plain discharger by applying an air blast at a great velocity to the electrodes.

### SPARK NOTE ADJUSTMENT

(1) The next important consideration in respect to spark gaps, particularly from the viewpoint of commercial operation, is the adjustment of the spark pitch or note. In brief, the pitch of the spark is reproduced in the telephone at the receiving station. Thus, 1,000 sparks at the transmitter will impulse the diaphragm of the telephone receiver 1,000 times.

(2) There are two principal reasons for employing high pitched spark notes:

- (a) the telephone diaphragm gives greater response when impulsed at rates from 700 to 1,000 times per second;
- (b) a high pitched spark note enables the receiving operator to distinguish radio signals from the crashing sounds of atmospheric electricity.

With different types of dischargers, clearness of tone is secured in different ways. The best tones are secured from apparatus harmoniously designed from the generator to the spark gap. Methods of spark gap adjustment will be presented in the explanation of the drawings to follow.

### OSCILLATION TRANSFORMERS

(1) The transformers employed to transfer energy at radio frequencies to the antenna circuit offer a striking contrast to those used for transformation at lower frequencies. The former types generally consist of a few turns of copper tubing or copper strip wound in the form of a solenoid or a pancake. They are called radio frequency transformers. They do not possess iron cores although such cores have been employed for radio frequencies between 10,000 and 100,000 cycles.

(2) **Transmitting oscillation transformers** are either of the **conductive or inductive type**. Electrostatic coupling has been employed but not extensively. The **conductive type** may comprise a **single coil or helix** or a **variometer inductance**. The **inductive or two-coil type** may take various shapes and forms as will be shown in the drawings to follow.

(3) In the construction and design of oscillation transformers, some of the essential points to be considered are:

- (a) The conductor of the primary and secondary coils must have good surface conductivity.
- (b) The inductance of either circuit should be continuously variable, i.e., the coils are preferably fitted with sliding contacts so that the turns of either winding can be cut in or out of the circuit inch by inch.
- (c) The coupling between the primary and secondary coils must be easily altered.
- (d) The coils must be well insulated between turns to avoid leakage.

### HIGH VOLTAGE CONDENSERS

(1) Three types of high voltage condensers have been employed:

- (a) The glass plate tin foil condenser.
- (b) The copper foil-micanite condenser.
- (c) The copper plated glass jar condenser.
- (d) Compressed air condenser (plated in tank under 250 lbs. pressure).
- (e) Air condenser (using air at atmospheric pressure as dielectric).

(a), (d) and (e) are employed in connection with high power transmitters. (b) and (c) are used principally for low power marine type of transmitters. (d), however, is not widely used.

(2) For low power transmitters, the **Leyden jar type of condenser** is almost universally employed. A single section of the average condenser using glass as the dielectric whether of the plate or Leyden jar type will withstand potentials up to 15,000 volts without breakdown of the dielectric. If the applied potential exceeds this value, **series parallel connections** are employed.

### SHORT WAVE CONDENSERS

(1) In general, the antenna condenser must withstand a high potential; hence, four or five jars or plates are connected in series.

(2) For the average ship's aerial the short wave series condenser should be approximately .0005 microfarad.

### AERIAL TUNING INDUCTANCES

(1) This coil may be of the **continuously variable type** wound in the form of a spiral pancake or in the form of a hoop or helix. Aerial tuning coils for the transmitters must have good insulation between turns and the conductor must have good surface conductivity.

(2) The most popular form at present is the "pancake" type made up of copper strip. A sliding contact controlled by a convenient handle permits the turns to be gone over inch by inch.

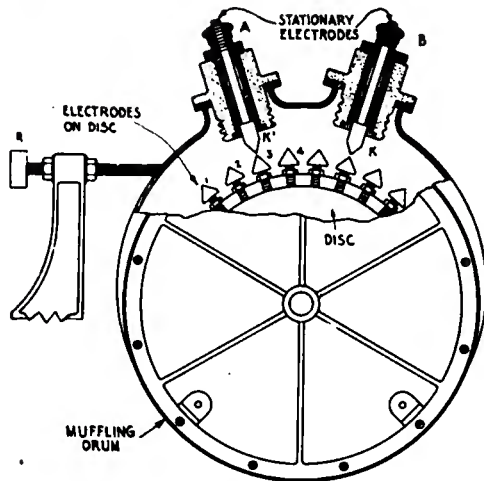


Figure 94

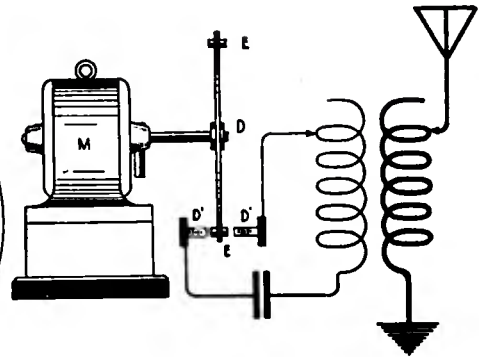


Figure 95

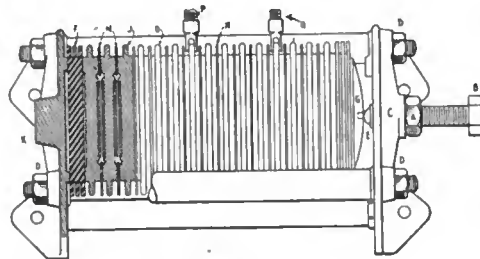


Figure 96

### OBJECT OF THE DRAWINGS

- (1) Figure 94. To show the construction of a modern synchronous rotary spark gap.
- (2) Figure 95. To show the construction and the circuit of the non-synchronous rotary spark gap.
- (3) Figure 96. To show in cross section the construction of a multi-plate gap (so-called quenched gap).

### PRINCIPLE

The note of the spark discharge at the transmitting apparatus is reproduced in the telephone at the receiving station, and since spark notes of high pitch are more readily read through atmospheric electricity, spark gaps are designed to give musical tones. The best tone is secured when the frequency of the charging current is 500 cycles per second. Transmitters operated from a source of low frequency current are provided with non-synchronous dischargers to produce a higher rate of sparking. Spark dischargers are constructed to quench the primary oscillations after one or two cycles.

### DESCRIPTION OF THE DRAWINGS

In figure 94, a revolving steel disc mounted on the end of the motor generator shaft carries the spark electrodes 1, 2, 3, 4, etc.

Two stationary electrodes A, and B, with the discharge points  $K^1$  and K respectively are mounted on a steel muffling drum which encloses the spark discharger, and insulated therefrom. Means are provided whereby the length of the discharge gap between the revolving electrodes can be adjusted to approximately .005 inch.



In figure 95, the non-synchronous disc discharger comprises the disc D mounted on the shaft of motor M; on the outer circumference of D are mounted the spark electrodes E, E from 8 to 30 in number depending upon the speed of the motor and the rate of sparking desired. Two stationary electrodes D, D permit the condenser in the closed oscillation circuit to discharge whenever electrode E comes directly opposite. The motor M may be driven by alternating or direct current and means must be provided whereby its speed can be closely regulated.

Figure 96 shows in partial cross-section the construction of the multi-plate spark discharger. A number of copper plates, J, with the cooling flanges, O, are separated by insulating gaskets or washers, N. A spark surface of one or two inches in diameter is provided at the center of each plate and a groove surrounds the sparking surface so that the insulating gasket does not come in contact with the spark discharge.

These plates are placed in an insulated rack and are tightly compressed by bolt B, which rests against the steel plate G. An insulating plate such as F is mounted on either end of the gap to prevent contact with the metal frame. Bolts D, D, take the strain of the bolt B, and the plates are insulated from D, D by micanite tubing placed over the bolts. Contact is made with the plates by the clips P and Q by which any number of gaps may be connected in circuit.

## OPERATION

One of the most important adjustments is the clearness of the spark note. It is the duty of the operator to maintain the spark gap in such condition as will afford a high pitched note free from irregularities.

The synchronous discharger of figure 94 is adjusted for clear tones by lowering the stationary electrodes K, K-1 until the gap between them and the electrodes on the disc is no more than .005 of an inch in length. Then the position of the stationary electrodes in respect to the disc is changed by turning the rod R to the right or to the left until a uniform note is secured.

The non-synchronous discharger of figure 95 is adjusted for clear spark tones, first, by regulation of the speed of the disc through a series resistance or a motor field rheostat, and second, by adjustment of the alternating current voltage.

The multi-plate gap of figure 96 is adjusted for clear tones principally by the generator field rheostat, the voltage being adjusted until a uniform discharge is secured. In addition, the note is effected by the number of gaps in use. The final adjustment of the note of this gap must be made after the transmitter has been tuned to the standard wave lengths.

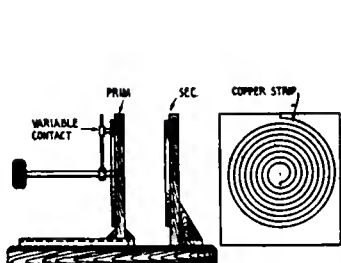


Figure 97

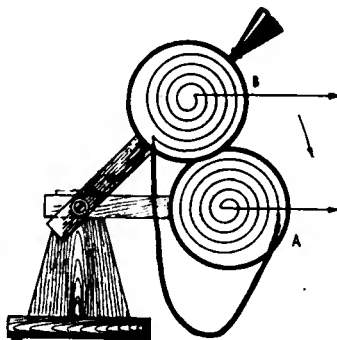


Figure 98

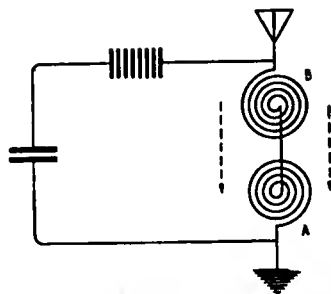


Figure 99

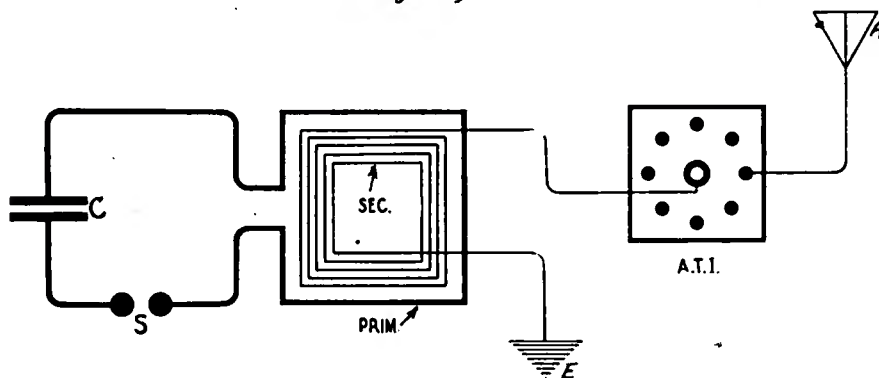


Figure 100

## OBJECT OF THE DIAGRAMS

(1) Figure 97. To show the general construction of a pancake type of oscillation transformer.

(2) Figures 98 and 99. To show the principle and use of the variometer as a coupling transformer.

(3) Figure 100. To show the general construction of one type of oscillation transformer wherein the primary and secondary inductances are of fixed value.

## PRINCIPLE

The requisite radio frequency current for the production of electric waves is generated in what is known as a closed oscillation circuit, and the energy of this circuit is transferred to the aerial wires through an oscillation transformer.

## DESCRIPTION OF THE DRAWINGS

In figure 97, the primary and secondary windings which are made of copper strip are mounted on a base. One of the windings is movable to permit variation of the coupling. It is customary to provide either the primary or secondary with a sliding contact rotated by a handle. This handle also is employed to draw the coils apart for change of coupling.

Figure 98 discloses the general construction of one type of variometer. Two spiral coils of fixed inductance are connected in series. When coil B is parallel with coil A, the self-induction of the variometer is zero. It is maximum when the coils are drawn apart.

In figure 99 the coils of the variometer A, B, constitute a conductively coupled oscillation transformer for transferring the energy of the closed circuit to the aerial wires. The coupling is maximum in the position shown and minimum when the coils are parallel.

In figure 100 the primary winding of the oscillation transformer consists of a single turn of cable especially constructed for conducting high frequency currents. The secondary winding consists of eight turns of stranded cable. The aerial tuning inductance indicated at A.T.I., has eight plug contacts which make connection with the various turns on the antenna tuning coil.

**OPERATION**

The coupling of the transformer may be varied in two ways. The windings may remain in a fixed position and the mutual inductance varied by cutting in and out turns in the secondary; or, the coils may be drawn apart.

In figure 97, the coupling is varied by drawing the primary away from the secondary. In figures 98 and 99, the coupling is altered by changing the relative position of the coils A, B. In figure 100, the coupling is more or less fixed.

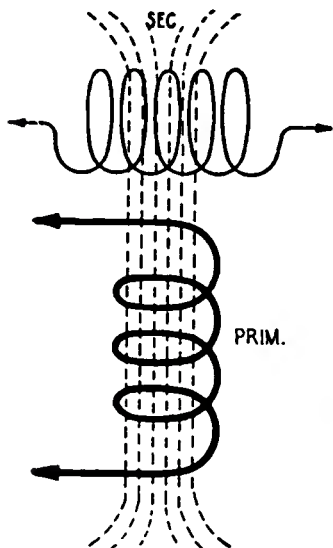


Figure 101

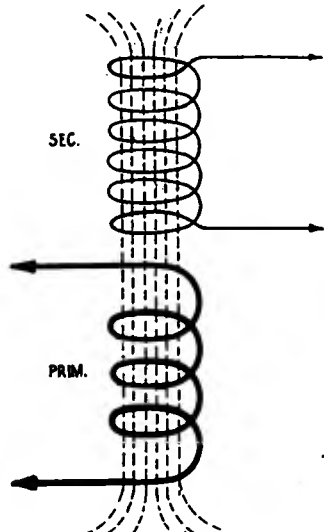


Figure 102



Figure 103

Figures 101, 102.—Showing how the coupling between the primary and secondary coils of an oscillation transformer is varied by turning the secondary at right angles to the primary. In figure 101, the secondary is at right angles to the primary, and no cutting by the lines of force takes place, since they move parallel to the turns. Hence, the coupling of the transformer is practically zero. In figure 102 the lines of force set up by the primary cut the secondary at right angles, the coupling being maximum in this position.

Figure 103.—Showing the construction of the type A oscillation transformer of the American Marconi Company. The primary winding consists of eight turns of 1/4 inch copper tubing mounted on specially designed porcelain oscillators. Connection is made with the spark gap circuit by means of two clips (attached to the top turn in the illustration). The secondary winding is a fixed inductance mounted so that it can be turned completely at right angles. In this way, the coupling of the oscillation transformer is adjusted to secure the pure wave required by law. Also, the radiating powers of the transmitter can be adjusted from zero to maximum.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

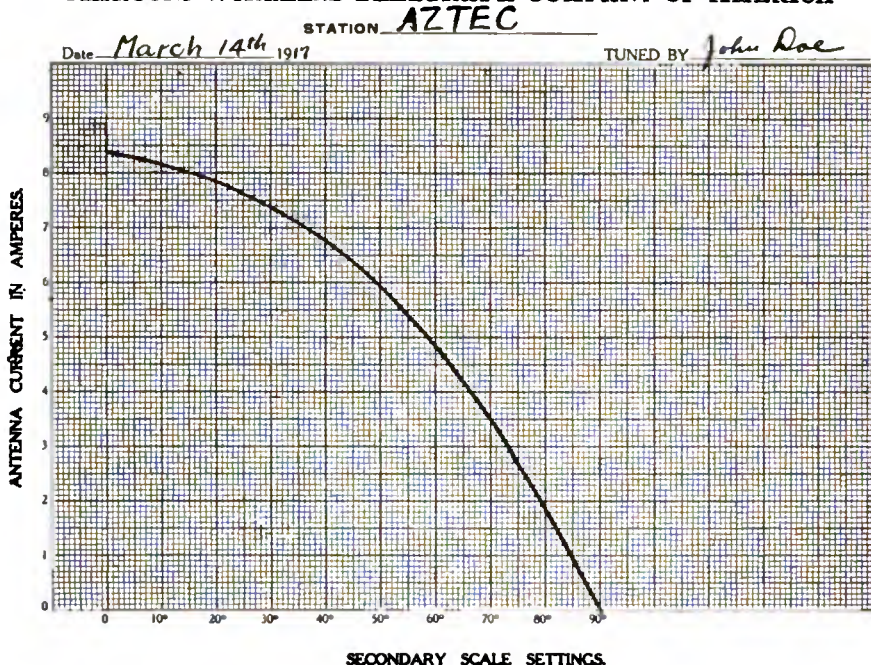


Figure 104.—Showing the reduction of the antenna current by turning the secondary winding of the Marconi type A oscillation transformer at right angles to the primary winding. If the secondary winding bears an angle of 90 degrees to the primary, the coupling is zero, and the antenna current is zero. Increasing the coupling increases the antenna current as shown by the curve. The antenna current is nearly 8½ amperes at maximum coupling. By turning the secondary winding at right angles to the primary, the operator can reduce the power for working over short distances.

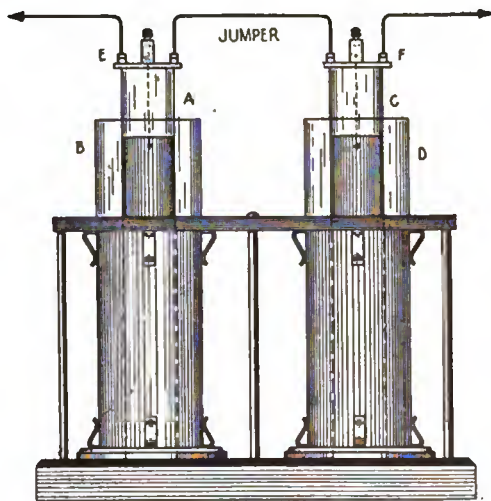


Figure 105.—Showing the construction of one type of short wave condenser used by the American Marconi Company. Four Leyden jars of .002 microfarad capacity each are connected in series, and when not in use they are cut out of the antenna circuit by means of the jumper shown. The complete circuit from binding post E to binding post F is as follows: Connection is made from binding post E to the inside of Leyden jar A. The outside coating of B makes contact with the outside coating of D through the base. The inside coating of D makes contact with the outside coating of C. The inside coating of C is connected to binding post F.



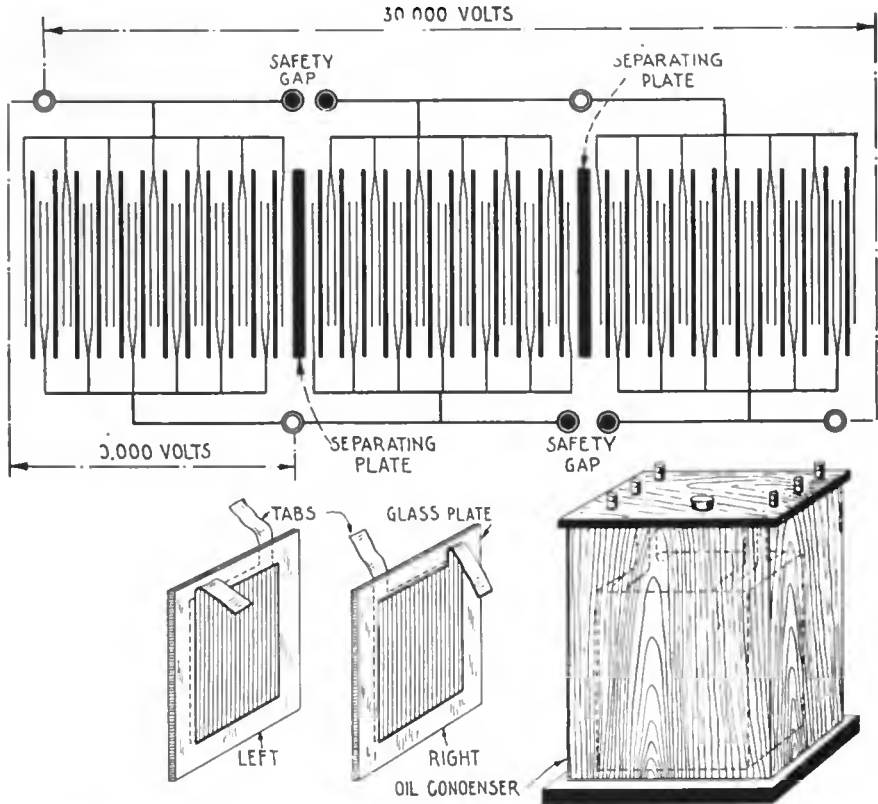


Figure 106

Figure 106.—Showing the general construction and assembly of an oil plate condenser. A number of glass plates are coated on either side with tin foil connecting tabs being attached to the foil as shown. On one set of plates, the tabs issue from the right side of the foil (when the plates face the operator) and on the other set, from the left side of the foil. In assembly, the RIGHT and LEFT plates are stacked together. The diagram shows three banks of high voltage condensers connected in series.

If the voltage of the transformer is 30,000 volts, by this connection the strain on each unit is only 10,000 volts. The liability of puncture thus is reduced. After a set of plates have been stacked up they are bound with canvas tape and immersed in a tank of oil, connections being brought out to binding posts on the lid.

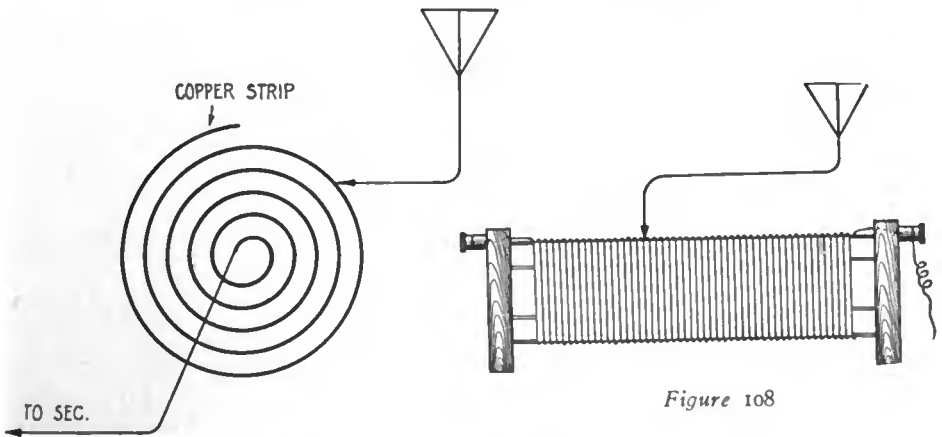


Figure 107

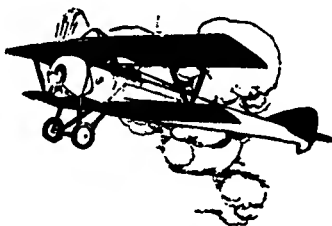
Figure 108

Showing the general construction of aerial tuning inductances. In figure 107 the aerial tuning inductance is made of copper strip over which slides a contact connected to the antenna. In figure 108, the coil consists merely of a number of turns of copper tubing or heavily insulated copper wire, connection being made to the antenna circuit as shown.



# How to Become an Aviator

The Eighth 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"

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**T**HE earlier articles of this series have dealt entirely with the theory of flight and the function and construction of the aeroplane as a flight medium. The student is now ready to consider the propulsion of the machine, upon which all theory of flight obtains.

Flight is made possible, as has already been explained, by the action of the air on inclined surfaces driven through the air at high velocity. The reader is aware that the driving force is a propeller actuated by a gasoline engine. Consideration of the propeller will be brief, as the military aviator is not concerned with the details of engineering mathematics upon which propeller efficiency is based. Some knowledge of the method of checking up the balance of the air screw is all that is required of the pilot, and this is given on the page following.

The study of engines must necessarily be brief, as the varying types of design in internal combustion engines make a full consideration of the refinements of operation a subject of voluminous proportions. What will be attempted in this and a following article will be a brief survey of the general principles which apply to the most familiar types of aviation engines and the essential information for the pilot who takes control of an aeroplane in flight. The aviation engine must have small weight per horse power, minimum head resistance and reliability of operation; for these reasons some minor changes in design from familiar automobile types will be noticed. The first consideration is the stationary water-cooled motor; later, the rotary air-cooled types will be described.

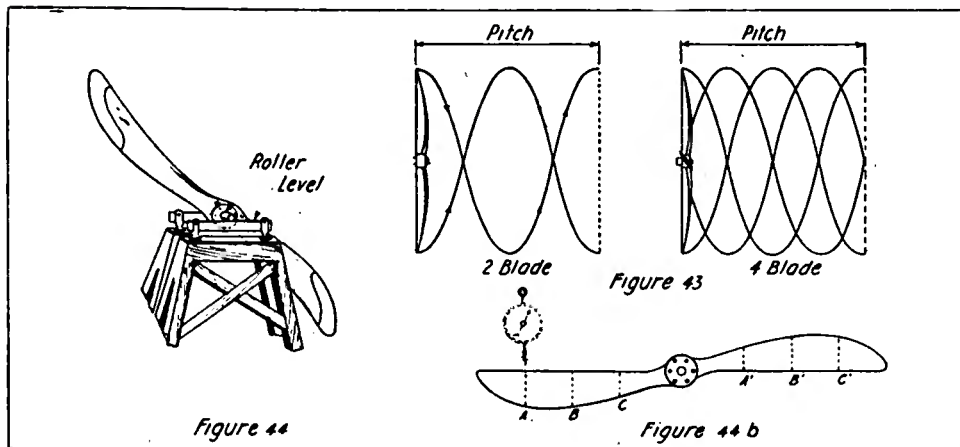


Figure 43—Action of propeller revolutions  
 Figures 44, 44b—Method of propeller test for balance and area

**THE PROPELLER OR "AIR SCREW"**

The propeller's revolutions represent thrust, its action in screwing through the air (see figure 43) translating the power of the engine into forward motion. The drift of the aeroplane, due to its resistance, is overcome by opposition of the thrust; it follows, therefore, that the power of the propeller thrust must be greater than the aeroplane's drift, or the velocity will decrease.

**BALANCE**

The propeller is mounted after the aeroplane is assembled. It should first be tested for balance, for if one blade is heavier than the other it will vibrate when run on the engine. The usual practice is shown in figure 44. A stand is leveled up; a roller is then inserted in the hub of the propeller, which turns freely on the roller; this roller is then allowed to roll freely on the level. Any lack of balance is thus easily detected.

Another method is indicated in figure 44b. Place the propeller in horizontal position and measure off three points on the blades equally distant from the center. By means of a spring balance weighing scale, the weights are taken at these points, and must correspond for each side.

Application of more varnish on the lighter side is usually sufficient to equalize a propeller out of balance.

**SURFACE AREA**

Measurement of three equi-distant points by callipers should show corresponding measurements to exactness of less than 1/8 inch. Figure 44b illustrates this measurement, A being equal to A', B to B' and C to C'.

**LENGTH**

Blades should be of equal length to 1-16 inch.

**STRAIGHTNESS**

With the propeller mounted on a shaft an object should be fixed in a position where the tip of one blade grazes it. With the point marked, the other blade is brought around and should come within 1/8 inch or graze it.

**CARE OF PROPELLERS**

They should never be leaned against a wall or allowed to remain long in horizontal position.

They should not be stored either in very damp, or very dry, places.

They should not be stored where the sun will shine on them.

The proper method of storage is hanging in vertical position on horizontal pegs.

(c) Committee on Public Information



*This picture, taken at one of the "Ground Schools" of the Army Signal Corps, well illustrates the earnestness and concentration of the men. The instructor is obviously having no difficulty in keeping his men at work, for these future American airmen know just as well as he how vital it is that they should understand every impulse of the engine which will soon mean so much to them in midair. A most thorough and fundamental course of training in engines is necessary for the men who will carry the responsibility for America's work in the skies*

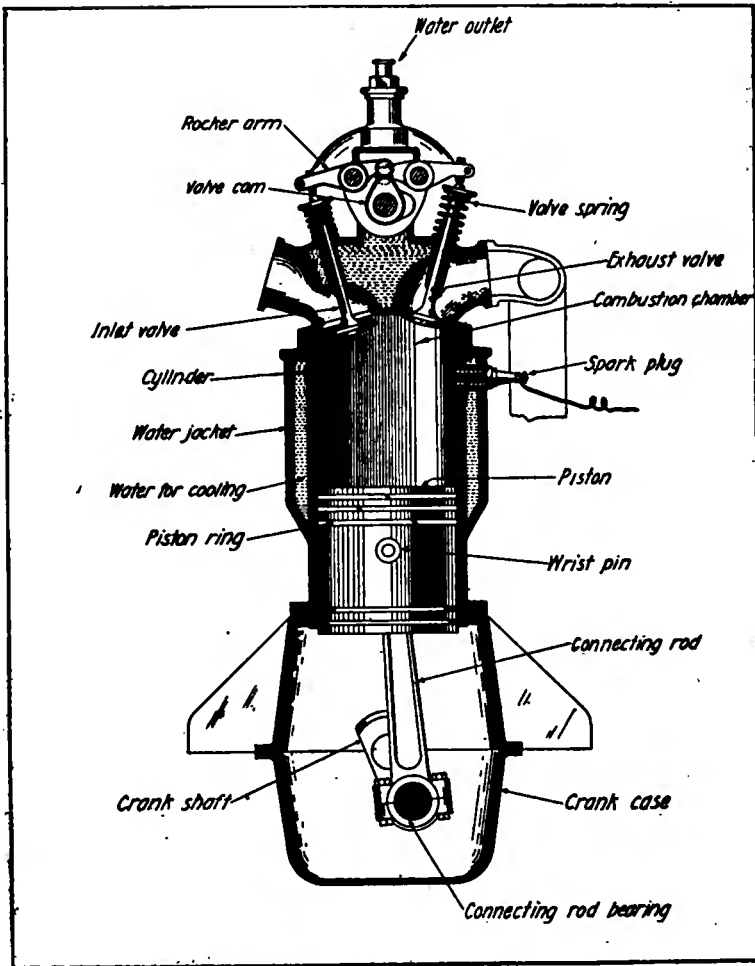


Figure 45—Single cylinder of a gasoline engine

### THE GASOLINE ENGINE

Vaporized gasoline mixed with air and set afire by an electric spark results in combustion (explosion), the intense heat from which develops the pressure which operates the engine.

Figure 45 shows a single cylinder of a gasoline engine in sectional view. The names of the parts should be studied.

#### COMBUSTION CHAMBER

The end of the cylinder which is closed, in which the combustion takes place is known as the cylinder head, the space between it and the piston being the combustion chamber.

#### PISTON

This is a cylindrical-shaped body which slides back and forth in the cylinder, the combustion (explosion) driving it downward.

#### CONNECTING ROD

Suspended from the piston is a connecting rod which acquires a *reciprocating motion* as the piston moves up and down.

#### CRANK SHAFT

The connecting rod is attached to the crank shaft, by means of which the reciprocating motion is changed to a *rotary motion* (as a wheel revolving on its axis) which turns the propeller.

#### REVOLUTION

A complete turn of the crank shaft, moving the piston down and back, is called a revolution.

## THE FOUR-CYCLE PRINCIPLE

There are two types of internal combustion engines using gasoline for motive power; viz.: the two-cycle and the four-cycle. These may be distinguished by considering them as two-stroke and four-stroke engines. The two-cycle engine has no valves, the gas entering and exhausting through ports in the cylinder walls, covered and uncovered at proper intervals by the travel of the piston up and down. The four-cycle engine, which will be considered exclusively in the text following, as its use is almost universal in aviation, has intake and exhaust valves operated by mechanical means.

Figures 46, 47, 48 and 49 show the action of the four-cycle engine, clearly indicating the operations during the four strokes.

### INTAKE STROKE

Suction caused by the piston starting downward, as the engine is "cranked," draws the explosive gasoline vapor into the combustion chamber of the cylinder. It enters through the intake valve, which is the only opening. The exhaust valve is closed, the intake valve being so adjusted that the cam opens it mechanically as the suction action of the piston commences.

### COMPRESSION STROKE

Both valves are closed as the piston starts on its up-stroke and the explosive mixture in the cylinder is compressed into the small space of the combustion chamber as it reaches the top of the stroke.

The explosive value of compression is illustrated by the action of gunpowder, which, ignited in the open air burns slowly but is instantly exploded if confined to a small chamber.

### POWER STROKE

As the piston reaches the top the spark is timed to jump the spark gap points and ignite the explosive vapor. The piston is driven down by the expansion of the gas, making the power stroke.

### EXHAUST STROKE

As the piston returns from the power stroke the exhaust valve is opened, the pressure from the explosion forcing out the burned gas. The upward move of the piston pushes out all of the burned gas that does not escape by its own pressure.

The exhaust valve closes as the piston reaches the top, and the inlet valve opens to admit a fresh charge of gas into the cylinder. The operation is then repeated as long as the engine runs.



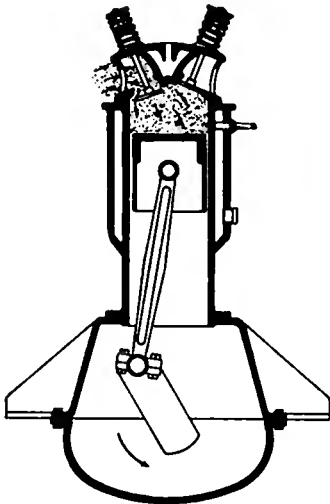


Figure 46

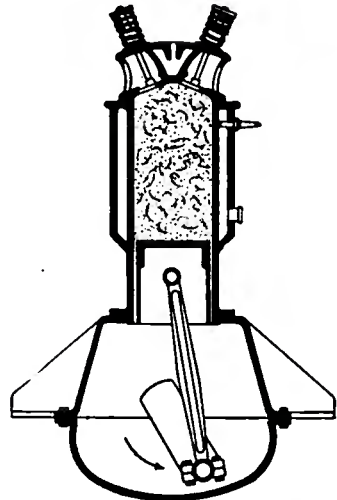


Figure 47

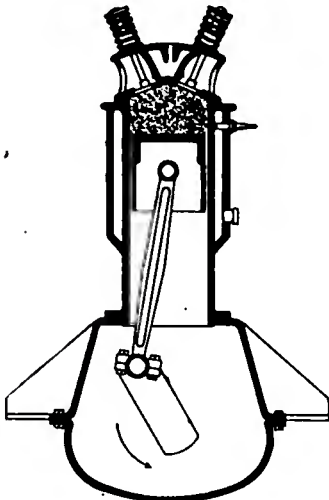


Figure 48

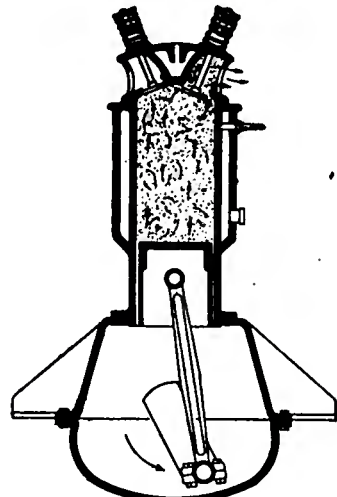


Figure 49

Figure 46—Intake stroke. Figure 47—Compression stroke. Figure 48—Power stroke. Figure 49—Exhaust stroke

### THE FOUR-CYCLE PRINCIPLE

#### FIGURE 46

This is the intake stroke. The inlet valve is open and the gas is entering the cylinder, drawn by the suction of the piston.

#### FIGURE 47

This is the compression stroke. Both valves are closed and the piston is returning, the upward stroke compressing the gas.

#### FIGURE 48

This is the power stroke. The electrical spark from the spark plug ignites the gas. Both valves are closed as the combustion drives the cylinder downward.

#### FIGURE 49

This is the exhaust stroke. Only the exhaust valve is open, the upward movement of the piston forcing the burned gases out of the cylinder.

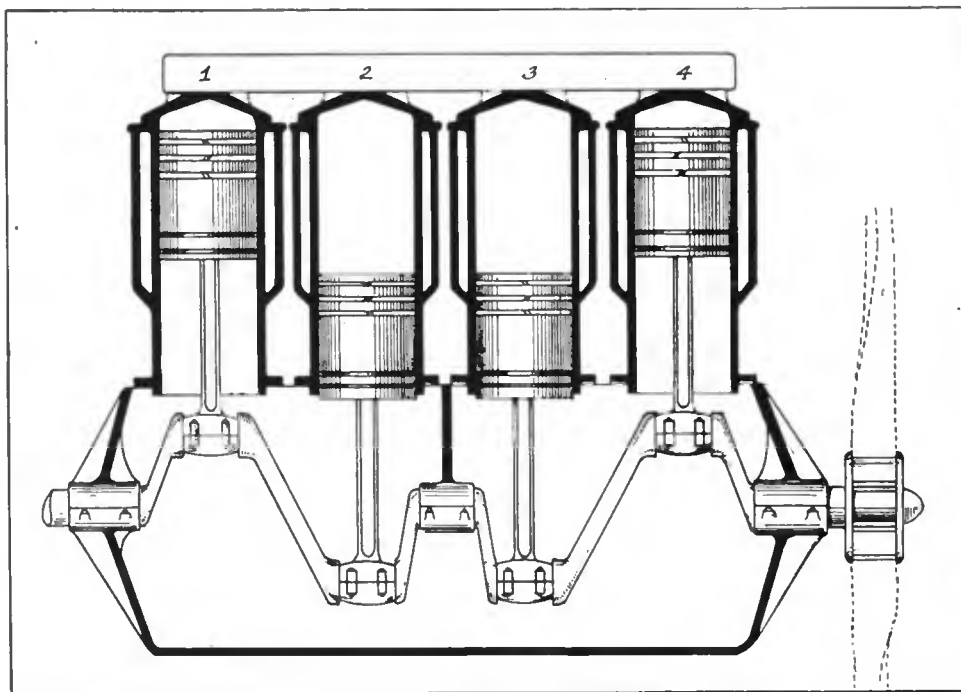


Figure 50—Cross section of a four cylinder engine

## MULTIPLE CYLINDER ENGINES

A cycle operation requires four strokes to two revolutions. Only one of the four strokes is a power stroke; therefore, in a single cylinder engine the piston must be carried through three dead strokes. This ordinarily requires a heavy fly wheel, which when started will continue to revolve. It is obvious that the more cylinders an engine has the steadier will be the power impulses, since the successive explosions may be timed to follow so closely that one of the pistons will always be on a power stroke. Thus in aviation engines where weight is a material factor, the heavy fly-wheel is dispensed with by use of multiple cylinder engines.

### 4-CYLINDER OPERATION

Four cylinder engines deliver a power impulse every stroke, or two power impulses to every revolution.

Figure 50 shows a four cylinder engine in cross section.

It will be noted that the crank shaft which delivers motion to the propeller is set at 180 degrees, the end pair being a half-revolution from the inside pair.

As piston No. 1 descends on the power stroke, No. 2 is coming up on exhaust; No. 3 is ascending on compression and will be fired next; No. 4 is taking in gas.

### FIRING ORDER

The rotation in which the explosions take place in the cylinders is therefore 1, 3, 4, 2.

This engine could as well fire 1, 2, 4, 3, but it will be obvious that explosions in the order 1, 2, 3, 4 would require a crank shaft alternately projecting to each side, 1 and 3 being up when 2 and 4 are down. This construction has the following disadvantages:

- (a) A crank shaft weaker and more difficult to make.
- (b) A rocking motion, or vibration, from side to side.

The alternate distribution of power impulses, where cylinders are fired in the order shown in the illustration, makes for smooth running.

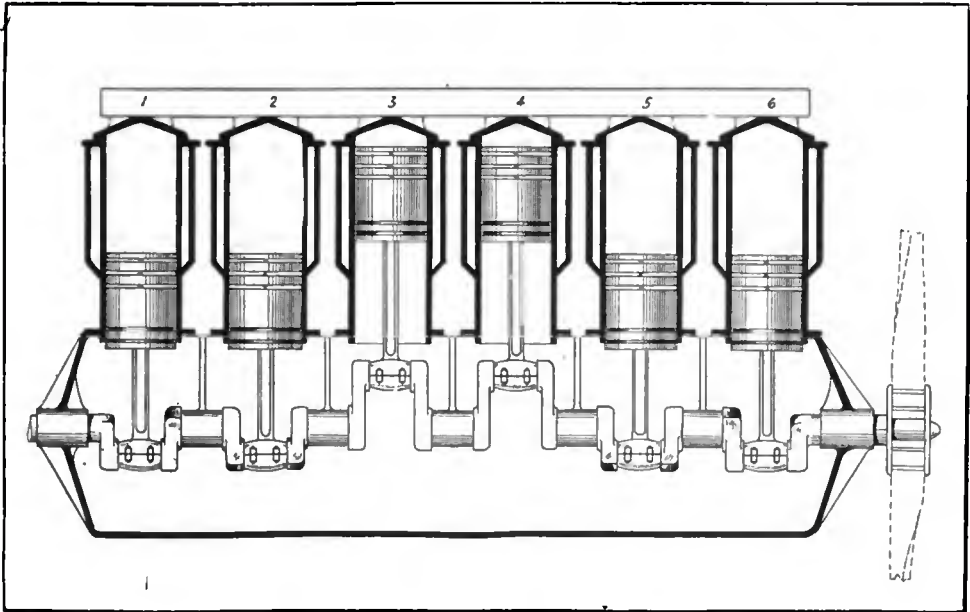


Figure 51—Cross section of a six cylinder engine

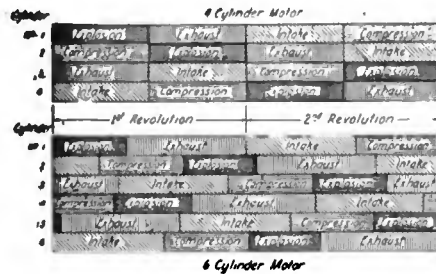


Figure 52—Graphic illustration of cylinder operation in four and six cylinder engines

**6-CYLINDER OPERATION**

The six cylinder engine is four-cycle, the same as the four cylinder engine. The principal differences in construction are in the addition of more cylinders and consequent change in crank shaft.

Figure 51 shows a cross section of the six cylinder engine.

It will be noted that the crank shaft is arranged to turn two revolutions during four strokes, as in the case of the 4-cylinder engine. The crank shaft is therefore divided into three pairs of throws, i.e., each pair is placed at 120 degrees, or 1-3 of a circle apart.

**FIRING ORDER**

In figure 51, cylinder No. 5 has just fired, No. 3 is ready to fire, after which the order will be 6, 2, 4, 1.

With 4-cylinder engines an explosion takes place each half-revolution; the 6-cylinder engine in the same half-revolution has 1½ explosions. That is, power impulses are continuous in 6-cylinder engines, in fact they overlap; this results in smooth running.

Figure 52 is a graphic representation of the sequence of cylinder operating in 4-cylinder and 6-cylinder types of engines.

The ninth article of this series, which will appear in the April issue, will continue the study of gasoline engines, considering carburetion and ignition.

# MILITARY AIRMEN



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## A. LEO STEVENS

Chief Instructor of the Army Balloon School  
at Fort Omaha

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Mr. Stevens has been active with balloons for twenty-five years, making ascensions, experimenting and manufacturing

**I**N APPOINTING A. Leo Stevens Chief Instructor of the Army Balloon School at Fort Omaha the Government has added to its forces doubtless the most experienced balloon pilot in America. No one has been associated so intimately with the development of the science of ballooning as Mr. Stevens, or has proved his ability to fill the post by such wide and varied experience. It is some twenty-five years since Mr. Stevens first attracted public attention by his daring balloon ascensions in many widely scattered sections of the country. About this period he became a manufacturer of balloons, when the free balloon was alone in the field and the dirigible was not yet thought of. Mr. Stevens has manufactured some 1,500 balloons of various types and has made in all more than 2,000 ascensions.

When the dirigible balloon began to attract attention Mr. Stevens was among the first to design and build a power-driven balloon and to actually fly it. His first flight with a power-driven balloon at Manhattan Beach, September 15, 1902, startled the country. His first flight lasted for forty minutes. He was also among the first balloon pilots to go aloft with a passenger. His daring and success in these early days of the new science will hold an important place in the history of American ballooning. Mr. Stevens contributed to the development of the power-driven balloon in America, and its present development is largely due to his ingenuity and energy. He has also been very active in developing the kite balloon, and in operating it.

When the Government looked about for the best talent to enlist in its balloon work it was recognized the long experience of Mr. Stevens would be of vital importance. He was selected to act as inspector of the balloon factories engaged in Government work and proved of great assistance in this activity. Later he was appointed Chief Instructor in the Government's first lighter-than-air flying station at Fort Omaha. His appointment was authorized December 1, 1917. Mr. Stevens gave up his extensive business as a manufacturer of balloons on receiving his appointment and has directed all his energies to the service of the Government. He has remained a civil instructor and has refused a commission of major.

# Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By CAPTAIN FRITZ E. UTTMARK

## ARTICLE V

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### CHAPTER IV (Continued)

#### Current

**A** BODY of water set in motion and carrying with it all floats thereon is called a current. Among the best known is the Gulf Stream. This generates in the Gulf of Mexico, obtaining its greatest speed or force in the Strait of Florida, setting in a North and Eastward direction, it crosses the North Atlantic, rendering mild temperature over and in waters adjacent to England, Ireland and Scotland; even the Northern part of Norway is influenced and therefore has mild winters with ice-free harbors all the year round.

The direction in which the current flows is called the *set* and the speed or velocity is called *drift*.

### CHAPTER V

#### Chart Sailing (Piloting)

Chart sailing or Piloting is the term generally used when the ship's position is found by observations or measurement of angles between terrestrial objects or when in any other way the ship is conducted through channels or along the coast, in sight of land or land marks, using the markings such as buoys, beacons, light houses, light ships, points of land, mountain peaks as marks in order to find the ship's way from port to port or until clear of land. The same term also applies when using the lead or sounding machine to obtain the depth of water and thence deduct the ship's position.

Piloting is the most important part of navigation and requires the greatest care, because if a mistake is made there may not be time to discover it before an accident occurs.

#### Cross Bearings

The simplest form of finding the ship's position is by cross bearings. This consists of observing the bearing or direction of two known objects, correcting the bearings for deviation so as to reduce these to magnetic bearings, then referring to the chart, from the objects two lines in a direction opposite to the bearings and where these lines intersect one another is the position of the ship. The following diagram, figure 44, illustrates this:

A ship sailing along the coast observed two points *A* and *B*.

*A* bearing by the compass  $W \frac{3}{4} N$ .

*B* bearing by the compass  $N$  by  $E$ .

From our deviation card we find the deviation is  $\frac{1}{2}$  point  $W$ . Required the position of ship.

The compass bearing of *A* is  $W \frac{3}{4} N$ . Deviation  $\frac{1}{2}$  pt. Westerly. Assuming we stand in the center of the compass looking in the direction of *A* and following the rule for applying deviation; Westerly Deviation to the right, we find the magnetic bearing of *A* to be  $W \frac{1}{4} N$ . Now place the parallel



rulers over the center of the compass rose, with the edge over  $W \frac{1}{2} N$  and  $E \frac{1}{4} S$  and move the rulers (taking care to preserve the parallel) until the edge comes directly over the point  $A$  and draw a long pencil line from  $A$  in

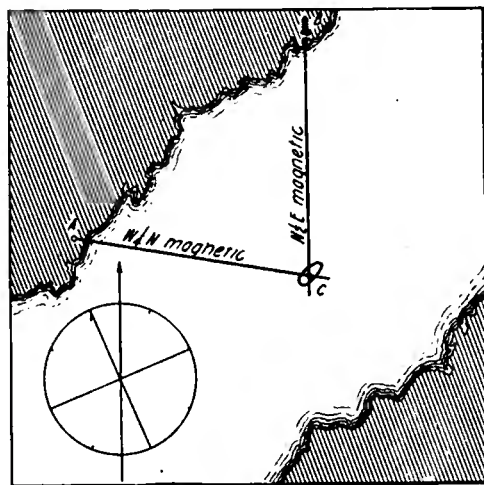


Figure 44

the direction toward the sea. The compass bearing  $B$  was  $N$  by  $E$ . To this apply  $\frac{1}{2}$  pt. West Variation according to the rule and we find the magnetic bearing of  $B$  to be  $N \frac{1}{2} E$ . Using the parallel rulers in connection with the compass rose as before, draw a line from  $B$  until it crosses the line from  $A$ . The position of the ship at  $C$  is found to be at the intersection of the two lines.

### Ship's Position by Two Bearings of the Same Object

When only one known object is seen, the method just described may be employed to find the ship's position. It is frequently very useful, especially during hazy weather, or intermittent fog. As a practical illustration let us suppose that the fog lifts for a short period and we can see a light at night or lighthouse during day. As soon as we are sure that we recognize the light we take a bearing of this by the compass, and at the same instant note what the log indicates; also the time and the course the ship is steering. If fog now sets in again we must wait until it clears sufficiently to see the light again, then take another bearing and read the patent log again. Now we have two different bearings; the course steered by the compass as well as the distance obtained by the difference between the two readings of the log. Correct the bearings as well as the compass course for deviation, if any, and using the parallel rulers, plot the two magnetic bearings. Using the compass rose we now place the parallel rulers in the direction of the ship's magnetic course, measure off the sailed distance with the dividers from the scale on the chart and keep this distance between the points of the dividers. Taking care to

keep the parallel rulers in the direction of the ship's magnetic course, move them until a plane is found between the two bearings where the distance corresponds to the sailed distance and draw a line; where this line which represents the ship's course intersects, the second bearing is the ship's position.

**Example**

A ship steering E by N observes a lighthouse *L* bearing N N E by compass, log showing 36 miles, continuing on the same course until the log registers 38½ miles, the bearing at that instant was N ½ W. Deviation ½ pt. E. Required the position of the ship.

In solving the problem, correct the first bearing for deviation and draw the line from the lighthouse *L* as shown in the diagram, figure 45, using the compass rose and parallel rulers. In a similar way, plot the second bearing. Then from the scale measure up 2½ miles with the dividers and having laid

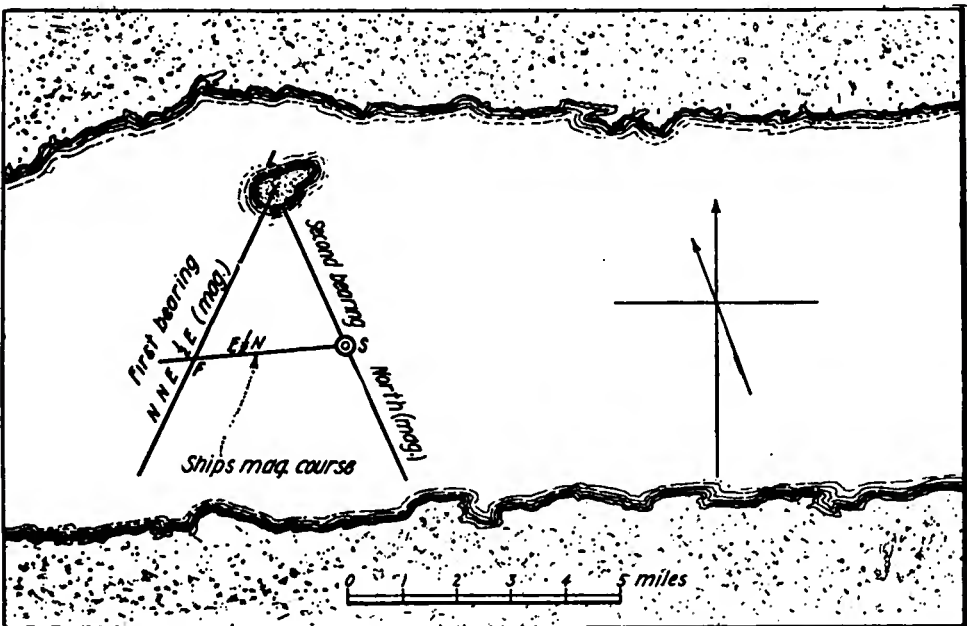


Figure 45

the parallel rulers in the direction of the ship's magnetic course (E ½ N) move same until the edge comes to a place where the sailed distance 2½ miles corresponds with the distance between the plotted bearings and draw a line F. S. The position of the ship is at *S* where the ship's course intersects the second bearing.

(To be continued)

**ERRATA**

In the January number, Chapter IV at the end relating to leeway the following sentence occurs: "The angular difference between this and an imaginary line pointing straight aft is the leeway, or in other words, the difference between the lubber line and ship's compass course." The last lines should read: or in other words, the angular difference between the lubber lines and the ship's actual way through the water.

# A Digest of Electrical Progress

The Effect of the War Upon Electrical Industries Abroad—Education in War Time—A Seaplane Minus Wings—Telephonic Time Service in Switzerland—Detecting Breaks in Transmission Lines by Wireless Telegraphy—The Electrical Vehicle Coming Into Its Own—Longest Power Transmission Span in the World—Air Blast Rectifier for High Tension Alternating Current—Lag on Wireless Time Signals

## The Effect of the War Upon Electrical Industries Abroad

**I**T is difficult at this writing to predict just what the final effects of the European War will have on the habits and customs of the people of the world, but it is certain that far-reaching revolutionary conditions will result. There is some consolation, however, in the thought that such events are in reality but the beginning of a new order of things. No matter how severe the price paid by humanity, marked progress in many directions is frequently the outcome.

Commenting upon the effects of the war upon the electrical art in England, an Englishman's views are set forth in a recent issue of *The Electrical Review*.

The first regret is for the loss of life among the ranks of professional men in the war—men who, had they lived, would undoubtedly have contributed greatly to scientific progress:

"It is lamentable to think with what prodigality there have fallen out of life, while engaged in actual fighting, young men of proved or potential genius who might have conferred untold benefit upon millions by continuance in the exercise of inventive ingenuity and research. What the world has lost in this way never can be known, of course; and it is useless to deplore it now; some of them entered, fired with patriotism, before it was evident how scientific and engineering a war would be. Yet, notwithstanding this lamentable loss, we cannot help recognizing how great has been the effect upon thousands of men of their kind who still continue their work and have labored during these two or three years under the impelling influence of emergency and absolute necessity, calling imperatively for the best that they could give, the best that they could contrive. In such a matter we never shall be able to tell whether our gains have been greater than our losses, but we certainly know that we should have been richer still had statesmen appreciated at an earlier state the value of the scientific mind."

The increased importance that the war has given to science and scientists is remarked upon, and it is declared that the engineer has had his status raised substantially by the part he has played, whether in the field or in the munition works. Additional comment was as follows:

"No state in future will be able to cold-shoulder its engineers, its chemists, electrical experts; they have proved their value as a veritable

national bulwark. What they have done will not only help in the conduct of the war but the application of much that they have done, to the industrial and general life in peace time, will be noted and continued for years to come. . . . In this connection when all can be told it will be found that the part that electricity has performed forms one of the most fascinating chapters of the war. Experience and discovery in these departments are not limited to soldiers; the civilian benefits too; they are also international."

### Education in War Time

**W**E cannot neglect our educational institutions if we are to maintain consistent progress in the present national crisis. We should profit by the mistakes of our Allies who at the outset committed the error of thinking that this war would be of short duration. We must not repeat this blunder. We must educate a great army of technologists who will be prepared to take the rank of the depleted body of foreign scientists.

So important is the matter of the education of rising America that the Counsel of National Defense held a conference with university officials in Washington last May to consider the situation as a whole and to prescribe means for keeping our schools filled during the war time. A definite connecting link between the educational institutions of the country and the National Government in matters pertaining to war is maintained by the Bureau of Education and the States Relation Service of the Department of Agriculture. These two bureaus co-operate with the Education Section of the Advisory Commission of the Counsel for National Defense.

In a circular recently issued, Dr. Claxton, Educational Commissioner, says:

"When the war is over, whether within a few months or after many years, there will be such demands upon this country for men and women of scientific knowledge, technical skill, and general culture as have never come before to any country. The world must be rebuilt. This country must play a far more important part than it has in the past in agriculture, manufacturing and commerce. . . . Russia and China are awakening to new life and are on the eve of great industrial development. They will ask of us steel, engines and cars for railroads, agricultural implements, and machinery for industrial plants. They will also ask for men to install these and to direct much of their development in every line."

The proposal to keep our universities and educational institutions filled during the war is commented upon by The Scientific American as follows:

"If we are in for a long war then it is equally important from a military point of view to add to the brain power of the nation by increasing the attendance at universities, colleges, normal schools and technical schools—now constituting a little more than one-half of one per cent. of the total population of productive age. Tuition fees should be lowered as much as possible. The hours of classes and the length of the course should be arranged so as to give students better opportunities for working their way through college. The abolition of the long summer vacation and the adoption of a school year of four terms of twelve weeks has been suggested as a means of enabling some students to complete their education more rapidly, and others to give a large proportion of their time in school or college to productive work. We must have more and more technically trained men, whether for war or peace—more doctors, more engineers, more experts in every line."

One of the most promising professions in the technical engineering field is that of radio engineering. Even now the requirements for the services of a skilled

wireless engineer or telegrapher are so great that in all probability special courses will have to be inaugurated in our universities throughout the country. Practical workers, above all, are immediately required, but the services of a certain number of skilled scientists who can guide and conduct operations on strictly scientific lines are positively essential.

### **A Seaplane Minus Wings**

**W**E are advised in a recent issue of *The Scientific American* that the French are making use of a novel water glider which is designed directly after the ordinary seaplane with the exception that it does not possess weight. The advantages of the arrangement, of course, are the absence of water propeller troubles and the great rate of speed with which it can travel over the surface of the water. Consequently it makes an excellent machine for the hunting down of submarines and for scouting. *The Scientific American* describes the machine as follows:

"The wingless seaplane consists of two main pontoons and a tail float, supporting a framework which carries a two-passenger nacelle and the usual tail members of an aeroplane. The tail members are used for steering the craft. The power plant is placed at the forward end of the nacelle and drives the tractor screw. Capable of a high rate of speed, it is obvious that this wingless seaplane performs invaluable service as a patrol scout in the hunt for German U-boats, in conjunction with its aerial counterparts and surface craft. Because of its shallow draft and high speed it is practically immune from attack by U-boats, and it is quite possible that it may be used in a small sort of a way in attacking the periscopes of the German subsurface raiders, which probably accounts for the rifle held in the hands of the observer in one of the accompanying views. At any rate, the wingless seaplane appears to be a valuable adjunct in the U-boat campaign, for work in calm weather and in covering large areas."

### **Telephonic Time Service in Switzerland**

**T**HE Swiss Government evidently deemed it advisable at the outbreak of the European War to suspend the operation of all private wireless stations, and consequently the jewelers of Switzerland were hindered considerably in obtaining the radio time signals from the Eiffel Tower in Paris. It seems that the Swiss clock and watch makers were put to such inconvenience by the lack of this service that arrangements were made by the federal telegraph and telephone service to supply these signals over the telephone lines.

The plan has been in operation since May, 1916, and accurate observations made at the federal observatory at Zurich show that the accidental errors involved in the transmission of the signals rarely exceed a tenth of a second.

### **Detecting Breaks in Transmission Lines by Wireless Telegraphy**

**I**T is reported in a recent issue of the *Electrical Review* that amateur radio telegraph apparatus has been used in a novel way by a local power company in Chattanooga, Tenn. Some employes of the power company are officials of the Chattanooga Wireless Club of Tennessee, and they have been able to tell by their wireless telegraph equipment when the power transmission lines break. The arc caused by breaking of wires or, in fact, by leakage, causes a peculiar hissing sound which can readily be detected by a sensitive wireless receiver and in this way the power company is warned of the trouble.



Many instances other than those referred to, whereby leakage in power lines has been detected by a radio telegraph receiver, have been recorded. An aerial, for instance, erected in the immediate vicinity of a power line in which there is leakage on the insulators (arcing between a 2200-volt line and a wet tree), can immediately be detected by the wireless receiver. A peculiar, rasping, intermittent note, similar to the discharges produced by atmospheric electricity, will be produced in the receiving head telephone. Amateurs, on more than one occasion, have been able to report leakages on power lines when the power company was not aware of the trouble.

### **The Electrical Vehicle Coming Into Its Own**

**T**HE threatened shortage of gasolene as an automobile fuel is bound to give an impetus to the further development and use of the electric vehicle. The reliability of this method of automobile propulsion has long since been established, but its chief limitation is, of course, the small mileage obtained for a single charge of the battery. But even with this defect it may become necessary to adopt this type of automohile power throughout the period of the war and for some time afterward.

The technical press, fully aware of the situation, is urging the adoption of the electric automobile and its wider use in all lines of work. The general public does not seem to be aware that the electric automobile has long ago passed the experimental stage, but this lack of knowledge is probably due to the more spectacular performances of the gasolene automobile.

### **The Longest Power Transmission Span in the World**

**T**HE 4,427-foot span across the Carquinez straits in California for the transmission of electrical power has been considered an engineering feat of the highest order, and to date, has the record span of the world. However, we are told in a recent issue of the Journal of the Royal Society of Arts that the Shawinigan Power Company will soon undertake to span the St. Lawrence River with a 5,000-foot transmission line that will carry current at pressure of 100,000 volts.

It is remarked that in order to have these cables clear the water by the 160-foot minimum permitted by law it will be necessary to make the towers on either side 350 feet in height. This is the same elevation as the top of the Quebec Bridge.

These towers will rest on concrete foundations located in the river 500 feet from each shore. The foundations will consist of four circular concrete columns, eleven feet in diameter, descending to a depth of forty feet below the river bed and twenty-five feet above it. The concrete foundations will be protected against the action of ice by a low crib dam located about 100 feet up stream and arranged so that the ice will pile up and break into small pieces before it can reach the tower foundations. The four legs of the towers will be anchored in these four piers, the towers being built of structural steel.

It will also be necessary to widen out the top of the towers into a platform in order that the cables may be kept fifty feet apart. This will prevent them from swinging together in a heavy storm.

As is to be expected, the cables will not be anchored at the top of the towers, but are brought down to the rear of the towers to an anchor in the ground, located at a considerable distance from the towers' base. The supports are especially designed to permit a certain amount of movement in the cable due to expansion which may be caused by changes in temperature.

Special insulation had to be devised because of the extreme pressure of 100,000 volts. The magnitude of the problem will be better understood when we consider that these insulators are not only subjected to the electrical strain, but will also have a mechanical stress each of 150,000 pounds. The insulators must also be so arranged that any breakage which may occur will not permit the cables to part and fall into the river.

### **Air Blast Rectifier for High Tension Alternating Current**

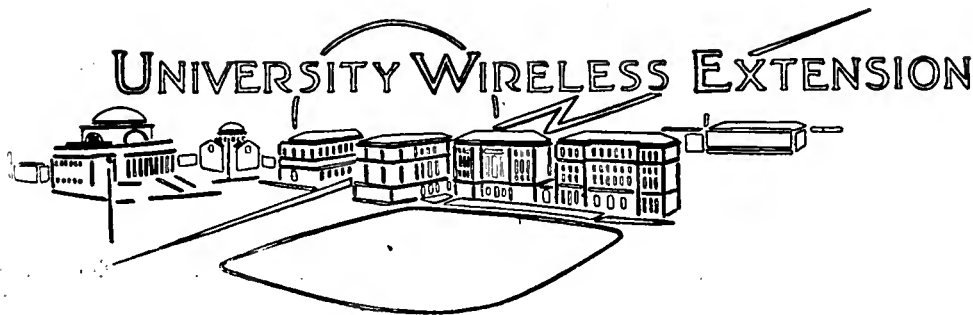
**I**T has been known for a number of years that if a high tension alternating current is discharged from a point to a plate, partial rectification will occur, but some difficulty has been experienced in applying this method, especially if a considerable amount of power is involved. E. J. Erickson and E. R. Woolcot in a recent issue of the Physical Review show that complete rectification can be obtained by utilizing a current of air flowing from the discharge point to the plate. The apparatus is described in detail and oscillographic curves are reproduced to illustrate the effect obtained. With the air blowing, the discharge obtained by rectification is quite rhythmic, but an ordinary colored arc results when the air blast is removed.

The authors assert that considerable difficulty was experienced at low voltages but good results were recorded with about fifteen kilovolts, the current amounting to from twelve to twenty-five milli-amperes. Up to 350 kilovolts, at a frequency of 500 cycles per second, practically complete rectification was obtained.

### **Lag on Wireless Time Signals**

**A**SERIES of observations were recently made by F. D. Urie to determine the time lag between the Arlington and Great Lakes (Lake Bluff, Ill.) wireless stations' time signals, both of which are received by wire from the Naval Observatory and converted automatically into radio signals through the medium of electromagnetic relays. There are between 750 and 900 miles of telegraph wire between Washington and the Great Lakes station, the circuit including telegraphic repeaters at the radio station. The lag between the two radio stations, as observed in Washington, was found by a series of tests to average .085 second with an error of approximately .002 second.

This time interval is, of course, due to the lag in the telegraphic relay at the radio station which repeats the time signals into the radio transmitter. This difference in time observation has often been observed by radio operators along the Atlantic coast when the ships on which they were stationed were in localities which permitted copying time signals simultaneously from two naval stations.



# 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 XV

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(g) **STRAYS.** We have previously considered "Stray Interference in Radio Telephony" to some extent, and have shown a number of methods of reducing such interference. We shall now consider some further points in connection with strays and radio telephony. To begin with, it must be noted that with the modern sensitive receivers (e. g., the regenerative vacuum tube receivers), heavy strays do much more damage than to act merely as incidental noises. They break up the incoming sustained wave trains so far as the receiving system is concerned and thus prevent resonance phenomena in circuits of small (or even zero or negative) damping from being fully utilized. In addition, some types of detectors (e. g., sensitive crystals or gas-containing bulbs) may be "paralysed" by heavy strays and take some little time to regain their sensitiveness. Even very high vacuum tubes may show this effect, since a very powerful stray impulse may charge the grid negatively to such an extent that the plate current will be practically cut off until the grid charge escapes by the normal leakage. Then, too, the ear will be so shocked by heavy bursts of strays that it will take some little time to regain its normal sensitiveness.

The Author has found, in connection with some tests in radio telephony over fairly considerable distances, that really good reception requires that the signal audibility shall be 3 times that of the strays, and that the strays shall not occur continuously even then but intermittently, and not more frequently than say once or twice per second. Fair reception can still be accomplished even if the (intermittent) strays are 2 times as strong as the signal. Reception becomes difficult if the strays are 5 times as strong as the signal, and almost impossible if the ratio is greater, particularly if the strays are continuous.

Dr. C. J. de Groot has given in the "Proceedings of The Institute of Radio Engineers" for April, 1917, a classification of the strength of tropical strays (with a crystal detector and normal Telefunken receiver) and the signal

strength necessary for telegraphic communication through such strays. The number of the class is on an arbitrary scale.

0. No disturbance. (Signal strength would be a few times audibility).
1. Weak strays. Requiring a signal of 10 times audibility.
2. Medium strays. Requiring a signal of 20 to 30 times audibility.
3. Strong strays. Requiring a signal of 60 times audibility.
4. Heavy (or very heavy) strays. Requiring a signal of 250 to 500 times audibility.
5. Overwhelming strays or thunderstorms. This case occurred only for an hour or two during the very worst days in the least favorable part of the year. Reception under such conditions is not possible.

Dr. de Groot showed that musical spark signals could be read through strays that had (at least intermittently) an audibility nearly 70 times as great as that of the signal and an audibility at almost all times of 10 or 20 times that of the signal. This he imputes to the remarkable selective sensitiveness of the ear to musical tones. This advantage is not present to the same extent in radio telephony.

Dr. de Groot further classified strays into three classes electrically and gave the details of the production, nature, and elimination of each class.

**Type 1.** These are strays originating in nearby thunderstorms, and they have only a short range. They are found to be of periodic character (i. e., decaying wave trains of definite period and decrement). They are heard in the receiver as loud, widely separated clicks, and may be eliminated by audio or radio frequency compensation. The arrangement given by de Groot for this purpose is shown in Figure 201 and is explained by him as follows: "Two receiving antennas,  $L_1$ ,  $L_2$  of the same shape and dimensions were installed near enough together (10 or 20 meters or 30 to 60 feet apart) to make them respond in the same way to strays. (For the aperiodic disturbances, this distance could be easily increased, but for periodic disturbances the distance of separation must be small compared to the wave-length of the strays, in order to get the induced e.m.f.'s in phase). On the other hand, the antennas must be placed sufficiently far apart so that the signals set up in the one which is made aperiodic ( $L_2$ ) shall not cause currents in the tuned antenna ( $L_1$ ). One of the antennas,  $L_1$ , is tuned to the incoming signal and coupled to the detector circuit  $D_1$  in the ordinary way. The detector  $D_1$  will rectify signals as well as strays and send the rectified current into the telephones; or, as in the case of the Figure, into the differential transformer  $T_r$ . The antenna  $L_2$  is tuned either to the same, or preferably to a longer wave-length, thus making it less sensitive to the signals and more sensitive to the long wave strays. The detector  $D_2$  is switched directly into this antenna, thus making it aperiodic or nearly so. This arrangement makes it almost impossible to receive any distant signals on the antenna  $L_2$ , but loud signals on wave-lengths different from those to which  $L_1$  is tuned and strays give a response that is nearly as loud as can be obtained on the tuned antenna  $L_1$ . The rectified current is sent to the same telephone mentioned before; or, as in the Figure, to the differential transformer  $T$ . However, this second current from the aperiodic antenna  $L_2$  is arranged to act in the opposite direction from that of  $D_1$ . The

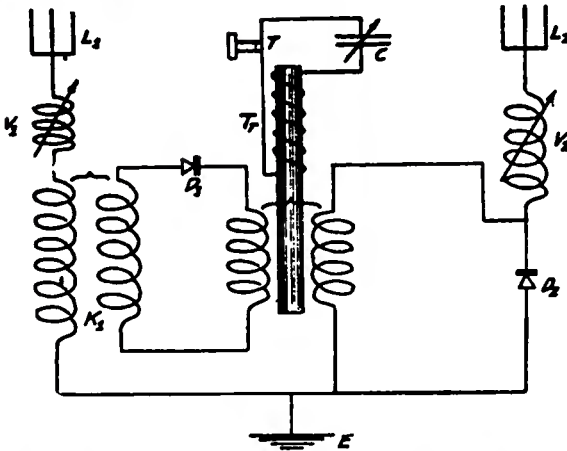


Figure 201—de Groot audio frequency compensation method for the elimination of periodic strays

telephone *T* is either connected in series with  $D_1$  and  $D_2$ ; or, as in the Figure, in a third winding of the differential transformer and in series with the condenser  $C$  to permit tuning to the spark frequency. Since  $D_2$  does not respond to distant signals, there will be heard in the telephones the signals from  $D_1$  only, whereas the strays rectified by  $D_1$  and  $D_2$  tend to compensate. By varying the coupling  $K_1$ , this compensation may be made complete." Dr. de Groot mentions that the detectors must both have the same characteristic and states that carborundum

crystals with suitable auxiliary potential meet the requirements. The theory here given yielded very promising results when tested. For further details of this method, the reader is referred to the original article.

**Type 2.** These strays are associated with low-lying (electrically charged) rain clouds and are of very short range. Electrically, they are found to be intermittent uni-directional currents due to actual discharges to or from the antenna. They are audible as a constant hissing sound, and are eliminable by the Dieckmann electrostatic shield shown and explained in connection with Figure 11.

**Type 3.** These are most common or night strays and cause most of the interference with reception. They are believed to originate in the Heaviside layer or conducting portion of the upper atmosphere when this is subjected to the cosmic bombardment of small particles and comets. The range (with the receiver used) was several hundred miles, and these strays gave a continuous rattling noise. They were successfully eliminated by means of the Dieckmann cage of Figure 11.

Much valuable information on the daily and seasonal variation of strays is given in Dr. de Groot's paper. The reader is also referred to the Author's discussion on that paper for a further explanation of the Dieckmann cage.

The first approximation to the ratio of heavy summer strays to light winter strays is probably between 100-to-1 to 1,000-to-1 or even more.

**(h) RANGE IN RADIO TELEPHONY.** As has been previously stated, the effective range of a radiophone transmitter depends on the loudness of strays at the receiving station; and consequently any method of reducing strays will increase the effective power of the transmitter in just that proportion.

In 1908, Mr. Fessenden, as the result of some rather elaborate analysis, reached the conclusion that the amount of power required to cover a given range radiophonically was from 5 to 15 times as great as that required to cover it radio telegraphically. It is certain, however, that some of the reasoning there given is not valid, and particularly that dealing with the greater amount of power required in radio telephony because of the relatively small amplitude of the higher harmonics in the human voice. It seems much more likely that about the same amount of power is required to cover a given distance by means of either system of communication.



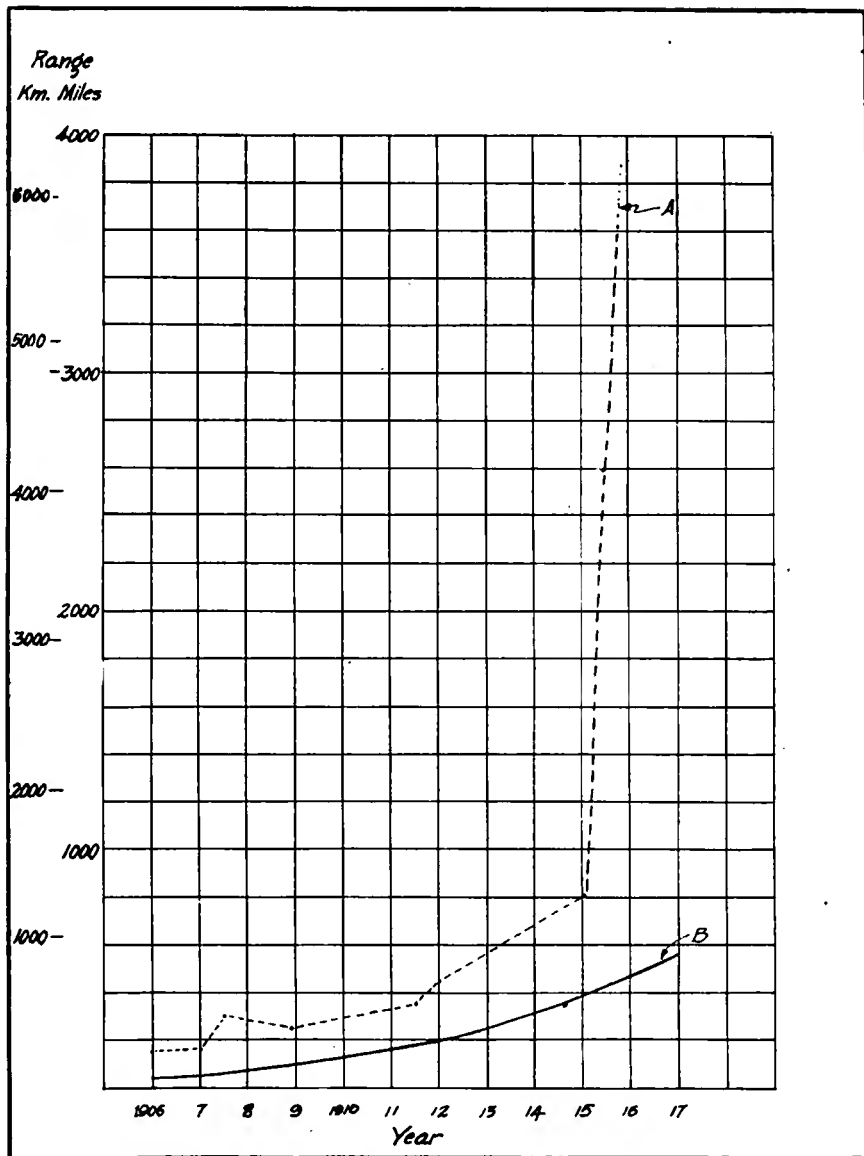


Figure 202—Yearly increase in range in radio telephony

We have compiled from the material presented in this volume the maximum distance covered each year radiophonically. The data is given in the chart of Figure 202. It will be noticed that, practically speaking, radio telephony began in 1906 when a range of 160 miles (250 km.) was covered. It must be mentioned, however, that Fessenden had transmitted speech by a radio-frequent spark method a distance of 1 mile (1.6 km.) as early as 1900. The range increased fairly steadily at the rate of about 60 miles (100 km.) per year until 1915, when it took a sudden jump to the extreme range of 5,100 miles (8,000 km.). The dashed curve A shows this material clearly. We have, however, endeavoured to distinguish between distance actually covered as an extreme achievement and the distance which could have been reliably covered with the apparatus

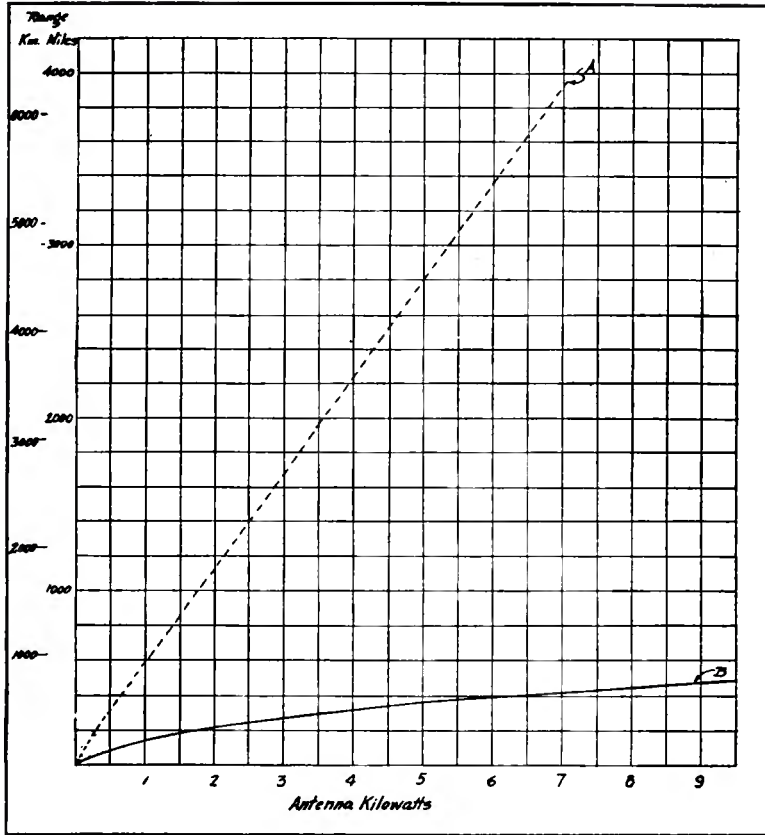


Figure 203—Relation between range and antenna power in radio telephony

available at any given time. The second curve *B* gives the range of probable reliable communication at any given year. It will be seen that this range has risen from about 40 miles (65 km.) in 1906 to about 500 miles (800 km.) in 1917. In fact, it is believed that with the equipment the performance oscillograms of which are given in Figure 186 (that is, the Alexanderson alternator-magnetic amplifier combination controlling 35 kilowatts) reliable overland telephony over 1,000 miles (1,600 km.) or more could be accomplished. We desire to emphasize particularly the distinction between “extreme range” and “range of reliable communication.” It is to be regretted that we have had so much of the former type of achievement in radio telephony and so very little of the latter. In view of the large ratio between them, it is felt that only the latter type is of any real interest, and that it only should be stressed hereafter.

In Figure 203 are given two curves connecting the range in radio telephony with the *antenna kilowatts* (not transmitter input). These curves are also based on the data given in this book. The upper curve *A* gives “extreme ranges,” and shows the following interesting facts. With an antenna power of only about 0.5 kilowatt, 300 miles (500 km.) can *sometimes*, though rarely, be covered. With

1 kilowatt, this rises to 600 miles (1,000 km.). At 10 kilowatts, it rises to 5,000 miles (8,000 km.). The "range of reliable communication," given in Figure 203, curve *V* is very different. It will be seen that 1 antenna kilowatt will cover reliably about 150 miles (250 km.) overland at the most desirable wave-length. For about 10 antenna kilowatts, this range rises to 500 miles (800 km.). The difference is very significant between curves *A* and *B*, and these curves cannot be brought closer together until the matter of stray elimination is settled. Even then, daylight and summer absorption of the electromagnetic waves will prevent the curves from being identical.

## 10. RADIOPHONE TRAFFIC AND ITS REGULATION.

(a) **DUPLEX OPERATION.** Any one who has compared normal telephone conversation with the irritating substitute provided by an ordinary speaking tube will realize the full necessity for duplex operation, i. e., simultaneous transmission and reception without the necessity for handling any switches or other devices when the speaker desires to listen, or vice versa. Experience teaches that sending-to-receiving switches lead to endless annoyance and confusion unless there is some skilled person standing next to the user of the radiophone to explain in detail how the switch is handled and to rectify errors of manipulation. While this latter procedure may be possible with a ship radiophone station, where the passenger desiring to telephone to land may put himself under the temporary guidance and instruction of the skilled radiophone operator, it would not be feasible on land since any system of land radio telephony must provide that calls can originate at any wire line subscriber's station, whether at his home or place of business. Since the land subscriber cannot, therefore, come to the radiophone station there will be no opportunity to give him the necessary personal supervision and instruction.

A practical system of duplex radio communication (applicable to telephony) has been worked out by Senatore Marconi. The arrangement at the duplex sending and receiving station is shown in Figure 204. The transmitting antenna *A* is a long horizontal antenna, and directive (at any rate, for moderate distances and in reception). The main receiving antenna, *A*<sub>1</sub>, is directive and parallel to the first. Both of these therefore point to the distant station. In addition to the main receiving antenna *A*<sub>1</sub>, there is a balancing antenna *A*<sub>2</sub>, so placed as to receive strongly from the transmitting antenna *A* but very little from the distant station. The distance *CD* in practice is anywhere from 25 to 30 miles (40 to 80 km.). A telegraph or, in our case, telephone line connects the stations. The receiver at *BD* is so arranged that it is coupled to the coils in both antennas *A* and *A*<sub>1</sub> differentially. By suitable adjustment, it then becomes possible to cut out completely the signal from *A* while retaining the signal

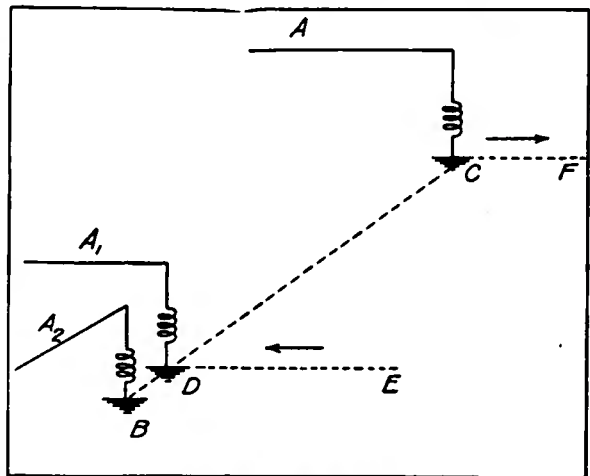


Figure 204—Marconi duplex station

from the distant transmitter almost undiminished. Thus simultaneous transmission and reception become possible.

Another method, due to Mr. Fessenden, is indicated in principle only in Figure 205. The four batteries *A*, *B*, *C*, and *D* are connected in series assisting as indicated. Resistances  $R_1$  and  $R_2$  are inserted as shown. Under these conditions, the points *X* and *Y* will be found to be at the same potential,

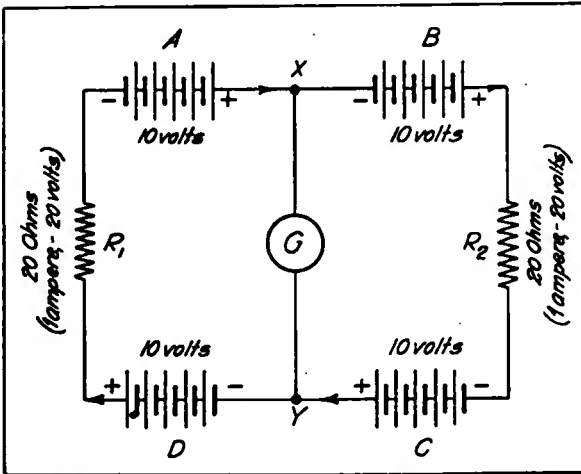


Figure 205—Principle of Fessenden duplex system

and a sensitive galvanometer connected across them will show no deflection. Translated into the corresponding radio equivalent, the actual arrangement is shown in Figure 206. The radio frequency alternator *J* (in series with the microphone *M* or other controlling device) sends current through the coils *H*, *G*, *E*, and *F*. There are thus induced in the coils *C*, *D*, *A*, and *B* assisting currents. The resistance  $R_1$  of Figure 205 is replaced by the artificial antenna  $R_1$  of Figure 206, and the  $R_2$  of Figure 205 by the actual antenna of Figure 206. The four coils in the antenna circuit correspond to the four batteries. As will be seen, the points *X* and *Y* in Figure 206 are at the same potential so far as the alternator is concerned, and a receiving set may be connected across them when the arrangement is properly adjusted. This receiver will respond (to some extent) to incoming signals. This entire arrangement, while very ingenious, suffers from a number of practical disadvantages. To begin with, the exact balance is very difficult to secure and even more difficult to maintain because of changes in antenna and ground conditions. Furthermore, the points *X* and *Y* while at equal potential, are far above ground potential, and consequently capacity currents will flow from the receiving set to ground, disturbing the balance and giving false signals. In addition, at least half of the available energy will be lost in the artificial

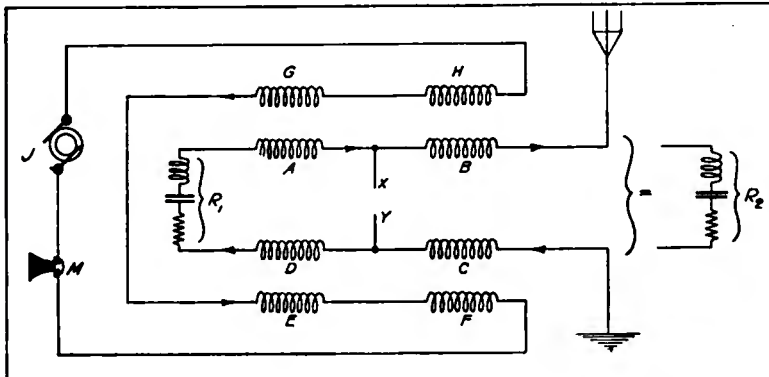


Figure 206—Fessenden duplex system for radio telephony

antenna  $R_1$  and more than half of the incoming signal energy will be lost in all cases.

A somewhat similar arrangement, invented by Mr. J. H. Carson and assigned to the American Telephone and Telegraph Company, is shown in Figure 207. It will be seen that the secondary  $L'$  of the output transformer of the radio frequency alternator  $Q$  has two equal parallel load circuits. One of these is the path  $C_2, L_2$ , and the artificial antenna  $A_2$ , while the other is the exactly similar path  $C_1, L_1$ , and the actual antenna  $A_1$ . The receiving set is coupled differentially to the two paths, and will therefore respond only to incoming signals. It contains the loop circuit  $L_3, C_3$ , intended to cut down any unbalanced energy at the transmitting wave length which may chance to get into the receiver.

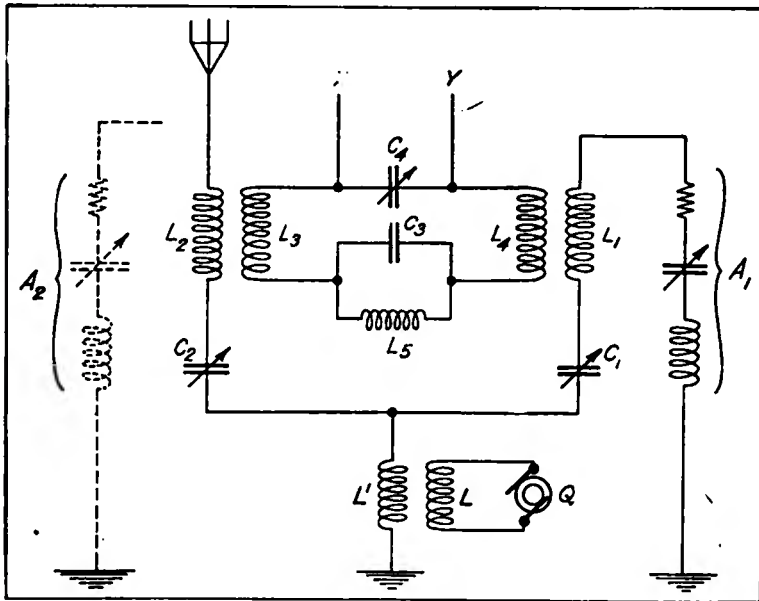


Figure 207—American Telephone and Telegraph Company—Carson system for duplex radio telephony

This arrangement is subject to exactly the same defects as those pointed out in connection with Mr. Fessenden's above.

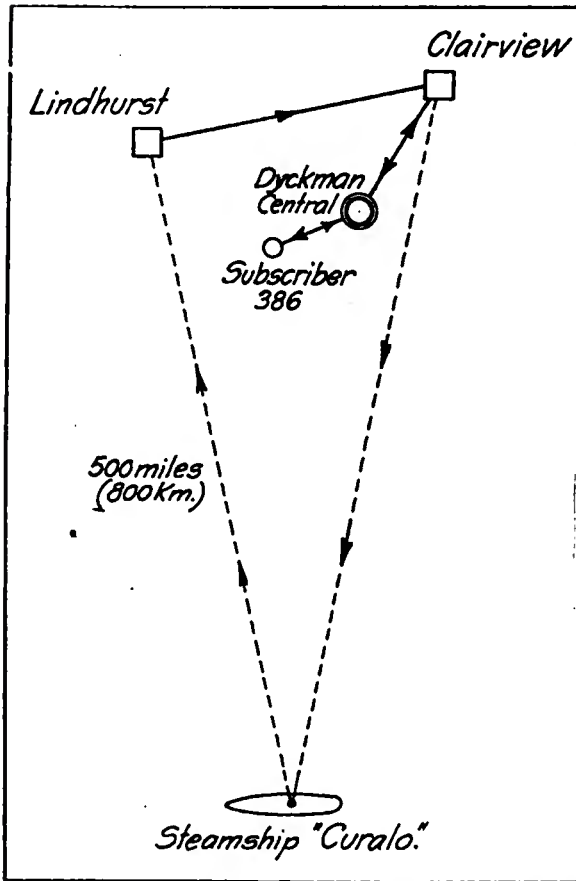
Another type of system intended to accomplish the same results as actual duplex working has been worked out by Dr. de Forest and along independent lines some of the engineers of the General Electric Company. This consists of a voice-controlled relay which changes the set over from receiving to transmitting when speech is begun. A sluggish contact device (e. g., mercury in a capillary tube) is closed by the voice vibration or the exhaled breath and the set is then thrown, through the action of more robust relays, into the transmitting setting. The controlling device is usually located in or very near to the microphone transmitter. Other systems along similar lines have been proposed, all depending on changes caused by the voice or voice currents, but there is no data available for publication as the extent to which they are capable of practical application.

We will not discuss here such methods of duplex working as the commutator method, wherein the antenna is thrown in rapid succession from the transmitter to the receiver and back. While these may be suitable for telegraphy, they are obviously unsuited for telephony because of their almost certain destruc-



tion of the quality of the speech. Even if the commutation is done above audio frequency (which, in itself, is hardly very practical), the method would be open to grave objections.

(b) **SHIP-TO-SHORE RADIO TELEPHONY.** The most casual consideration of the question of ship-to-shore radio telephony forces us to accept



the conclusion that this vastly important system is dependent for its full development on the voluntary or enforced co-operation of the wire telephone companies. It is obvious that it is not possible to have a fairly large radiophone set at the home or office of every one who may at some time or other desire to speak with a person on board a ship, but that the land end of the conversation must be carried on from a large commercial radiophone station which automatically relays the speech out from the wire lines. Similarly the incoming speech from the ship must be received at the same or another radiophone station and there relayed back to the wire lines and thence to the subscriber. The procedure may be made clear from Figure 208. We will suppose that Mr. Frank Jones, whose wire telephone number in New York City is Dyckman 386, desires to radiophone to Mr. William Smith on board the steamship "Curalo," some 500 miles (800 km.) at sea. Let us sup-

Figure 208—Typical ship-to-shore radiophone system

pose that a duplex radiophone system (using, for example, the twin station Marconi plan given in Figure 204) is installed at the two towns near New York which have the assumed names of Clairview and Lindhurst. We shall take the transmitting station to be Clairview. At Clairview there will be a usual telephone connection, itself connected to a private telephone line between Clairview and Lindhurst. Lindhurst is the receiving station (with its balancing antenna as indicated in Figure 204). At Clairview, the incoming telephone line has inserted in it or across it the input side of a line amplifier which increases the energy of the speech current to the point of enabling control of the radiophone transmitter at Clairview. The wire line terminating in Lindhurst is there connected to the output side of an amplifier which increases the intensity of the incoming radiophone signals to the point where they can be sent through Clairview to the calling or called subscriber's station. On board the "Curalo" we have a moderately skilled operator, who, among his other duties, listens for distress calls. Either the operator or one of the ship's engineers keep the ship's radiophone set in order. We shall assume that the set on board the ship is not equipped for duplex

work, though it is probable that eventually even the ship sets will be duplex. The change-over will be assumed to be accomplished by pressing down a push button when talking and releasing it when receiving, the push button circuit actuating some form of relay control switch which transfer from sending to receiving or vice versa.

We shall now proceed to give in detail the conversation between practically all the parties involved in the above call between Messrs. Jones and Smith. It is understood that this will be somewhat imaginative and subject to revision in details, though it is probably a fairly faithful impression of the actual procedure:

MR. JONES (on his wire telephone): Radio long distance, please.

OPERATOR (AT DYCKMAN CENTRAL): One minute, please. (She connects his line to the Clairview Radio Station line. The internal procedure at the central or centrals is here omitted.)

OPERATOR (AT CLAIRVIEW): Radio long distance speaking.

MR. JONES: I wish to speak to Mr. William Smith on board the steamship "Curalo."

OPERATOR (AT CLAIRVIEW): Mr. William Smith on board the "Curalo." What is your number?

MR. JONES: Dyckman 386, Mr. Frank Jones, the subscriber, speaking.

OPERATOR (AT CLAIRVIEW): Thank you. Hang your receiver on the hook. I will call you as soon as your connection is ready.

OPERATOR (AT CLAIRVIEW, talking out on the radiophone): Hello. Curalo. Hello, Curalo. Hello, Curalo. New York calling.

OPERATOR (ON "CURALO"): Hello, New York. "Curalo" talking.

OPERATOR (AT CLAIRVIEW): I want Mr. William Smith. Mr. Frank Jones of New York calling.

OPERATOR (ON "CURALO"): Mr. Frank Jones calling Mr. William Smith?

OPERATOR (AT CLAIRVIEW): Yes, please.

OPERATOR (ON "CURALO"): Hold the air, please. I will call Mr. Smith. (The operator on the "Curalo" then calls Mr. Smith to the radio cabin, and explains to him how to change from talking to listening by releasing the controlling push button. The method being learned, he resumes as follows):

OPERATOR (ON "CURALO"): Hello, New York. Mr. Smith is ready for you now.

OPERATOR (AT CLAIRVIEW, on wire line): Hello, Dyckman. Clairview calling. Give me 386 again, please.

OPERATOR (AT DYCKMAN): 386?

OPERATOR (AT CLAIRVIEW): Yes, please.

MR. JONES (at his wire telephone): Hello. This is Dyckman, 386. Mr. Frank Jones speaking.

OPERATOR (AT CLAIRVIEW): Mr. Smith is ready for you now. Go ahead, please. (The operator at Clairview here closes the necessary amplifier circuits and takes a supervisory role only.)

MR. JONES: Hello, Mr. Smith. Jones calling.

MR. SMITH: Hello, Jones. This is certainly a pleasant surprise. How are . . . . .

It will be seen from a careful reading of the above that the procedure is no

more elaborate than for any ordinary "particular person" long distance call. Furthermore, so far as the calling and called persons are concerned, there is no more difficulty or confusion than in any ordinary call. To verify this, the reader is urged to re-read Mr. Jones' and Mr. Smith's remarks above.

It need hardly be said that the system of charging for a radiophone conversation would be on the basis of time and not on the basis of words as in telegraphy. As to the extent of the charge, this might depend on several factors. To begin with, a somewhat deferred service corresponding roughly to "day letters" or even to "night letters" in ordinary telegraphy seems feasible at a considerably lower rate per minute. The season of the year and the distance over which the call has been made might also be factors of the situation, though to what extent only practical experience and the development of the art can determine.

There is one direction in which radio legislation properly conceived can greatly assist the radiophone field. This is by providing a system whereby every ship and its corresponding shore station have available not one or two, but a considerable number of wave lengths. These wave lengths, which should be designated by letters or numbers for the sake of brevity, would all be available for communication except those that were in actual use *near the receiving station*. That is, the receiving station, after listening for a moment, would dictate to the transmitting station the suitable wave length for communication without interference. Naturally all calling would be done on a common wave length which might be, for example, the present-day 600 meter wave. This system of a multiplicity of legal wave lengths and the choice of one of them for communication in accordance with traffic conditions at the receiving station has great possibilities, and should be carefully considered for future action.

One further interesting possibility of radio telephony on board ship may be mentioned. A simple phonograph recording and reproducing device run by a small motor might be provided so that, in case the passengers and crews are forced to desert the ship after a serious accident, the phonograph can continue to repeat into the radiophone transmitter the necessary call for help, the name of the ship, its location, the type of accident, and the action taken by the passengers and crew. This would, to some degree at least, relieve the operator from the heroic, but frequently fatal, stand which up to the present he has always taken. With this simple device installed, he has at least the same chance of rescue as the other officers of the ship.

(c) **LONG DISTANCE RADIO TELEPHONY.** This also must be accomplished with the co-operation of the wire telephone companies, and it is to be hoped that they will adopt a broad policy of co-operation with radio telephony in this regard. Since a large portion of the long distance radio telephony will be trans-oceanic (in which case wire telephony cannot come into competition), such an attitude on the part of the wire telephone companies will involve no inordinate sacrifice, and will, indeed, probably add very largely to the long distance land wire line tolls.

We shall give here also the sample procedure of a long distance radiophone call over the 5,500 miles (9,000 km.) between New York City and Buenos Aires. We shall suppose that Mr. Frank Jones of Dyckman 386 is calling Mr. J. Desigante of Ciudad 762 in Buenos Aires. We shall assume now that Clairview and Lindhurst have the same functions as in the case described previously except that they are naturally provided with a much more powerful transmitter and a suitable receiving set. At Buenos Aires, the transmitting station is at the (assumed) town of Sol del Plata, and the receiver at the (assumed) town of Parina.

The wire line connections, line amplifiers, and auxiliary apparatus are like those at Clairview and Lindhurst. Speech from Mr. Jones to Mr. Desigante travels over the following route:

Mr. Jones at Dyckman 386—Dyckman central—(possible intermediate centrals not here considered)—Clairview—(by radio) Parina—(by wire) Sol del Plata—(possible intermediate centrals not here considered)—Ciudad central—Mr. Desigante at Ciudad 762.

Speech from Mr. Desigante to Mr. Jones travels as follows:

Mr. Desigante at Ciudad 762—Ciudad central—(possible intermediate centrals not here considered)—Sol del Plata—(by radio) Lindhurst—(by wire) Clairview (possible intermediate centrals not here considered)—Dyckman central—Mr. Jones at Dyckman 386.

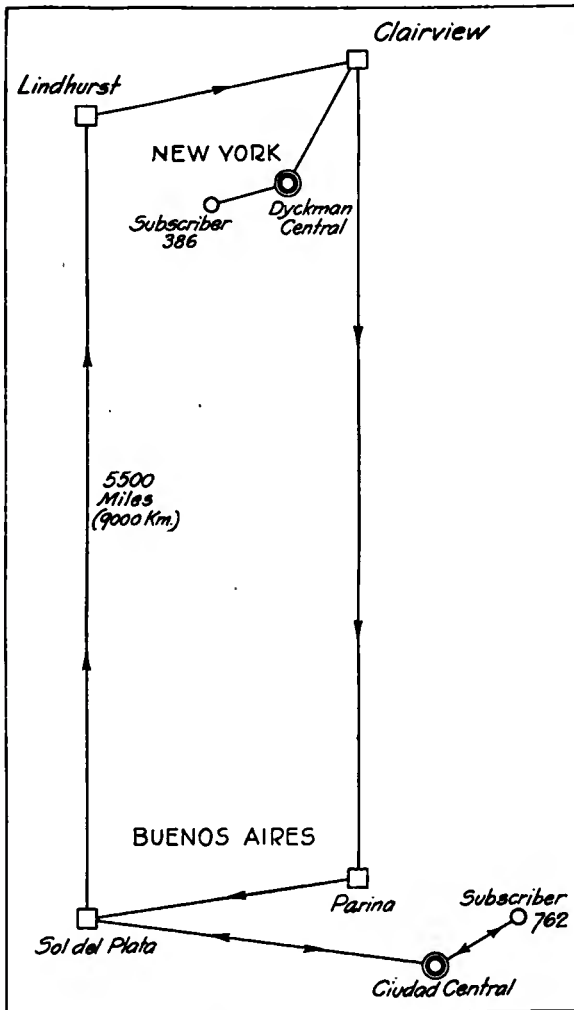


Figure 209—Typical duplex long distance radiophone system

These paths are shown clearly in Figure 209. The detailed dialogue between all parties involved is here given. In addition, before each remark we give the elapsed time in minutes and seconds very roughly estimated:

0.00—MR. JONES (on his wire telephone): Radio long distance, please.

0.05—OPERATOR (AT DYCKMAN CENTRAL): One minute, please. (She connects his line to the Clairview Radio Station line. The internal procedure at the central or centrals is here omitted.)

0.25—OPERATOR (AT CLAIRVIEW): Radio long distance speaking.

0.30—MR. JONES: I wish to speak to Buenos Aires. A particular person call for Mr. J. Desigante, D-e-s-i-g-a-n-t-e, whose number is Ciudad 762.

0.45—OPERATOR (AT CLAIRVIEW): Buenos Aires, Mr. J. Desigante, D-e-s-i-g-a-n-t-e, of Ciudad 762. What is your number?

1.00—MR. JONES:

Dyckman 386, Mr. Frank Jones, the subscriber, speaking.

1.05—OPERATOR (AT CLAIRVIEW): Thank you. Hang your receiver on the hook. I will call you as soon as your connection is ready.

1.20—OPERATOR (AT CLAIRVIEW, talking out on the radiophone): Hello, Buenos Aires. Hello, Buenos Aires. Hello, Buenos Aires. New York, calling.

1.45—OPERATOR (AT SOL DEL PLATA, receiving through Parina): Hello, New York. Buenos Aires speaking.

1.50—OPERATOR (AT CLAIRVIEW): I want Ciudad 762, Mr. J. Desigante, D-e-s-i-g-a-n-t-e. Mr. Frank Jones calling.

2.15—OPERATOR (AT SOL DEL PLATA): Ciudad 762, Mr. J. Desigante, D-e-s-i-g-a-n-t-e. Mr. Frank Jones calling. Hold the air, please. (Speaking on the wire line) Hello, Ciudad. Sol del Plata calling.

2.35—OPERATOR (AT CIUDAD) (The internal procedure at the central or centrals is here omitted): Hello, Sol del Plata. Ciudad speaking.

2.40—OPERATOR (AT SOL DEL PLATA): Ciudad 762, please.

2.42—OPERATOR (AT CIUDAD): 762?

2.45—OPERATOR (AT SOL DEL PLATA): Yes, please.

2.55—Mr. DESIGANTE (on his wire telephone): Hello, this is Ciudad 762. Mr. J. Desigante speaking.

3.00—OPERATOR (AT SOL DEL PLATA): Mr. Frank Jones of New York wishes to speak to you. Hold the wire, please. (By radiophone): Hello, Clairview. Ciudad 762 is ready for you now.

3.20—OPERATOR (AT CLAIRVIEW): Thank you. Hold the air, please. (By wire telephone): Hello, Dyckman. Clairview calling. Give me 386 again, please.

3.30—OPERATOR (AT DYCKMAN): 386?

3.33—OPERATOR (AT CLAIRVIEW): Yes, please.

3:50—MR. JONES (on his wire telephone): Hello, this is Dyckman 386 Mr. Frank Jones speaking.

3.53—OPERATOR (AT CLAIRVIEW): Mr. Desigante is ready now. Go ahead, please. (The operator at Clairview here closes the necessary amplifier circuits and takes a supervisory role only.)

3.56—MR. JONES: Hello, Mr. Desigante. Jones speaking.

4.00—MR. DESIGANTE: Hello, Mr. Jones. Desigante speaking.

4.01—MR. JONES: About that shipment number 1167 of April 18th on the "Curalo," I wanted to ask whether . . . . .

As stated before, the charges on such telephone service might well take account of the time of day and of the season of the year.

There will be an interesting competition between very high speed telegraphy (possibly with automatic recording *and transcribing* apparatus) and radio telephony in connection with the normal transaction of business. It is too early to venture any predictions regarding the results of such competition. However, for personal communications there can be no doubt as to which form of communication will be preferred.

(d) **FUTURE DEVELOPMENT OF RADIO TELEPHONY.** Now that the need for radio telephony is well recognized, we may confidently expect a very rapid development. Once a public demand is created, the technical advances required to satisfy that need must shortly follow.

Some interesting possibilities as to universal communication may be con-



sidered. As far as portable transmitters are concerned, it is unlikely that a man will be able for some time to come to carry a radiophone set capable of communicating more than a few miles. Some new motive force, the apparatus for producing which has a very small weight per kilowatt delivered, must first be discovered. So far as reception is concerned, however, very sensitive and light receiving apparatus, capable of receiving messages from hundreds (or even thousands) of miles is imaginable. So that it should become ultimately possible to keep in immediate touch with the traveling individual regardless of his motion or temporary location. A great field of usefulness is thus opened to development.

The linking of the wire telephone and radiophone systems of a country will go far toward making it possible for travelers to keep in touch with their homes and business at all times, and for the people of one nation to know the people of far distant nations in a close and intimate fashion. By the use of a deferred or night radiophone service (analogous to the day letter or night letter of the wire telegraph companies), reasonably inexpensive communication of this type should become feasible since such service might be rendered at times of light load and would tend to maintain the steady usefulness of the station. As is well known, stations are most efficiently operated when the load is nearly always full and constant. Plant efficiency requires, therefore, that some sort of premium be put on utilization of the plant facilities at times of normally light load.

In conclusion, it may be stated that it is certain that radio telephony, properly fostered by the Governments of the world, must become ever more useful to humanity. From ship and shore stations, from aeroplane and ground, from trains and depots, over forests and deserts, across oceans and continents will pass the spoken word of man. We may justly paraphrase President Elliot's splendid eulogy of another type of communication. His words apply with multiplied force to the radiophone of the future. We may rightly term this instrument for speeding the voice of man across space as:—

CARRIER OF NEWS AND KNOWLEDGE.  
 INSTRUMENT OF TRADE AND INDUSTRY.  
 PROTECTOR OF LIFE AT SEA,

---

MESSENGER OF SYMPATHY AND LOVE.  
 SERVANT OF PARTED FRIENDS.  
 CONSOLER OF THE LONELY.

---

BOND OF THE SCATTERED FAMILY.  
 ENLARGER OF THE COMMON LIFE.

---

PROMOTER OF MUTUAL ACQUAINTANCE.  
 OF PEACE AND GOOD WILL AMONG MEN AND NATIONS.

(THE END)

# From and For those who help themselves

Experimenters'



Experiences.

## FIRST PRIZE, TEN DOLLARS Building and Erecting a Steel Aerial Mast

**W**IRELESS experimenters of limited means usually find the construction of a good aerial mast one of their greatest difficulties, both because of the cost and the mechanical problems encountered. The 110-foot steel mast described herewith was built and erected at a cost of less than \$20, and any experimenter, with the proper amount of energy and the assistance of a few friends, can duplicate it at about the same cost. It must be admitted at the outset, however, that although inexpensive, the outlay of labor and patience will be considerable. Two of these masts, erected two years ago, have passed through several terrific windstorms without showing the least symptoms of instability; in fact, they are so substantial that a professional steeplejack did not hesitate to climb one for the purpose of scraping and painting it.

The accompanying drawings, figures 1, 2, 3, and 4, show the various stages of construction. Figure 1 is a detail of the sectional joints; figure 2, a cut-away portion of the topmast; figure 3, a detail of the base, and figure 4 the completed mast.

The first essential is the steel tubes which, in this case, are discarded boiler tubes. These can be procured at the junk yards in various sizes and conditions. They are seamless and comparatively light, weighing about 70 pounds to the 14-foot section, and can usually be bought for a cent a pound, or 70c. a section. The price has advanced somewhat in the last year,

however. Fourteen-foot lengths of  $3\frac{1}{2}$ -inch tubing are the most desirable. Avoid those which are heavily rusted; old boiler tubes are not rusty under the scales unless they have been exposed to the weather a long time.

The second essential is some heavy water pipe for connecting sleeves. A 20-foot section of discarded pipe, not too much corroded, is cut into seven sections of equal length. It is best to have this done in a plumbing shop. The charge is usually 90c. per hour. The boiler tubes should be taken to the same shop and the rough ends trimmed off at the same time. The ends of the sleeve section should be slightly reamed, so as to facilitate entering the tubes into the sleeves. If  $3\frac{1}{2}$ -inch boiler tubes are used, the sleeve pipe should be  $3\frac{1}{2}$ -inch water pipe, because boiler tubes are measured on the *outside* and water pipe on the *inside*.

The accompanying diagrams show exactly how the sections are put together.

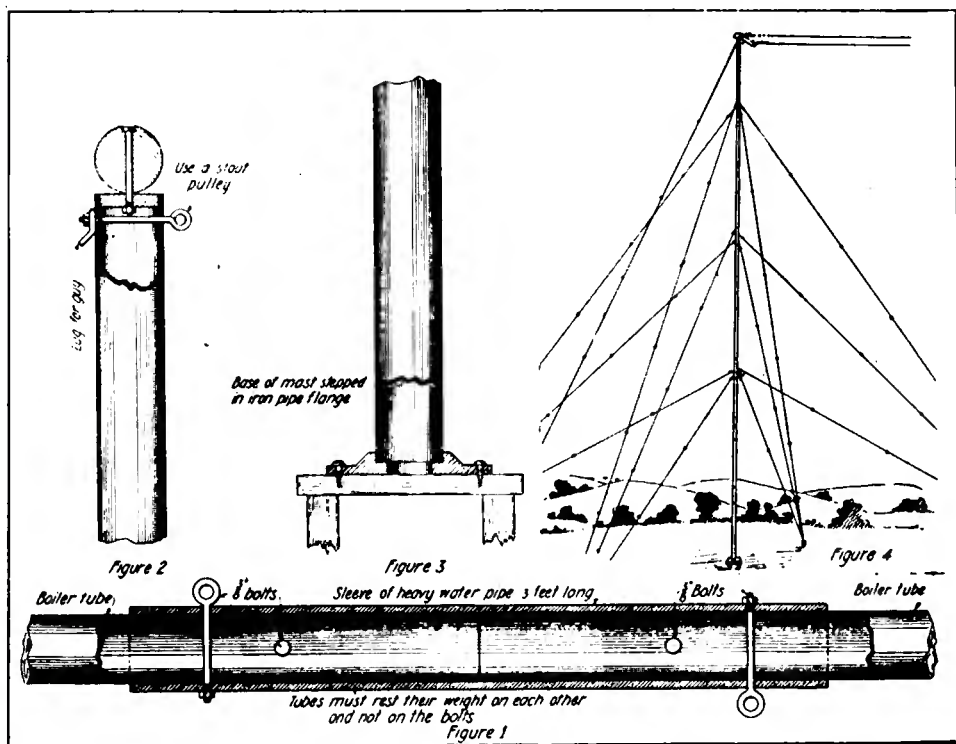
Probably the most important step is the fitting of the sleeves. It is absolutely essential, as will be readily seen, that the sections rest on each other so that the weight does not strain the bolts used in holding the sleeves in place. For this reason, it is best to fit on a sleeve and drill the holes for the bolts while the two sections are in place. Just how these sections are joined is shown in drawing, figure 1. One scheme is to lay the whole mast out on a level spot and drill the holes with an electric breast drill or ordinary breast drill. Or, if it is preferred to do the work indoors and a power drill is available, two sections can be fitted

at a time and drilled on a drill press by resting the sections on wooden hoises. It is best to drill the holes a little larger than the bolts to be used, so that there will be no trouble in fitting the parts together when erecting the pole. In laying out these bolt holes, an effort should be made to keep them along the *same centre line*, so that when the pole is erected the holes are in two straight lines at right angles to each other. Another matter of importance is to mark carefully the relative positions of the sections and sleeves as they are drilled so that when the pole parts are assembled, no trouble will be experienced in making the holes line up. This marking can easily be done with a centre punch. Also be sure to number each section with a centre punch.

Large bolts are not necessary, as their only functions are to hold the sleeves in place and provide means for fastening the guy wires. Bolts  $\frac{3}{8}$ -inch in diameter are sufficient. If eye-bolts

are not available they can easily be made. One of these eye-bolts is used to hold the pulley for the aerial rope. It is a good precaution, when erecting a pole of this type, to put on two pulleys so that if anything happens to the aerial rope, another is available. A cheap rope can be used on the emergency pulley.

In fitting the sleeves for boring, it may be necessary to knock and scrape off some of the boiler scale on the tubes. After the holes are all bored, the sections can be laid on a couple of trestles and most of the scales knocked off with hammers. Next, with a couple of old square files, the remaining scale is scraped off and when the job is finished, the sections will be quite smooth. They should then be given a coat of asphaltum, which preserves the metal from the weather. Later, as the pole is being erected, cotton packing should be caulked into the upper joint formed by each sleeve and section, and a liberal coating of the asphaltum ap-



Figures 1, 2, 3, 4.—First prize article

plied to prevent water running between the tube and sleeve. It is well to give the pole another coat of asphaltum as it is being erected.

To give the top of the mast a nice finish, and at the same time to preserve it by keeping out the rain, a plug can be driven flush with the end and a wooden croquet ball fastened on with a long spike or bolt as shown in figure 2.

The final step in the preparation of the mast is to drill a hole for the eye bolt which holds the aerial pulley. The eye bolt in this case was made in the blacksmith shop and a galvanized iron pulley, suitable for  $\frac{1}{4}$ -inch rope, was bought at a hardware store for 15 cents.

A small iron lug, to which a wire can be attached, is fastened under the nut on the bolt which holds the pulley. (See figure 2.) This makes it possible to attach a guy wire which acts as a direct brace against the pull of the antenna, if it is to be of the L or T type. A small iron device for holding the lower end of the rope, such as is used in fastening awning ropes on store fronts, is attached to the bottom section at a convenient height.

#### Raising the Mast

This is not as difficult as might be imagined, but it is a slow job unless plenty of help is available. It is presumed that the experimenter has picked out the location for his mast and has selected four trees or buildings to which the guy wires can be fastened. In our case we used three conveniently located trees and set one heavy post for the fourth guy pole.

From a friendly telephone or electric light plant manager, borrow a twenty-five or thirty foot pole. Set the pole in a hole four or five feet deep. This is to be used as a gin-pole in raising the mast sections. Setting this pole is quite a task and rather dangerous. It is best to borrow three or four pike poles such as linemen use, and with the aid of these the pole can be safely raised to a vertical position and slid into the hole. Four strong guy wires or ropes are fastened to the top of this pole and attached to heavy stakes

driven well into solid ground. If a good ladder is not available, wooden cleats should be spiked to the gin-pole to facilitate getting up and down.



*Mast described in first prize article*

Near the top of the wooden pole a heavy rope is looped and securely fastened. This provides a loop in which to hook the hoisting device. For this purpose a good one-ton chain hoist with a long chain is desirable and can usually be borrowed. If it is of large size and long reach, so much the better, for the completed mast weighs about 700 pounds and a clearance of 15 feet must be provided to permit sections to be inserted. If the hoist is a short one, the mast can be raised as far as it permits, then securely blocked from below, and a new hold taken lower down.

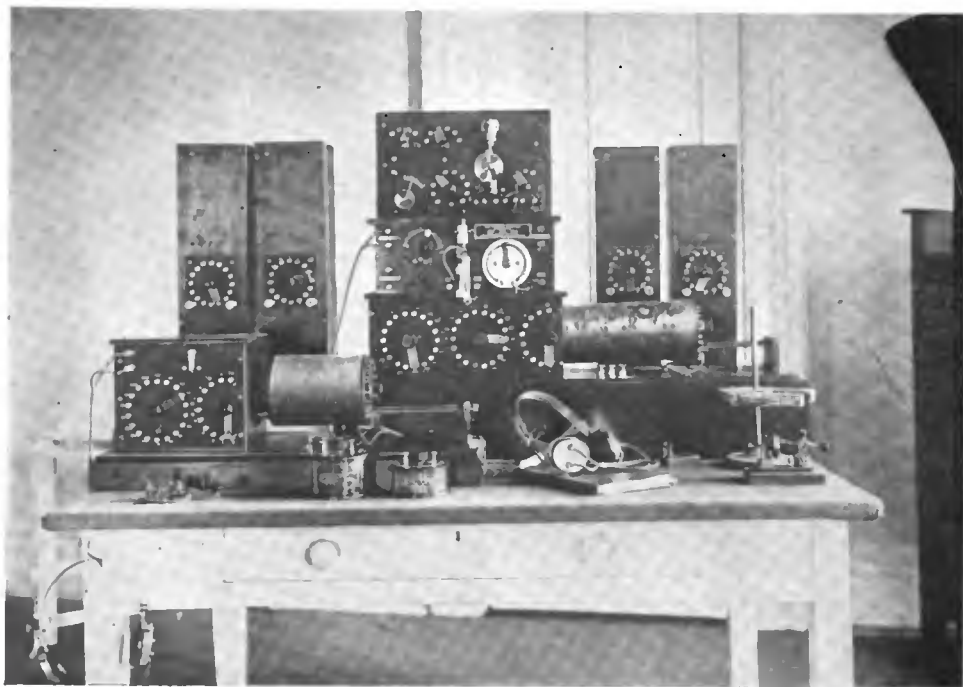
Before starting hoisting operations, the guy wires should be cut into sec-

tions and insulators attached. If No. 8 or No. 10 galvanized wire is used, three sets of guy wires will support the pole. The wire should be cut into 40 or 50-foot sections and a good porcelain knob insulator attached to one end of each wire. Thus it is possible to lengthen the guys, as the mast is raised, by simply adding on sections of wire. The insulators can be procured for two cents each. The kind with the groove in the center is preferable.

When the hoist is in position, bolt sections No. 1 and No. 2 together with the base of section 2 at the foot of the gin-pole. Then it will be necessary to thread the aerial rope through the pulley. It is safest to tie the loose ends of the rope together and coil the rope in a bucket so that it will uncoil easily without tangling as the mast is raised. After the rope is in place, a section of guy wire is fastened to the lug on the pulley bolt. This guy wire is used as explained previously to take the strain of the aerial off the top section of the mast.

By means of the chain hoist or a block and tackle, the two united sections are then raised upright alongside the gin-pole and lashed safe with rope. Now caulk the top joint of the sleeve and run in a little asphaltum. Next fasten guy wires to the four lugs on the sleeve. It now becomes necessary to raise this portion of the mast 15 feet before another section can be added. It is a simple matter to take a hitch around the lower end of the tubing and hoist it, but it must be kept vertical by allowing it to slip through lashings of stout rope at the top of the gin-pole and at the base of the mast sections. When it is raised sufficiently, the third section, which has been equipped with its sleeve meanwhile, is placed in position and bolted.

Before raising the mast further, means must be provided for keeping it perpendicular as it is raised. If there is plenty of help, a man at each guy wire, with a hitch around a post, can hold it; if not, the four wires must be loosened a little each time the mast is



*Station of first prize winner*



raised 2 feet. This necessitates many trips to the guy posts and takes a lot of time.

Care must be exercised all the time, that the sleeve joints are well caulked and that the rope to the pulley runs free. It is also important that the base of the ascending mast be kept fastened to the gin-pole with a sliding rope noose; otherwise it would be likely to veer sideways. And don't stand directly under the mast. Let the man at the chain hoist keep his eyes and ears open and be prepared to jump if anything breaks. If care is exercised, no accidents need happen.

Guy wires need only be fastened at every other joint, but sometimes it is best to guy the two uppermost joints and then every other joint after that. As a base for the mast, a small platform built over four stout posts set in the ground close to the gin-pole should be provided as shown in figure 3. This should be framed heavy enough to carry the weight of the pole. The top should be watertight and an apron dropped around the platform to a depth of 6 inches, to insure several inches of the supporting post remaining dry in the stormiest weather. As this is built close to the gin-pole, it is easy to set the completed mast on it. A heavy block with a 3½-inch hole bored in for a depth of 1 inch, makes a good base in which to set the mast. This block is then spiked to the platform.

The last step is to guy the pole perfectly perpendicular. Iron turnbuckles can be used but are not absolutely necessary.

In the event that one of these masts is to be erected on a barn or other two-story building the operation is quite simple. It is only necessary to cut a hole in the roof and in the hayloft floor, and by using the chain hoist the sections can be spliced together and pushed up through the roof. In this case, the base of the pole when completed rests on the upper floor of the building.

The following table gives the material required and the approximate cost:

8 lengths 14-ft. boiler tubing 3/8 in. diameter	
at 1c a lb.....	\$5.60
20 ft. 3/4 in. heavy water pipe.....	1.50
13 eye bolts 3/9 in. x 4 1/2 in.....	.55
16 bolts 1/2 in. x 4 1/2 in.....	.35
Having pipe cut and tubes trimmed (2 hrs. at 90c)	1.80
Pulley.....	.25
Rope—115 feet 1/4 in. Manila.....	.90
Paint, one quart.....	.75
Insulators, 100 at 2c each.....	2.00
Guy wire, 150 lbs. at \$4.00 per C.....	6.00

I may add, in conclusion, that practically all of my apparatus is home-made from ideas found in THE WIRELESS AGE. Take, for example, the receiving apparatus shown in the photograph. It comprises long and short wave receiving tuners and a vacuum valve amplifier, with complete circuits for the reception of damped and undamped oscillations. With it, I can hear stations thousands of miles off. These results were made possible by the advice given to the experimenter from time to time through the columns of your valuable publication.

FRED W. JAMESON, *Kansas.*

### SECOND PRIZE, FIVE DOLLARS A Serviceable Switchboard for the Experimenter's Laboratory

**I**N the electrical laboratory or wireless operating room it is often desirable to have some form of a switchboard to facilitate the mounting and handling of experimental apparatus. Figure 1 shows the details of construction for a simple yet substantial board that can be easily built without machine work or special tools. The board may be of marble, slate, or any good insulating material such as bakelite. A large board should be made up of several sections or panels, as the small sections are easier to handle and mount, and are less liable to crack when boring the holes. The standards should be made of one iron pipe and standard pipe fitting.

The panels, C figure 1, are first bored to receive the bolts that hold it to the pipe standard. After this the holes for the various switches or instruments should be bored. In the event that marble is used, a steel drill should be employed and water allowed to drip on it constantly during the operation. This will prevent both the board and

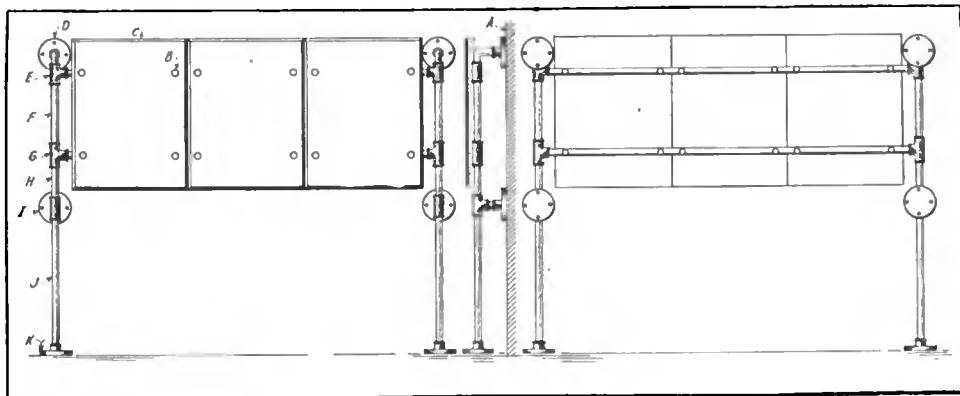


Figure 1—Second prize

the drill from breaking. Care should be taken to drill the holes very slowly. Each panel should be completely bored ready to mount before building the standards.

As shown in the accompanying drawing, the board is supported by two upright pipes; the panels are supported on two horizontal pipes by machine bolts *B*; two additional horizontal pieces are employed to fasten the board against the wall *A*.

Referring again to the drawing, a deck flange *K*, screwed to the floor, holds the upright firmly in position. A section of pipe *J* ends in a T-fitting *I*, which in turn connects with another deck flange bolted to the wall. This is clearly indicated in the side view of the drawing. The spacing in the rear will be governed by the builder's requirements. Continuing from the upright section, another section of pipe *H* terminates in a T-connection *G*, which holds one end of a horizontal length to which the lower end of the board is attached. The horizontal lengths of pipe are in one piece with a T-connection on each end.

Another short length of pipe *F* terminates in a T-fitting *E* which holds the upper deck flange *D*, the latter is screwed to the wall and also the upper horizontal length of pipe to which the panels are bolted. The upright at the other end of the board is built up in the same manner. As each panel is bolted in four places to the pipe standard, and the standard in turn screwed

to the floor and back wall, the entire structure forms a strong, substantial and well appearing switchboard with plenty of room on the face, and capable of carrying considerable weight. If the pipe standards are connected to earth there will be no trouble from induction or static electricity.

R. H. FOSTER, *Florida*.

### An Instrument for Daily Code Practice

It would be well for amateurs to engage in daily code practice during this period to keep up to the mark. A satisfactory instrument for this purpose is the one described here which can be made for a few cents. The only material required is: An old alarm clock, a test buzzer (an old, ordinary bell buzzer will do) two binding posts, some sheet brass, tin or copper, and a discarded cigar box.

First, the paper is taken from the box and then the clock is taken apart, that is, the case, hands, dial, are removed. The works are then set in the box and if of the correct dimensions, the shaft will protrude about half an inch. A place is marked in the corner, and a hole bored so that the shaft will have the position shown in Figure 1. Next, the clockwork is screwed to the bottom of the cigar box. The buzzer is then mounted about 1 inch from the clockwork, the binding posts being placed at the right hand end of the box. Figure 1 shows the necessary details. The omnigraph is now complete except for the record and brush.

The record can be easily made. There are, I might say, two methods of con-

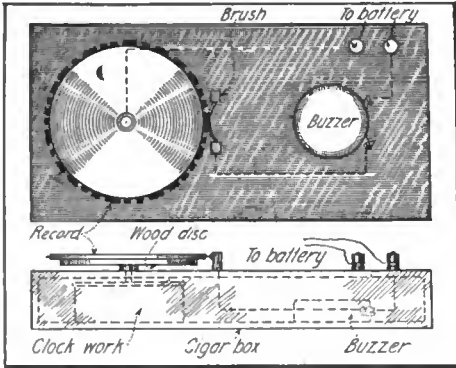


Figure 1

struction. The first is to take a sheet of copper, or tin or some other metal that carries electricity well, about 1-32 of an inch in thickness and cut the dots and dashes as shown in Figure 1. Sheet brass is the best. Describe a circle  $4\frac{1}{2}$  inches in diameter with a compass. Next, cut the code characters you wish to learn or practice. The successive letters must be evenly spaced. Then describe a circle 4 inches in diameter on a piece of cigar box wood and cut it out with a compass saw. Then bore a hole that will fit tightly over the shaft of the clockwork. The disc is now ready for mounting. First force the wooden disc, about half-way down, which ought to leave about 3-16 of an inch between the record and the cigar box. Then force on the record (after punching a hole just a trifle smaller than the shaft of the clockwork). The last thing in the order of construction, is to mount the brush. The disc may be laminated, in fact it ought to be  $\frac{1}{2}$  inch in thickness. This will form a more positive contact with the brush which should be adjusted so as to touch only

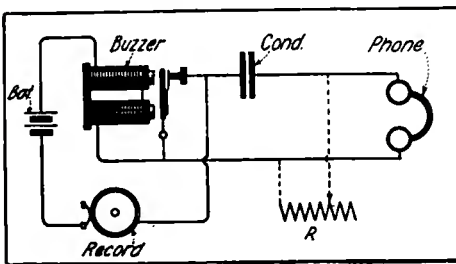


Figure 2

one dash or dot at a time. The records for this machine may be purchased, if the constructor so desires. The wiring diagram is given in Figure 2.

MAURICE STEPHEN MIRANDA,  
New York.

### Changing a Low Voltage Buzzer to Operate on 110 Volts

An ordinary low voltage buzzer may be easily changed over to operate on 110 volts, but it must be remembered that the moment a buzzer is operated on this voltage its entire wiring must be installed to conform with the rules under Class C, National Electrical Code, exactly like any other interior light or power wiring.

The modification in the buzzer required is this: Shift the position of the contact spring so that it touches the back of the fixed point when the armature approaches the magnet pole, instead of the usual break. If necessary, change the coil contacts so that the action of the vibrator is to short circuit the coil instead of opening the circuit.

Then put the buzzer in series with a 25-watt Tungsten lamp (better than a carbon on account of the temperature coefficient of the metal), using standard B. & S. No. 4 R. C. wire on porcelain insulators for connections. If you do not take this precaution you will have trouble with the local electrical inspection department, municipal or insurance bureau.

W. L. S., Massachusetts.

### Use of Radio by German Raiders

Officers of German war vessels cruising along the Pacific Coast erected a wireless station on Easter Island late in the year 1914, and because of the remoteness of this island from the outside world the apparatus was undetected for a number of months. It was employed for keeping in touch with the movements of their vessels. It is understood that this station and apparatus have been confiscated by the Chilean authorities.

# The Monthly Service Bulletin of the NATIONAL AMATEUR WIRELESS ASSOCIATION

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

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## A Model Amateur Station

Members of the Association who have owned long distance amateur stations and who at one time or another have entered into the great trans-continental relay contests, will recall with much enthusiasm the signals of station 2 PM. This record-breaking apparatus was owned and formerly operated by A. J. Faraon and J. F. Grinan of New York City. Investigation reveals that the efficiency of this station is accounted for by the fact that it was not constructed on a "hit or miss" principle, but it represented a co-ordination of the latest and best in the amateur field at that date.

Not only have the owners of 2 PM broken all long distance records in amateur wireless telegraphy, but they have been able to communicate with amateur stations almost throughout the United States. They have also operated 2 PM as a relay for messages originating in the New England States.

The antenna of 2 PM consists of two wires, spread forty feet apart, stretched from two water tanks on the roof of a twelve-story apartment house across West End Avenue to two tanks on top of another apartment house. Insulators are placed three-quarters of the way across the street, thus reducing the natural period of the antenna to 184

meters. The wires are made up of fifty strands of No. 34 enamelled magnet wire.

As shown in figure 1, the transmitting apparatus consists of a 1 kw. Northern Electric motor-generator, a 1 kw. open core transformer, ten copper-coated leyden jars and the so-called



Figure 1—The 1 kw. transmitting set known to all amateurs as 2 PM



Blitzen oscillation transformer. A synchronous rotary spark gap is mounted on the coupling between the motor and the generator and is enclosed in a muffling box. A hot wire ammeter is also connected in series with the earth lead, as shown at the right of the photograph.

With this apparatus, the antenna meter registers a current of 2.6 amperes on the wave-length of 200 meters, the decrement of the oscillations being .09.

cently made a trip on the s. s. Manchuria, reports their signals, Q S A, 2,100 miles east of Nantucket.

2 PM, as stated in the June issue of THE WIRELESS AGE, was the starting point for the record-breaking transcontinental message. This station gave its direct O. K. to 9 ZF in Denver, who said that its signals were strong throughout the evening. The signals from 9 ZF were also easily readable in New



*Complete view of the station which started the record-breaking relay*

The power input is 450 watts—well within the United States regulations.

The receiving set consists of a Paragon regenerative coupler with a one-step amplifier.

Messrs. Grinan and Faraon have communicated with stations as far West as Denver, Colo., with their equipment. Station 9 ZF has repeatedly been communicated with. Their signals were also heard in Los Angeles, Cal., by J. B. Farrington. A. F. Pendleton, who re-

York City at the same time, and since this preliminary test these two stations have repeatedly communicated with each other.

Outside of the second district, station 2 PM worked with twenty-seven stations in the eighth district, thirty-two stations in the ninth district, seven stations in the first district and eleven in the third district. This was accomplished during February and March,

*(Continued on page 525)*



# Queries Answered

Answers will be given in this department to questions of subscribers, covering the full range of wireless subjects, but only those which relate to the technical phases of the art and which are of general interest to readers will be published here. The subscriber's name and address must be given in all letters and only one side of the paper written on; where diagrams are necessary they must be on a separate sheet and drawn with India ink. Not more than five questions of one reader can be answered in the same issue. To receive attention these rules must be rigidly observed.

**Positively no Questions Answered by Mail.**

R. W., Portsmouth, Ohio:

The amplification you may expect from the cascade amplifier such as is described in the book, "How to Conduct a Radio Club," depends largely upon the type of vacuum valve bulb you employ. Also take into consideration that although this apparatus was designed to amplify audio frequencies, there is some amplification of the radio frequencies; therefore the amplification to be expected will depend largely upon the part played by either current.

No harm will result from placing this amplifying coil near the other parts of equipment nor will you experience any losses by the use of telephone jack switches for changing connections from one circuit to the other.

\* \* \*

F. D., San Francisco, Cal., inquires:  
Ques.—(1) Please publish in THE WIRELESS AGE a wiring diagram for a regenerative receiver employing a three-

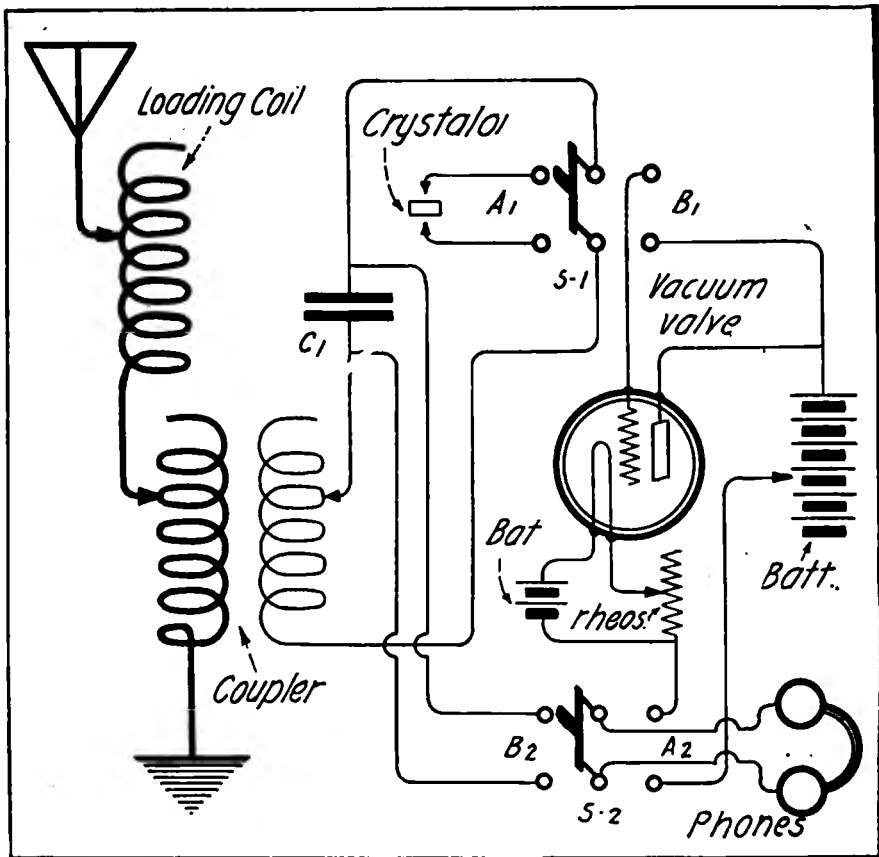


Figure 1

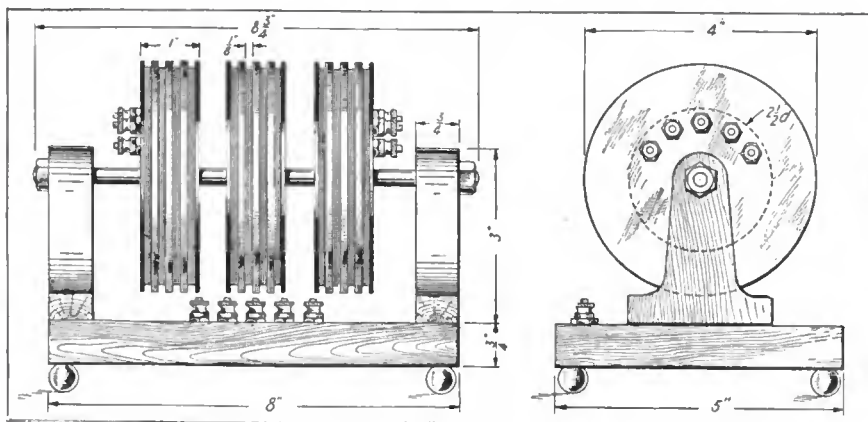


Figure 2

electrode vacuum valve and the following additional apparatus: a loading coil, coupler with a variable secondary and primary; a secondary variable condenser of .0004 microfarad. If possible, arrange this circuit so as to include a crystaloi detector for alternate use with the vacuum valve. I should like, if possible, to have this change take place by the operation of one double-pole, double-throw switch.

Ans.—(1) A complete diagram of connections for a regenerative circuit is shown in figure 1, also the connections and switch arrangements for the crystaloi detector. It will not be possible to make the necessary changes by a single, double-pole, double-throw switch because the telephones in the vacuum valve circuit are connected differently in the crystaloi circuit. The switching arrangements for changing from one detector to the other are shown at S-1 and S-2. When the switch, S-2, is thrown to the position, A-2, and the switch, S-1, to the position, B-1, the vacuum valve is connected ready for use, and if both switches are thrown in the opposite direction, the crystaloi detector will be connected in series with the secondary winding, and the telephones will be shunted around the grid condenser, B-1. The crystaloi detector requires a rather large value of capacity at C-1, and, therefore, you may obtain increased strength of signals by placing a small fixed condenser of .01 microfarad in shunt to the condenser, C-1, which usually is one of very small capacity for use with the valve. By slight re-arrangements of these connections, you can construct a four-blade, double-throw switch by means of which all the connections can be shifted simultaneously with one operating handle. For longer wave-lengths, increased strength of signals will be obtained with the regenerative circuit by placing a variable condenser in shunt to the battery and head telephone.

Ques.—(2) What would be the possible wave-length adjustment of a tuner, the pri-

mary of which is wound with No. 26 S. S. C. wire on a tube 4 inches in diameter, the winding being 47-8 inches in length. The secondary winding is 31-2 inches in diameter, 5 7-8 inches in length wound with No. 29 S. S. C. wire. This is to be used with a two-wire aerial, 30 feet above the earth and 200 feet in length. The secondary capacity will be variable up to .0004 microfarad.

Ans.—(2) This receiving set will respond to waves of about 3,200 meters in length.

Ques.—(3) Some day I will construct a regenerative short wave receiving set such as described in the April, 1917 issue of your magazine, but I do not wish to vary the coupling between the primary and secondary by the method suggested by that writer. Is there any other way by which I can vary the coupling?

Ans.—(3) You could mount the secondary winding on a sliding rod, and have a knob extend through the side of the case by which the secondary coil could be drawn in and out of the primary winding.

Ques.—(4) Kindly give me the dimensions of a receiving tuner that will respond to wave-lengths up to 15,000 or 20,000 meters with a .001 microfarad condenser connected across the primary, and one of practically the same capacity connected across the secondary winding.

Ans.—(4) If you constructed a long wave receiving tuner using single-layered windings for both the primary and secondary, you would require two tubes from 20 to 25 inches in length, and from 5 to 6 inches in diameter, the actual dimensions, of course, depending upon the size of the wire with which the coupler is to be wound. It is customary nowadays to use multi-layered windings because they give the required amount of inductance with a minimum amount of ohmic resistance. A multi-layered tuner was described on page 677 of the June, 1917, issue of THE

(Continued on page 524)

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Over 3 lbs. up to 4 lbs..	7c	8c	12c	19c	.26	.33	.41	.48
Over 4 lbs. up to 5 lbs..	7c	9c	14c	23c	.33	.41	.51	.60
Over 5 lbs. up to 6 lbs..	8c	10c	16c	27c	.38	.49	.61	.73
Over 6 lbs. up to 7 lbs..	8c	11c	18c	31c	.44	.57	.71	.84
Over 7 lbs. up to 8 lbs..	9c	12c	20c	35c	.50	.65	.81	.96
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(Continued from page 515)

WIRELESS AGE, but the dimensions were not quite complete. This tuner was designed by F. N. Tompkins of Providence, R. I., and has given very good results on long distance reception. In order that you may have a complete set of dimensions, we publish (figure 2) a detailed plan of construction showing the exact dimensions throughout. If, after noting these, you will refer to the article in the June issue of the WIRELESS AGE, you will have no difficulty in constructing the tuner.

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\* \* \*

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\* \* \*

L. L. Z., Saginaw, Mich.:

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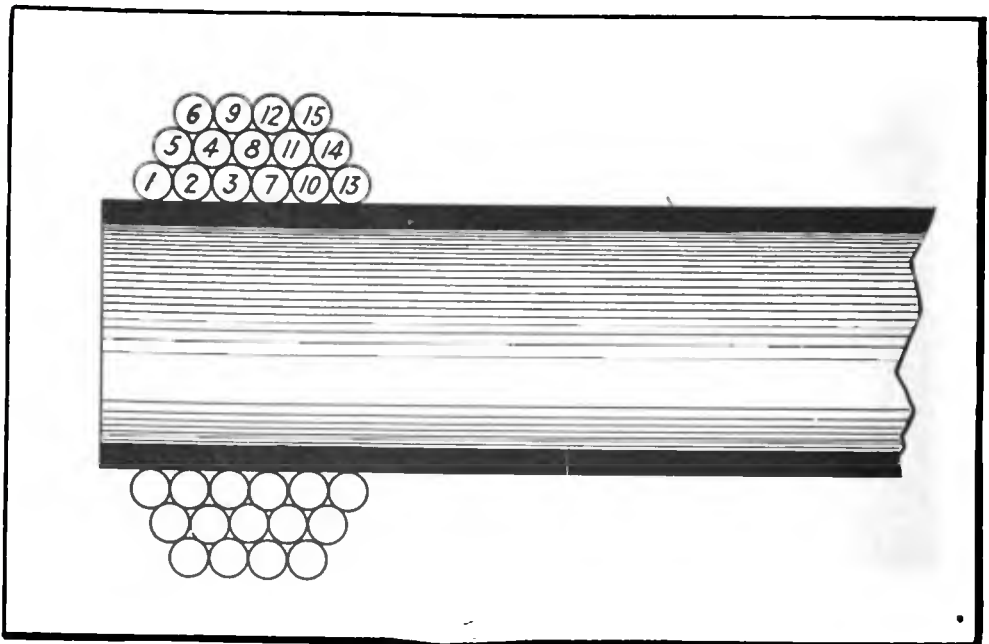


Figure 3

A. R. L., Bloomington, Ill.:

It is our understanding that the Telefunken Company employed a piece of graphite in contact with a crystal of galena as their oscillation detector. It is asserted by some that this type of contact possesses greater stability than the ordinary cat whisker. Our experiences along this line do not indicate increased sensitiveness, but under certain operating conditions it seemed much easier to find a sensitive contact point with a piece of graphite than with a piece of steel. It is doubtful, however, whether our observations would hold good under all conditions and circumstances.

As we have mentioned time and time again in this department, commercial wireless telegraph companies have found the carborundum crystal to be the most dependable of all the crystal rectifiers.

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**N. A. W. A. Bulletin**

*(Continued from page 513)*

1917. During this period the stations handled a total of 654 messages, most of them transmitting over distances of 1,000 miles.


The success attained in long distance communication by these experimenters is accounted for by the fact that their set is well balanced throughout, no pains having been spared to obtain the best apparatus. The set was installed to reduce energy losses to a minimum and also to comply strictly with the law. This is in striking contrast to some amateur stations wherein basic principles have been ignored and any apparatus which would make a spark has been installed.

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tion transformer in order to prevent the reaction of the antenna circuit upon the spark gap circuit. All high voltage transformers for radio work should have a certain amount of magnetic leakage and should draw no more current on short circuit than under normal operating conditions. This will tend to prevent arcing at the spark gap and therefore will assist in quenching out the primary oscillations. A much closer coupling, therefore, can be employed between the primary and secondary without reaction between the two circuits and with increased antenna current.

The use of an abnormal spark discharge gap is in all cases to be avoided, as generally the best results are obtained from the plain gap by separation of the electrodes to a distance of no more than  $\frac{1}{4}$ th or  $\frac{3}{8}$ ths of an inch. With any spark gap there is a length which gives the minimum of resistance, and generally this is the condition sought for. Extremely short gaps tend to assist the quenching of the oscillations, but the purity of the note is destroyed and a very low degree of efficiency thereby obtained. Of course, this can be eliminated by putting a number of discharge gaps in series, as is done with the multiple plate or series spark discharger.

### Modulation of Antenna Current in Wireless Telephony

It is not generally known by experimenters at large that the apparatus employed in the Arlington, Paris and Honolulu wireless telephone sets was so designed that when the transmitter was spoken into a variation of antenna current was secured almost equal to that obtained by opening and closing a telegraph key. This, coupled with the sensitiveness of the receiver employed, accounted for the fact that the voice could be carried over such extremely great distances.

At the receiving station in Honolulu, six three-electrode vacuum valves were employed in cascade for detection of the signals. Great care had to be taken in mounting the apparatus away from

metallic objects, otherwise the valves would "sing" at audio-frequencies and thereby produce interfering sounds. The sensitiveness of this receiving apparatus was such that time signals from Arlington could be heard at Honolulu with the receiver several feet from the observer's ears.

## Book Review

**Radio Communication.** By John Mills. Soft leather binding; 5 x 7 1/4 inches; 203 pages; McGraw-Hill, New York. Price \$1.75 net.

In the preparation of this volume, the author has evidently taken into consideration the necessity for instruction in the fundamentals of the art, and in consequence the volume is in the main devoted to theoretical principles.

The book will be found suitable for students in engineering colleges who desire simple mathematical explanations of the fundamental facts surrounding the audio frequency and radio frequency currents.

The material for this book was primarily prepared for a company of the U. S. Signal Corps organized at the Western Electric Company.

The rear pages of the book are devoted to problems of wire and wireless circuits, and in order to aid the beginner in their solution complete answers are given; in some cases the problem is worked out through all its steps.

Obtainable through the Book Dept., The Wireless Age.

**Acquiring Wings.** By William B. Stout. Cloth binding; 5 x 7 1/4 inches; 57 pages. Mot-fat, Yard & Co., New York. Price 75 cents net.

The author of this book compiled its contents originally for the information of a group of civilians sent abroad by the Government. It therefore deals solely with basic principles of aviation in language which the layman can easily understand.

The little volume will find its main usefulness as an introduction to the art of air navigation.

Obtainable through the Book Dept., The Wireless Age.

**Learning to Fly in the U. S. Army.** By E. N. Fales. Imitation leather binding; 5 x 7 1/4 inches; 180 pages. McGraw-Hill, New York. Price \$1.50 net.

The instruction given in the U. S. Ground School of Military Aeronautics, University of Illinois branch, under the direction of the author, is the basis of the preparation of this book. Professor Fales has sought to supply the student aviator desired essentials of aviation, purposely omitting technical details of main interest to aeronautical engineers.

About one-half of the volume is devoted to chapters on rigging, serving as a valuable reference text for the men whose training period is necessarily short under emergency conditions. So practical is the form of this material it is to be regretted that the author

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