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WIRELESS ON MILITARY AIRPLANES
GERMANY'S ABUSE OF THE S O S CALL
VALVE MEASUREMENT OF RADIO SIGNALS
THRILLING EXPERIENCES OF AN OPERATOR
BULLETIN OF THE N. A. W. A.
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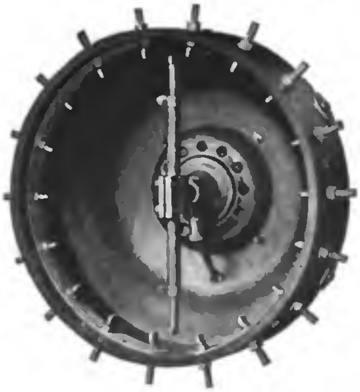

THE WIRELESS AGE

An Illustrated Monthly Magazine of RADIO COMMUNICATION

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

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THE FUTILITY OF IDLE COMPLAINTS

THE wireless man with the grievance is with us. He appears before the National Amateur Wireless Association by proxy regularly. Represented by a letter usually, his plea is that the closing down of his station, which at first seemed an injustice, has assumed the proportions of a tragedy. And then he airs his complaint and calls for drastic remedy, forgetting that we—all of us—

Stand by the Government.

The law must be obeyed. The nation is at war, and its interests ours. Everything that the President asks for must be given cheerfully. And it must not be forgotten that the experimental field in this country has been extended more privileges in peace times than is given by any other nation. A renewal of these privileges at the conclusion of the war is of paramount interest. To hold the recognition, amateurs must demonstrate unwavering, unquestioning loyalty in this hour of emergency.

This is no time for complaints.

Instead of wasting energy by bemoaning his fate, the experimenter should realize that he should be engaged in intensive study. Development of the art under war conditions is proceeding so rapidly that the well-informed man of today knows little tomorrow, unless he readjusts his point of view to embrace the new applications.

To those who cannot conceive existence without radio, the course is clear.

Enlist.

The Navy needs you.

The Army Signal Corps wants you.

Where physical and age limitations put up the bars to active service, there is always the field of the instructor to consider. But instruction is preceded by study.

WIRELESS SIGNALING FROM MILITARY AIRPLANES

THE extensive application of wireless to aircraft with which Mr. Marconi dealt so interestingly in the September issue of THE WIRELESS AGE opens up a wonderful field of new possibilities. The combination of flying with radio phenomena is unquestionably the most fascinating one which Fate could have devised for the American mind. Since the publication of the Marconi message to American amateurs, one of the most prominent military aeronautical engineers in the country has stated his belief that "the day is just around the corner when all aviators must be wireless operators, as well."

Thus an amplification of the present method of spotting artillery fire from airplanes should be of interest.

The observer in aircraft at the fighting fronts must have, aside from his knowledge of wireless, some grasp of the fundamentals of artillery fire. He must know, for example, the trajectory of shells, or the arc they describe, and be able to distinguish between the use of field guns for barrage fire and howitzers for destruction of heavy guns. This knowledge is required because in locating his piece's objective he may have to fly low, and, after reporting the enemy location, ascend to a safe height above the trajectory of the shell fire which he thereafter directs.

The usual height of an observer's flight is 4,000 to 6,000 feet; flying in circles and figure 8s, he sends by wireless a report of the effect of each shot and directions for greater accuracy. A word or two, such as "right," "left," "too short," and so on, is the extent of the direction given, and so skilled are gunners and observers nowadays that it seldom takes more than three or four shots to score a hit on the enemy battery emplacement.

At night the positions are revealed by the lights required by the gunners and by the flash of the gun. While special knowledge is required for night flying, fire spotting in the inky darkness is really safer for the aviator, because of the consequent ineffectiveness of enemy anti-craft guns.

The wonderful accuracy with which a target is located is mainly due to the carefully prepared maps given to observers. These maps are divided into squares representing 1,000 yards a side and numbered. Subdivisions of these squares into four parts are assumed, and given the letters a, b, c, d. Thus the first report of a location might be "4c," the principle being then extended by further subdivisions of the sides of squares into 100 parts, the calculations being based upon the southwest corner as the point of origin, the first figure giving the distance east along the southern side and the second figure the distance north along the western side. Thus a corrected signal, "2732," would locate the enemy battery twenty-seven parts east and thirty-two parts north of the southwest corner of the map's square previously signaled. When it is realized that such an observation, accurately made, gives the location within ten feet, the airplane wireless man's great importance in war is realized more fully.

The maps are similar in appearance to those which appeared in the September article on map reading, in this magazine under "Signal Officers' Training Course."

The method of communicating with the airplane observer is one of great interest. While it is reported that great strides in improvement of receiving sets have been made, the problem of overcoming the noise of the machine and similar difficulties has meanwhile led to the adoption of visual means of transmitting directions to airmen. This is accomplished by white strips of cloth, 6 feet long by 1 foot wide, laid on the ground to form letters and symbols. These are easily visible from a height of 3,000 feet.

Assuming that the observer is serving three batteries and has been given the general direction and the nature of the enemy emplacement before rising, he will watch for specific directions as he ascends to the required height in safety behind his own batteries. The strips are then seen formed in the shape of the letter Z, which may mean "observe for time shrapnel," or perhaps a P, meaning, "observe for high percussion," or LYD, for high explosives. Later, at his post of observation he may note any one of these symbols prefixed by an X, meaning "change to," or maybe two strips in parallel, which tells him, "am not receiving your signals."

Both methods and codes change continuously, but the basic principles are as just outlined, from which it can be seen that the mastery of manipulation of the wireless and the air machine itself are the principal difficulties in preparing a military aviator for service.

In this new field lie wonderful opportunities for wireless men. They have scarcely been realized, but this much is definitely known. The skilled wireless operator receives preference in military aviation service.

GERMANY'S ABUSE OF THE S O S CALL

IN line with the stories told from time to time of the disregard of Germany for the rules of civilized warfare is the charge made by the survivors of the Norwegian ship Benguela. A German undersea boat captured the Benguela, and for sixteen days used her as a decoy by sending out S O S signals. The vessels which came in response to the call were promptly sunk by the U-boat.

The difference between the misuse of the S O S code and the treacherous sniping by Germans after they have indicated their wish to surrender, is that in the latter case there is usually swift punishment for the violators of the code. It follows also that when the German soldiers are guilty of such treachery their comrades, who have not offended, may have to suffer because their appeals for mercy are ignored.

On the other hand, generous tributes have been paid to the qualities of the Turk as a fighter. The conduct of the Turkish army on the battle line, no matter what excesses it committed in Armenia, has been up to the standard of the accepted code. The Turks are clean fighters, according to word from the front. They respect the insignia of the Red Cross, they treat their prisoners well and they do not seek to gain their ends by poisoning water.

It does not seem likely that Turkey would be guilty of using the S O S call as did the commander of the submarine which captured the Benguela. By contrast with Germany Turkey seems a model civilized nation.

WIRELESS STATIONS AND SPIES

DISCLOSURES by the United States showing collusion between Swedish and German diplomatic officers in transmitting military news from neutral countries to Berlin have again revived the subject of secret radio stations and their use by spies, although there is no proof that wireless was used in the cases in point.

In Buenos Ayres, which was the center of some of the German-Swedish activities, a secret wireless outfit was discovered several weeks before the disclosures were made. This equipment was located in a house at a considerable distance from the heart of the city in a street known, curiously enough, as Calle Estados Unidos (United States Street). The suspicions of the police regarding the house were aroused during the visit to Buenos Ayres of the United States squadron under Admiral Caperton. At that time the police said that they were satisfied that the wireless outfit was used to convey information concerning the ships. This information could not have been sent out by any other means, it was asserted.

Following the investigation in Argentina, a similar inquiry was begun in Uruguay, with the result that a wireless station was also discovered secreted in that country. The equipment was demolished by the police.

Revelations showing that a Swedish diplomat in Mexico had acted as the medium for transmitting military news to Germany give significance to a published story to the effect that what is believed to have been a German information forwarding wireless station was discovered on Lobos Island, a lighthouse station off the Mexican coast, northeast of Tuxpam. A Mexican Government official found a complete wireless set on this island. The equipment had been built by the lighthouse keeper, who was formerly a mechanic. He was unable to give a satisfactory account of how he had obtained the wireless apparatus, and he was placed under arrest.

Another station was also found in Campeche, at the mouth of the Champoaton River. As a result of these discoveries the Mexican coast is being scoured in search of wireless plants.

Such revelations bring to mind with considerable force the fact that the dangers of war are ever imminent, and that the spy menace is chief among them. No precautionary measures are being spared to guard the coastal stations of our country. Flood lighting is being employed to a considerable extent in radio-aerial and yard protection, and drastic means have been devised to keep away the unwelcome visitor.

As an instance of the vigilance which the guards exercise, it is related that a visitor who could not present a satisfactory excuse for his presence was recently ordered off the premises of a naval station by a marine. The visitor afterward preferred a technical charge of assault against the marine, but the United States Supreme Court has since sustained the latter for carrying out orders.

A MYSTERIOUS APPEAL AND WARNING

When the war is at an end it is likely that a lengthy chapter can advantageously be devoted to the unsolved mysteries of the struggle. To illustrate: A British steamship which arrived at an American port on September 15th brought reports that a German submarine was shelling a steamship sixty-five miles southeast of Nantucket on the previous day. Wireless messages to this effect had been picked up from the attacked craft, the story ran. The commander of the steamship did not turn back to go to the aid of the vessel because it was against the instructions of the Admiralty to do so. From the same steamship, apparently, came an S O S call a half an hour later. The commander of an oil tank steamship also reported having picked up the S O S, but the identity of the vessel in need of aid was not revealed.

The incident was shrouded still deeper in mystery by the information brought to port on September 16th by another American steamship, which reported that she had received the following warning from the Cape Ray wireless station at three o'clock in the afternoon of September 14th:

"Submarine seen near Nantucket Lightship early today. She is described as being 300 feet long, carrying one gun forward and one aft, and having two periscopes."

The operator at Cape Ray, published reports of the incident said, had attempted to get the name of the vessel sending the warning, but was unable to obtain a reply. The signals were very faint, he declared.

As a precautionary measure, the captain of the liner altered his course, but officers of the ship seemed doubtful regarding the genuineness of the appeal and the warning. Their doubts are shared by others who believe that the messages originated from a German source or were sent by irresponsible persons as a hoax.

AMATEURS FOR ESPIONAGE

ENDORSEMENT of the suggestion made in THE WIRELESS AGE that the amateurs of this country should be used for radio espionage has been given by others. It is their belief that one central large wireless sending station, installed somewhere in North or South or Central America, receives its information from spy operators.

This, of course, is mere surmise, but it has been proposed that amateur operators could be utilized to put an end to the putative wireless spy system. "Instead of forbidding these amateurs to receive messages," runs one comment on the subject, "they should be organized and encouraged to receive as much as possible, to keep a record of all they receive, no matter how innocent the messages may seem, and to transmit this record every day to Washington."

Putting aside the consideration of the acceptance of this plan, the question of what is going on silently in the air during this war of the world provides opportunity for a wealth of conjecture.

TRAINING OPERATORS FOR THE NAVY

INTERESTING proof of the added recognition which the war has brought to wireless is found in the fact that the United States Navy is training radio operators at two schools, Mare Island, Cal., and Harvard University. Approximately 1,500 pupils, men of the regular service and the reserve, are undergoing instruction at Harvard, the buildings and facilities of the institution having been put at the disposal of the Navy by President Lowell. With the transfer of the regular Navy radio school, formerly at the New York Navy Yard, to Harvard, the wireless training activities of the service are now largely centered in Cambridge. The course is of four months' duration and embraces military drill as well as technical and other subjects. The men take their meals in Memorial Hall, the refectory erected in honor of Harvard men who fell in the Civil War, and use the Harvard gymnasium as a dormitory.

Seamen and apprentice seamen are given instruction in the rudiments of radio telegraphy at the naval training stations at Newport, R. I., Great Lakes, Ill., San Francisco, and Norfolk, Va., and at the naval camps at Philadelphia, Charleston, Mare Island, San Diego and Puget Sound. Those who are able to receive ten words a minute in the continental code and who show promise are transferred to Harvard for the four months' course.

The Regular Navy accepts enlistments under two ratings—landsman for electrician (radio) and electrician, third class (radio). For the former rating the recruit must be able to receive twenty-five words a minute in the Morse code or ten words a minute in the continental and possess a foundation in radio. For the electrician rating possession of a commercial radio license and ability to pass an examination in electrical subjects are necessary. Upon acceptance the recruits are sent to the radio school for instruction.

Five ratings are available in the Naval Reserve: Landsmen for electrician (radio); electricians, third class (radio); electricians, second class (radio); electricians, first class (radio); and chief electricians (radio). Men are enrolled in the first two classes according to their ability in the Morse or the continental codes, in the other ratings according to their experience as commercial radio operators on merchant vessels, and other qualifications.

Enlistments in the Navy or enrollments in the Navy Reserve for radio operators will be accepted at any Navy recruiting station. The monthly rate of pay for radio men ranges, on the present war basis, from $32.60 for landsmen to $72 for chief electricians.

MR. SWANSON'S WORK IN THE TROPICS

Additional details regarding the scientific expedition of Dr. Alexander Hamilton Rice and the members of his party into the wilds of Rio Negro, South America, an account of which was published in the September issue of The Wireless Age, show that the success of obtaining the time signals from Washington along the Amazon and Negro Rivers was due to the efforts of John W. Swanson, United States Government radio inspector, of New York City, who accompanied the explorers as wireless expert. He employed a small, portable wireless set, which was assembled by Paul Godley of Upper Montclair, N. J. Mr. Godley is not unfamiliar with wireless in the tropics, having had experience at the station at Manaos, Brazil.

Mr. Swanson's work, it is said, was the first ever attempted in utilizing the Arlington signals under the conditions that existed. It will have a place in wireless history.

Radio Science

MEASUREMENT OF THE INTENSITY OF WIRELESS TELEGRAPH SIGNALS WITH THE OSCILLATING VACUUM VALVE*

MEASUREMENT of the strength of the incoming signals at a wireless telegraph station or of the relative power required to give an audible sound in the receiving telephone, has engaged the attention of radio telegraph engineers for a number of years. Although galvanometers which are exceedingly sensitive and can be employed for direct measurement, have been developed, they have proved almost wholly impracticable on account of the intensity of atmospheric disturbances.

The usual procedure, therefore, has been to shunt the telephone by an adjustable resistance having a scale calibrated directly in terms of audibility.

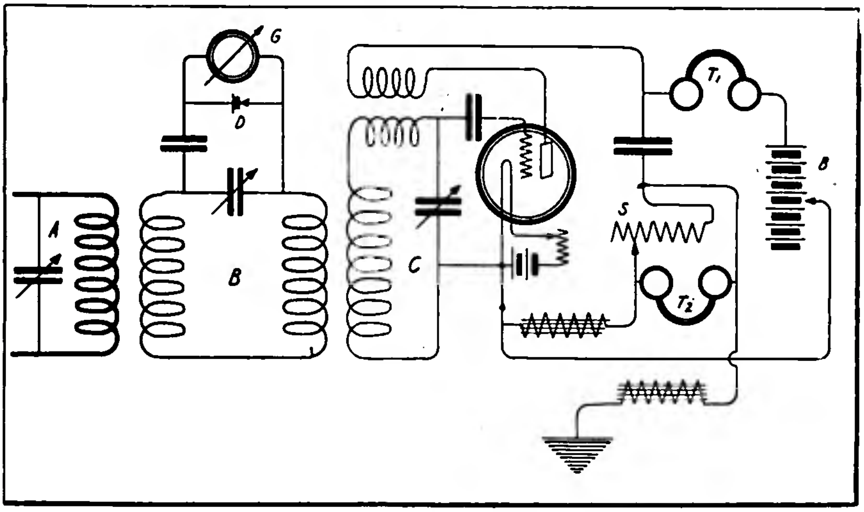


Figure 1

This resistance is gradually reduced in value until the signals from a given transmitting station are barely audible. If t is the effective resistance of a telephone for a particular frequency and wave form of the current, and s the value of the shunt, then the audibility factor,

$$A = \frac{t+s}{s}$$

When made by a properly trained or experienced ear, such observations of audibility will suffer an error no greater than ten per cent., but under the conditions found in the ordinary wireless station the error is seldom less than twenty per cent. and sometimes may reach a value of fifty per cent.

There has been considerable criticism of this method of measurement broadcast during the past few years owing to the elusive quantities involved as well as the personal equation in observations. But in a recent issue of the Proceedings of the Institute of Radio Engineers, Dr. L. W. Austin of the United States

*Abstract from the Proceedings of the Institute of Radio Engineers.

Naval Radio Telegraphic Laboratory endeavors to show that the shunted phone method is quite within the limits of experimental error, even when applied to the oscillating vacuum valve detector circuit of the type in use in the United States Navy.

Briefly told, this measurement was carried out by setting up an artificial antenna circuit (Figure 1) fitted with a silicon detector, D, shunted by the galvanometer, G, the circuit, B, being inductively coupled to the source of radio frequency oscillations, A. The oscillating vacuum valve circuits are indicated at C, the circuit being coupled to the artificial antenna, B. The observations were made with the view of determining the ratio of the current ratio to the audibility ratio with various ranges of audibility at the receiver.

First the current in circuit B was varied by changing the coupling with A, and the range of audibility in the vacuum valve circuit C was fixed by the coupling, B. The observations were carried out by means of a telephone having a direct current resistance of 2,040 Ohms and a current sensitiveness of $5\text{x}10^{-10}$ at a frequency of 1,000 sparks per second. The procedure follows:

With a variation of the coupling, A, B, the coupling between B, C was fixed, corresponding audibility and galvanometer readings being noted. The coupling, B C, was then changed and the observations repeated for a new audibility range. The result of five sets of observations follows:

TABLE 1

Ranges of Audibility	$\frac{\text{Ratio of Current}}{\text{Ratio of Audibility}}$	Sets of Observations
1- 2	0.95	6
1- 10	0.93	6
10- 100	0.94	5
100-2,000	1.05	7
250-5,000	1.03	16

A second set of observations were taken with audibilities from three to eighty, showing further that the $\frac{\text{current ratio}}{\text{audibility ratio}}$ varies from 0.03 to 1.15, a fairly close agreement. These data are shown in Table 2.

TABLE 2

Audibility Ratio	Current Ratio	$\frac{\text{Current Ratio}}{\text{Audibility Ratio}}$
$\frac{12}{3}$	$\frac{5.24}{1.14}$	1.15
$\frac{20}{3}$	$\frac{7.78}{1.14}$	1.02
$\frac{50}{3}$	$\frac{19.24}{1.14}$	1.01
$\frac{80}{3}$	$\frac{28.8}{1.14}$	0.95
$\frac{20}{12}$	$\frac{7.78}{5.24}$	0.89
$\frac{50}{12}$	$\frac{19.24}{5.24}$	0.89
$\frac{80}{12}$	$\frac{28.8}{5.24}$	0.85
$\frac{50}{20}$	$\frac{19.24}{7.78}$	0.99
$\frac{80}{20}$	$\frac{28.8}{7.78}$	0.93
$\frac{80}{50}$	$\frac{28.8}{19.24}$	0.93

The absolute sensitiveness of the navy three-electrode regenerative vacuum valve circuit next came up for discussion, and it was mentioned that the relative audibility of the oscillating vacuum valve to the plain vacuum valve circuit was about 600. Also, the mean sensitiveness of the old type of vacuum valve circuit was found to be 1.7 times that of the three-wire electrolytic. It is further mentioned that in the earlier Brant Rock tests, it was determined that it required $25x10^{-16}$ to produce an audible signal in the receiver telephone, but with the improved modern telephone this figure has been reduced to $12.25x 10^{-10}$ watts.

It is estimated that the least power capable of producing a signal in the oscillating vacuum valve is $1.2x10^{-15}$ watts, which is more than 10^{-16} times the watt sensitive of the electrolytic.

From this value a table was calculated, assuming that the oscillating vacuum valve produces a current variation in the telephone proportional to the square root of the received watts.

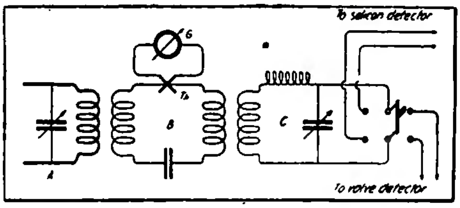


Figure 2

A series of measurements were carried out by Dr. Austin, to determine with greater certainty the sensitiveness of the vacuum valve, and to secure a direct determination of the power in the receiving system corresponding to unit audibility in the vacuum valve. The arrangements of the apparatus are shown in Figure 2. The wavemeter, A, was excited by an oscillating valve which permitted loose coupling between the circuits, A B. A sensitive vacuum thermoelement of twenty-eight ohms resistance was placed directly in the circuit of A and connected to a galvanometer, D. A double-pole double-throw switch was included in the C circuit so that the receiving circuit proper could be connected to the vacuum valve or to a silicon-detector galvanometer. When the silicon detector was adjusted to give the largest deflection on the silicon galvanometer, a comparison was made between the thermoelement deflection in circuit B and the detector deflection in C. By exterpolation the galvanometer, G, was employed to measure the radio frequency current in C.

The result of some observations on a circuit adjusted to the wave-length of 3,000 meters follows:

The resistance of the B circuit plus that occasioned by the coupling of the C circuit, was found to be sixty-five ohms. The inductance of the secondary of the C circuit was twelve microhenries. One millimeter deflection of the silicon detector galvanometer corresponds to 6.2 (10)-6 amperes in circuit B. In table No. 3, which follows, I is the current in circuit B, W is the watts in circuit B, A is the corresponding audibility on the vacuum valve, and Wo is the ratio of $\frac{W}{A^2}$ in other words, the watts for unit audibility.

TABLE 3

λ =3,000 m.
R=65 ohms.
Lc=12 m h.

D	D	I 10^{-6} amps.	W 10^{-10} watts	A	W 10^{-15} watts
2.3	1.52	9.4	57.2	2,500	0.92
4.0	2.00	12.4	100.1	3,000	1.11
2.0	1.41	8.7	50.1	2,000	1.25
2.2	1.48	9.2	55.2	2,300	1.02
4.0	2.00	12.4	100.1	3,000	1.11
					1.09 Average

Other observations were made on wave-lengths of 3,000, 6,000 and 10,000 meters, using secondary inductances of twelve microhenries and thirty-six microhenries. It is found that the average power required for unit audibility over this range of wave-length amounted to $1.45 (10)^{-15}$.

In the discussion which followed it was brought out by Edward H. Armstrong that the average radio experimenter's concept of audibility is a misnomer. He said:

"Primarily, when we speak of the audibility of a signal in a telephone, we have a concept of the energy necessary to produce that signal. We would naturally suppose that when a telephone is supplied with four times the energy necessary to give unit audibility that the audibility of that signal would be four. Certainly the amount of energy which has gone into the production of sound waves is four times that necessary for unit audibility. But by the present standard, since the telephone current is only twice the value of the current necessary for unit audibility, the audibility is only two. This leads to an absurdity in the case of the oscillating audion receiver. One of the great virtues of this receiver, and in fact of nearly all heterodyne receiving systems, is that the energy delivered to the telephones is directly proportional to the received energy. But according to the present definition of audibility, it becomes necessary to say that the audibility is proportional to the square root of the received watts!"

In a further discussion of this paper, Armstrong attempts to prove by a simple analogy that the power received in the antenna circuit fom the signalling source is distinctly more different when employed with the regenerative receiver than when used with a simple crystal rectifier. This is due to peculiar phenomena of the regenerative circuit. In fact, the effect of the local or regenerative E. M. F. is to increase the power supplied to the antenna system by the signalling source by an amount approximately equal to $\frac{E_2}{E_1}$

Where E_2 equals the final value of the steady regenerative E. M. F. and E_1 equals the signalling E. M. F. the limitations of the analogy are discussed. It is also shown that the Austin formula for the current received at a given station requires a considerable modification for use with regenerative circuits, being made to read as follows:

$$I_r = \frac{(1+E_2)}{E_1} \; \frac{377 h_1 \, h_2 \, I_s}{\lambda \, d \, R} \epsilon^{\frac{-0.0015d}{\lambda}}$$

Furthermore, on account of the presence of the regenerative electromotive force, E_2, a proper understanding of the term "received current" is in order. It is remarked that the electromotive force due to the incoming waves and that part of the power in the antenna which is actually drawn from the energy of the waves, are the only quantities which can properly be termed "received current."

AN UNDER-SEA TELEGRAPH EQUIPMENT

FOLLOWING up, to a greater or lesser extent, Professor Morse's earth current telegraph system, which he devised and employed in the year 1842, Frank P. Fischer and Hugh Dehart, of Radford, Va., have devised a scheme of undersea communication which they believe can be profitably utilized by submarines for short distance communication.

As will be seen in Figure 3, the transmitter employs an induction coil with a telegraph key and battery, the secondary terminals of the coil being connected to two metallic plates, P-1 and P-2, which are separated by a certain distance and submerged in the ocean. When the telegraph key is closed, an alternating current is induced in the secondary winding of the induction coil, S, which flows to and fro between plates P-1 and P-2.

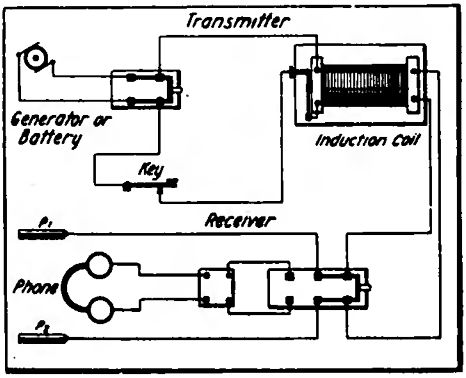


Figure 3

A similar set of plates is provided at the receiving station, being immersed in the water, and, as will be observed in the diagram, they are joined together by a copper conductor in series with which is placed a telephone receiver. A part of the current flowing from plate to plate at the transmitter subdivides.

takes the path afforded by the copper conductor from plate to plate at the receiver, and accordingly, sounds are produced in the head telephones which can be the ordinary Morse characters.

It is, of course, apparent that this system does not employ electric waves in any manner, it simply being an extension of the often used earth current system. The system is expected to have some application for communication from submarines when submerged, and it is also believed that it may be of use in locating sunken submarines. But the way in which this is to be accomplished has not been explained.

ADAPTING THE VACUUM VALVE FOR USE WITH THE EINTHOVEN GALVANOMETER AND PHOTOGRAPHIC DEVICE

THE Einthoven galvanometer has frequently been employed in connection with a photographic recording device for the reception of radiotelegraphic signals, particularly in connection with crystal and magnetic detectors. But it has not been found possible to use it with the vacuum valve on account of the large volume of current flowing in the local telephone circuit. This often amounted to one or two milliamperes, which of course would not permit a sensitive instrument such as the Einthoven galvanometer to be inserted directly in the measuring circuit.

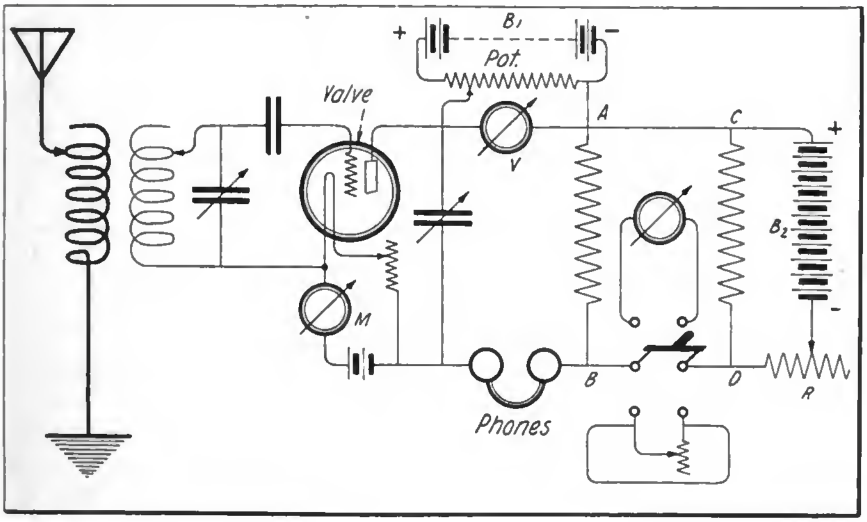
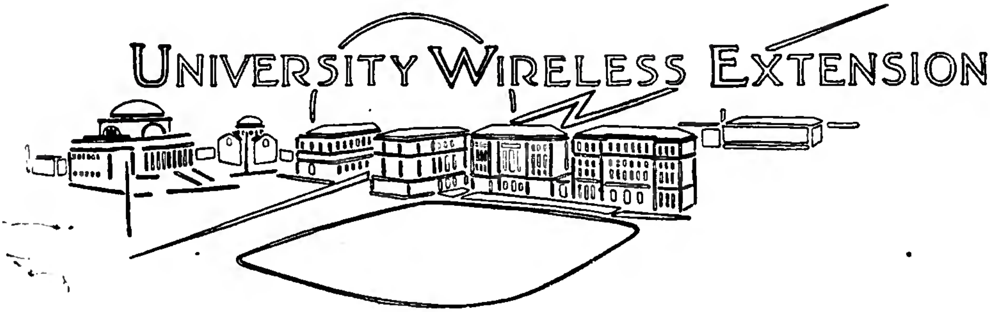


Figure 4

In a recent issue of the Physical Review, a method is shown whereby the vacuum valve can be employed with this galvanometer and photographic recorder, in a relatively simple manner. Referring to Figure 4, a resistance coil, A B, is inserted in series with the telephone and the battery, B-1, of the local telephone circuit, and accordingly a potential difference exists across its terminals. But this is balanced by an equal potential difference across the resistance coil, C D, which is fed by the battery, B-2. An additional small regulating resistance, R, is connected in series with C D to obtain a perfect balance.

When signals are not being received, the galvanometer, if the circuits are in proper adjustment, will give no deflection, but when signals *are* received, the potential difference across A B varies, which disturbs the balance and causes a deflection of the galvanometer in accordance.

The writer mentions that it was found most satisfactory to keep the resistance of the coils, A B and C D, at about 2,000 ohms.



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 X

7. **MODULATION CONTROL IN RADIO TELEPHONY.** We have, up to this point, considered many matters which are common to radio telephony and radio telegraphy since the sustained wave generating systems are naturally applicable to the latter field as well as the former and indeed were originated principally in connection with telegraphy. We pass, now, however, to a matter exclusively related to radio telephony, namely the modulation or control of amounts of power varying from a few watts to many kilowatts *by the human voice.* The problem is indeed a difficult one, and for a long time practically defied solution. When it is considered that the rate of energy radiation in the form of sound in ordinary speech is of the order of one one-hundred-millionth to one billionth (0.000 000 01 to 0.000 000 001) of a watt, and that the delicate and excessively complex variations of the sound energy must be faithfully reproduced with an energy amplification of *hundreds of billions,* and that the energy to be modulated is of the peculiar form associated with radio frequency currents, the difficulties of the problem become evident. And yet radio telephony is entirely dependent on the simple solution thereof.

Before describing in detail the various methods of modulation control which have been devised, we shall consider certain broader questions connected therewith. The first of these is the completeness of control systems.

(a) **DEGREE OF CONTROL.** In every radiophone transmitter, there is some point at which a controlling current, voltage, inductance, capacity, or resistance exists. The current might be, for example, the fluctuating current in a telephone transmitter circuit. The voltage might be the voltage applied to the grid of a vacuum tube of some sort, this voltage being derived from the secondary circuit of a transformer connected in a microphone transmitter circuit. The resistance might be the resistance of a microphone placed directly in the antenna of a radiophone transmitter. Whatever the controlling element, it must vary between certain extreme values when speech is being transmitted, these limits being reached for the peaks of the loudest sounds which are encountered in ordinary speech. Indeed, it is preferable that these peaks should be reached for such normal speech rather than for shouting since otherwise the control tends to be weak and excessive amplifications may be required somewhere in the set.

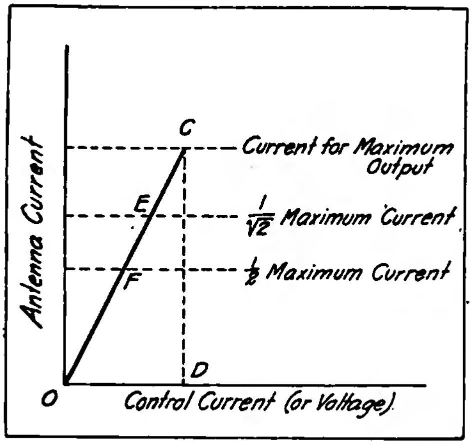


Figure 115—*Complete linear modulation control curve*

In Figure 115 we have a control characteristic of a desirable sort. Horizontally is plotted the controlling element (current, voltage, capacity, inductance, resistance, or a combination of these), this element varying between zero and the value *OD*. Vertically are plotted values of the controlled or antenna radio frequency current, this varying between zero and *CD*. It will be seen that we have a straight line characteristic curve; that is, the controlled current is proportional to the controlling current. Furthermore, the control is complete, since we assume that the current *CD*, is the greatest current which the sustained generator is capable of putting into the antenna; or, in other words, the current *CD* is determined by the actual maximum possible output of the alternator, arc, radio frequent spark transmitter, or vacuum tube transmitter used.

The question arises as to what will be the ammeter reading in the antenna when no speech is being sent out. This depends on whether we choose to have this point as that of half current or of half energy. In the former case, the current will center around the point *F* which represents one-half the maximum current. In the latter case, the current will rise and fall about the point *E* which represents the reciprocal of the square root of two (that is, 0.707) times the maximum current. Under normal conditions of speech, in some types of radiophone (particularly those with stable control to be described hereafter) the antenna ammeter does not change markedly from the point *E* (or *F*) when one actually carries on conversation. In other types (and especially those with unstable control) the average current in the antenna may change considerably when speech is being transmitted.

A curve representing incomplete control is given in Figure 116. It will be noted that the entire available variation in the controlling element will cause a variation in the antenna current only between the values *OG* and *DA* and not between zero and the maximum available current *CD*. In this case we may define the percentage of control as the quotient of *AB* divided by *CD*. Such a radiophone set with a normal linearly proportional receiver will be equivalent to a considerably less powerful transmitter than that represented in Figure 115.

The Author advocates control characteristics in which the microphone current is taken as the controlling element and the antenna current as the controlled element. First of all, these elements are

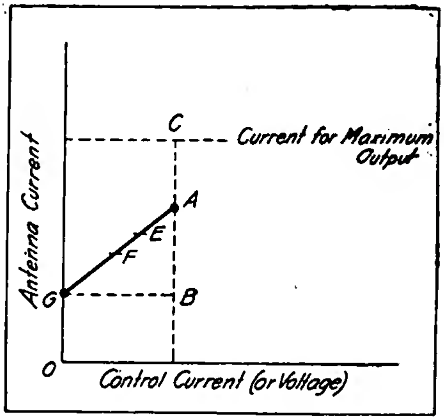


Figure 116—*Incomplete linear modulation control curve* fairly readily measurable. In the second place, what is, after all, desired is that the *current* variations through the receiver telephones shall be proportional to the *current* variations in the microphone transmitter as in an ordinary telephone line. It is accordingly deemed best to adhere to current control characteristics throughout.

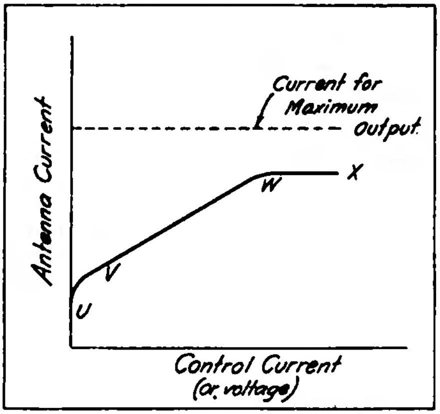


Figure 117—*Typical incomplete non-linear modulation control curve*

In practice, the perfect type of control characteristic shown in Figure 115 is not realized. A more common form which is fairly acceptable is shown in Figure 117. It will be seen that the antenna current never falls below *U* although this leads to a waste of energy. From *V* to *W* the control is linear and satisfactory, but at *W* it flattens, remaining at constant current to *X*. The maximum output current is never reached, the mere existence of the controlling element preventing its attainment.

(b) **STABILITY OF CONTROL.** The control system of a radiophone may be classified as stable or unstable depending on whether the points on the upper and lower portions of the control curve can be held steadily with the control system used or whether they can be reached for only a brief period of time. The simplest example of a stable control system would be the following: Imagine a radio frequency alternator, driven by a constant speed motor, placed directly in a tuned antenna; and in series with the alternator and directly in the antenna a microphone transmitter (or a variable resistance, which is its equivalent). It is evident that the system is perfectly stable no matter what the value of the microphone resistance, since the only possible effect of an increase or diminution of the microphone resistance is to lower or raise the antenna current. The control curve of such a system would be a "static" characteristic; i. e., one for stationary conditions. The simplest example of an unstable control system would be the following: A Poulsen arc is placed directly in the antenna in series with a microphone (or a variable resistance). Changing the resistance of the microphone will not merely cause the antenna current to change; it may actually cause the extinction of the arc altogether, if the inserted resistance is too high. So that the system would be unstable at this limit. This is illustrated in Figure 118 where the antenna circuit is plotted against time. The current remains constant from *P* to *Q*, it being supposed that the resistance in the antenna is moderate for this range of time. At *Q* a large resistance is inserted in the antenna, for example, by speaking into the microphone, or pulling out its diaphragm. The antenna current may not merely decrease; it may rapidly fall to zero at the point *U*. On the other hand, if the resistance is restored to its former small value after a time *RT*, the antenna current may recover the full value *Q* rapidly. In other words, while the system is unstable for permanent changes, it may be operative for rapid transient changes provided these changes are of very short

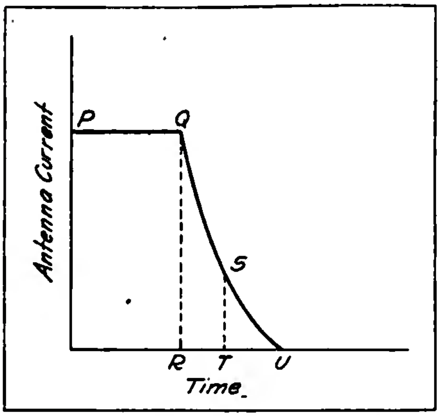


Figure 118—*Dynamic characteristic of falling current for unstable control system* duration. For this case, it is not possible to secure a complete static control characteristic; dynamic characteristics must be obtained by the use of an oscillograph or some other device for following the rapidly changing antenna and controlling currents.

Generally speaking, unstable control systems are objectionable. If the time *RU* of extinction in such a system is very short, then a low-pitched sound (of relatively long period) may lead to complete "breaking" or extinction. On the other hand, if the time *RU* is long and the slope of *QSU* less abrupt, there will be sluggishness of control and a blurring or muffling of speech. Rigid and stable control is desirable.

(c) **RATING OF RADIOPHONE TRANSMITTERS.** In a receiving set, when audibility measurements are being made on received speech (on the basis of just hearing sound of any character), it is the maximum transmitter current (*CD* of Figure 115) which is being considered. Consequently the Author recommends that radiophone transmitters be rated on the basis of maximum energy radiated, corresponding to maximum current. Here 100 per cent. control is assumed. If less than full control is attained, the rating of the transmitter should be the *maximum energy variation.* As has been stated, for unstable control systems, this requires an oscillograph for the determination of rating; but generally we may assume the maximum energy in this case to be twice the average or steady value, if the control is known to be linear. Many unstable control systems flatten out in control (as at *WX* in Figure 117) for high currents, and consequently their rating may be much less than that given by the double energy rule above.

In rating radiophone transmitters on the basis of maximum energy radiation, it must be understood that this does not imply that a 1 K. W. radiophone transmitter will enable the clear transmission of speech for the same distance as a 1 (antenna) K. W. spark transmitter will enable the transmission of telegraphic signals. More than just the peaks of the received speech is required for comprehensibility, so that the received speech must be considerably more than once audibility to be fully understood. The exact number of times audibility is required for satisfactory speech is not precisely determined at present and depends naturally on the freedom from speech distortion. It is probably not less than 2 nor more than 10.

(d) **TYPES OF CONTROL.** Control systems may further be classified as absorption systems or generator voltage (or current) control systems. The simplest instance of an absorption system is the plain microphone-in-antenna modulation where the microphone actually absorbs intermittently a considerable portion of the radio frequency generator output. Such systems, while distinguished by their simplicity and satisfactory behaviour for small powers are not so easy to apply to large powers because of the difficulty of absorbing considerable acounts of energy in any system sufficiently delicate to follow the voice inflections. One exception to this statement, however, are the vacuum tube absorptive systems to be described hereafter.

The generator-voltage control type is well illustrated by the use of radio frequency alternator in the antenna, the field of the alternator being excited by the microphone current and the alternator being driven by a constant speed motor. It will be seen that the generator output is variable in this case, and not constant as in the former. This requires quite special driving motors and is an objection. On the other hand, the absorption control systems tend to be constant load systems and do not require special driving machinery. However, unless an absorption system is carefully devised, it may be uneconomical of energy, since it is desirable to avoid having full load on all machinery regardless of whether speech is being transmitted or not.

(e) **MICROPHONE TRANSMITTER CONTROL.** An ordinary microphone transmitter of high resistance will carry a steady current of from 0.1 to 0.2 ampere at an applied voltage of 10 volts. Its resistance is therefore of the order of 50 to 100 ohms, and the energy which it can absorb steadily is about 2 watts. If it is attempted to pass more current than that mentioned through the microphone, a "frying" or crackling sound will be heard in the receiver, the carbon grains of the transmitter will overheat and burn, and the microphone will steadily deteriorate. A so-called "low resistance" transmitter will carry 0.4 to 0.5 ampere and have a resistance of from 10 to 20 ohms. It can absorb satisfactorily but little more energy than the high resistance form.

When a microphone overheats from the passage of excessive current, which is very likely to occur when the over-enthusiastic radiophone experimenter places it in the antenna circuit and attempts gradually to increase the antenna current, it "packs". That is, the grains of carbon expand and become tightly wedged in the carbon chamber and the microphone no longer responds. It then becomes necessary to shake the microphone mechanically to release the grains and restore its modulating power. In one form of radiophone made by Dr. de Forest, the shaking of the microphone was accomplished by fastening a buzzer to it and closing the battery circuit of the buzzer occasionally. The resulting vibration gave the desired result. A more simple means of accomplishing the same result is by tapping the transmitter. A "packed" transmitter rapidly deteriorates through overheating and burning of the carbon grains.

Dr. George Seibt has shown that, in order that the loudest signal shall be heard in the receiving station when a microphone transmitter is used for modulating the transmitted energy, a simple condition must be fulfilled. It is that the resistance (as determined by energy absorption of the microphone when undisturbed) shall be equal to the total resistance (as determined by energy absorption) of the remainder of the radio frequency circuits of the transmitter. For example, imagine an antenna of 8 ohms total resistance (including ohmic resistance, ground resistance, radiation resistance, and eddy current loss resistance) with an inserted microphone. The microphone resistance should also be 8 ohms. From this it is fairly obvious that a high resistance microphone is inapplicable, unless it is not in the antenna but so coupled or connected to antenna circuit (directly, inductively, or capacitively) that its effect is the same as if a smaller resistance equal to the antenna system resistance had been inserted.

We show in Figure 119 a number of arrangements which have been used for the direct control of the radiated energy by a microphone. Diagram *a* shows the microphone inserted in the direct current supply leads of the arc, thus causing appropriate variations of the arc current and arc output. Diagram *b* is somewhat different in that alternating electromotive forces are impressed on the arc as well as the constant supply voltage. The alternating voltages are transferred to the arc supply circuit through the transformer *T* connected to the microphone circuit and supply circuit. This arrangement is due to Mr. E. Ruhmer. In the Diagram *c* the microphone has been transferred to the oscillating circuit of the arc. This method would, except with very low resistance microphones, be an unstable control system. In Diagram *d*, which shows a circuit used by both Professor V. Poulsen and the Telefunken Company, the microphone is shunted across the antenna coupling and tuning coil. It would therefore act to detune the antenna circuit as well as to absorb energy intermittently. The method is quite effective. Diagram *e*, which is another arrangement due to Professor Poulsen, accomplishes the same results by coupling the microphone inductively to the antenna coupling coil. The only purpose of the battery in this case is to bring the microphone resistance (which depends on the current passing through it) to a desired value. Diagram *f* illustrates an arrangement used by Mr. Fessenden (principally with radio frequency alternators as generators) and others. In this simple case the microphone is directly in the antenna, and moulds the radio frequency current into the desired speech form envelope more or less fully. Diagram *g* shows the unusually elaborate arrangement adopted for modulation by Messrs. Colin and Jeance. A tuned circuit of desired constants is directly coupled to a portion of the antenna coupling coil. The microphone is directly inserted in the tuned shunting circuit which has sometimes been characterized as a "spill-over" circuit.

In order to modulate more energy than can be properly handled by one microphone, the idea was originated of using several in series, low resistance

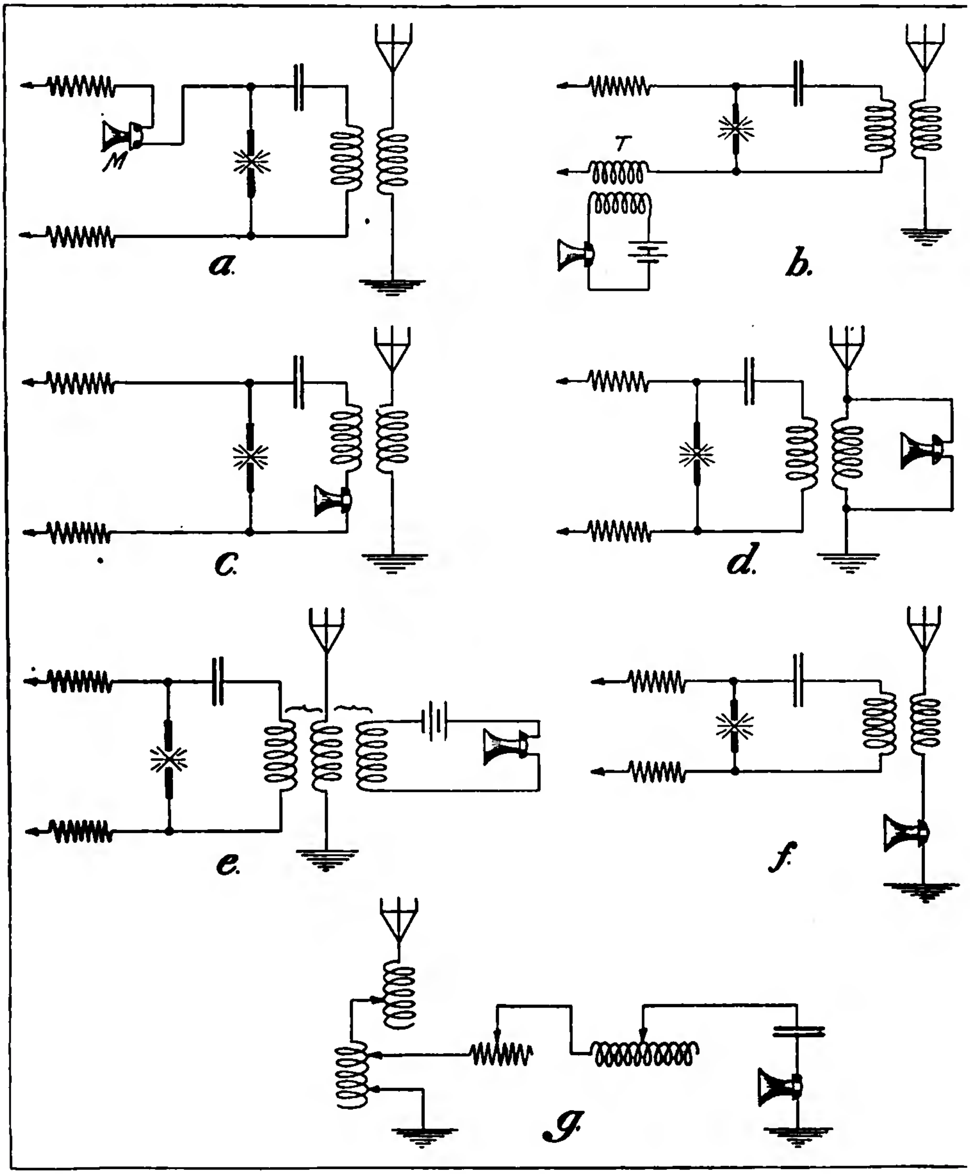


Figure 119—Various arrangements for microphone modulation of radiophone transmitter

microphones being thus employed. The idea is feasible to a limited extent, but rapidly leads to difficulties in carrying the energy of the speech to the diaphragms of many microphones. An extreme instance of this method is shown in Figure 120, which shows no less than 25 Berliner microphones being thus used by the C. Lorenz Company. A less extreme instance is illustrated in the radiophone set illustrated in Figure 23 in a preceding article, which shows 6 microphones in series. It is desirable in such arrangements to have the paths from the mouth of the speaker to the different microphones of equal length and as nearly as possible geometrically identical, so that each microphone gets full excitation.

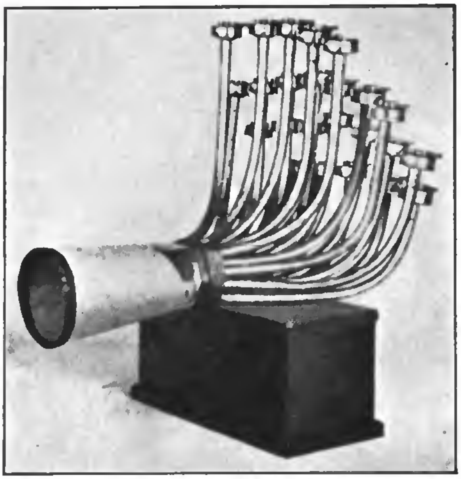


Figure 120—C. Lorenz Company multiple transmitter

A further expedient is to have more than one set of microphones available, and to change over from one set to the next whenever considerable heating occurs. Data is not available as to the practicability of this scheme, but it seems to be of some advantage.

Mr. R. Goldschmidt has devised a method of using several microphones in parallel. Normally this is not feasible, since if one begins to get more current than the remainder its resistance will rapidly fall and it will soon carry the entire current, thus leading to injurious overheating. The simplest form of the method mentioned is given in Figure 121. As will be seen, the microphones are each in series with a coil (L_1 and L_2 respectively). The coils in question are wound oppositely on a common core. As long as the current through each microphone is the same, equal currents will flow through each coil and the net inductance in the circuit will be zero. If, however, one of the microphones takes more current than the other, the balancing current begins to circulate in the circuit $L_1M_1M_2L_2$ and encounters a high inductance in L_1L_2 since it does *not* flow in the opposite direction in the two coils. The method of extending the idea to three microphones is also illustrated. Here coils L_1 and L are wound on the same core, as also are the coils L_2 and L', and the coils L_3 and L''.

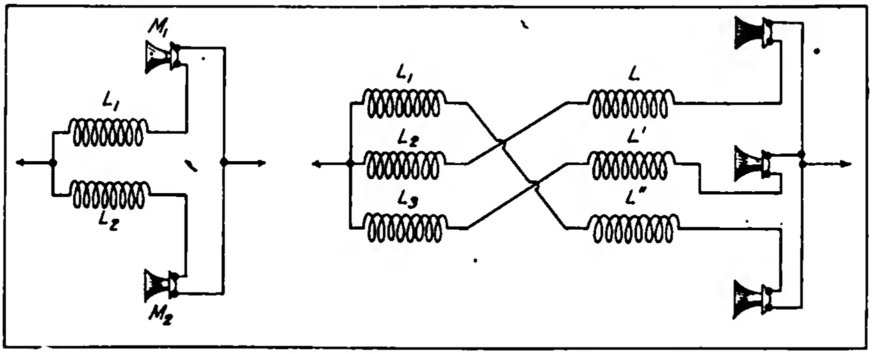


Figure 121—R. Goldschmidt's method of utilizing microphones in parallel

(f) **HIGH CURRENT MICROPHONE CONTROL.** The first thought that naturally suggests itself in connection with the securing of microphones that will modulate successfully more energy than will the ordinary carbon microphone is to replace the carbon by some more permanent and less inflammable material. Carborundum has been suggested by several inventors, but it cannot be said that any data is available favoring the belief that the expedient was successful.

In 1906 and 1907 Mr. R. A. Fessenden, at that time directing the work of the National Electric Signaling Company, devised a number of microphone transmitters which carried heavy currents for considerable periods of time. He also developed a heavy current telephone relay, which permitted controlling considerable current by means of smaller currents originating in an ordinary microphone circuit or coming from a telephone line. A description of these devices in his own words, with added comments by the Author, follows:*

"A new type of transmitter was therefore designed which the writer (Mr. Fessenden) has called the "trough" transmitter. It consists of a soapstone annulus to which are clamped two plates with platinum iridium electrodes. Through a hole in the center of one plate passes a rod, attached at one end to a diaphragm and at the other to a platinum iridium spade. The two outside electrodes are water-jacketed.

"The transmitter requires no adjusting. All that is necessary is to place a teaspoonful of carbon granules in the central space. It is able to carry as much as 15 amperes continuously without the articulation falling off appreciably. It has the advantage that it never packs. The reason for this appears to be that when the carbon on one side heats and expands, the electrode is pushed over against the carbon on the other side, (thus diverting a greater portion of the total current to the cooler side, which has thus been made of smaller resistance. It will be noted that the two halves of the carbon, on the opposite sides of the spade diaphragm are in parallel). These transmitters have handled amounts of energy up to one-half horse power (375 watts), and under these circumstances give remarkably clear and perfect articulation and may be left in circuit for hours at a time."

Such a water-cooled microphone, built to carry up to 6 amperes continuously, and suitably mounted, is illustrated in Figure 122.

A more complex and extremely interesting device is shown in Figure 123. This is† "a transmitting relay for magnifying very feeble currents. It is a combination of the differential magnetic relay and the trough transmitter. An amplification of 15 times can be obtained without loss of distinctness. The successful amplification depends on the use of strong forces and upon keeping the moment of inertia of the moving forces parts as small as possible. Amplifica-

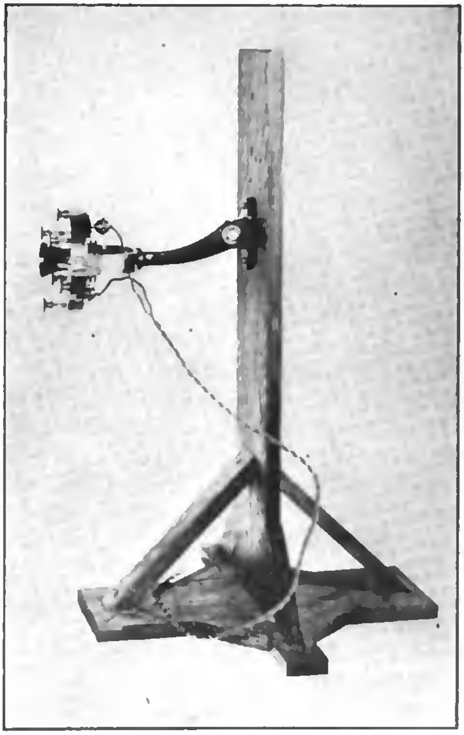


Figure 122—National Electric Signaling Company-Fessenden high current transmitter

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* "Proc. A. I. E. E.," June 29, 1908.
† "Proc. A. I. E. E.," June 29, 1908.

tion may also be obtained by mechanical means, but as a rule this method introduces scratching noises which are very objectionable even though comparatively faint." The amplifying relay shown in Figure 123 is capable of handling 15 amperes in its output side. Thus some ten years ago Mr. Fessenden recognized the desirability of being able to control the radiophone transmitter from a wire line, and this relay was developed to enable the desired result to be obtained.

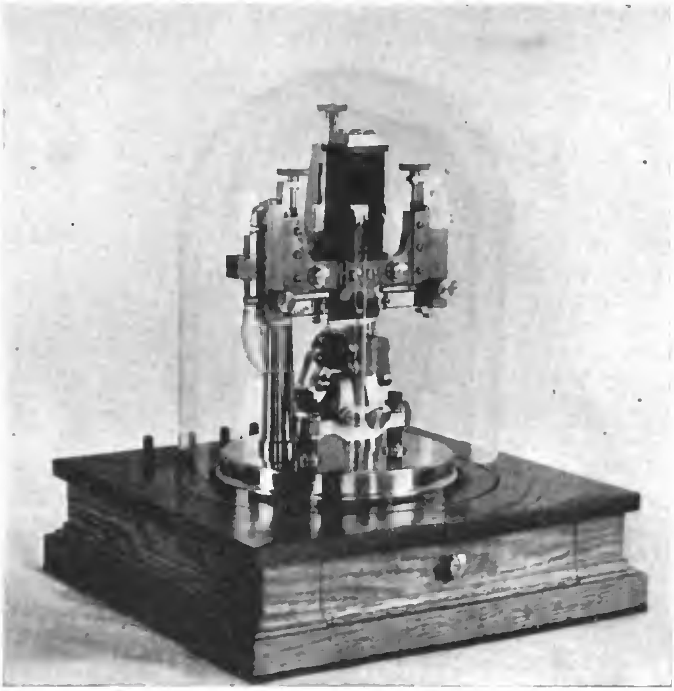


Figure 123—Fessenden heavy current telephone relay

A complete radiophone station at Brant Rock embodying the idea just mentioned is illustrated in Figure 124. Although completed in 1906, the design thereof was remarkably advanced. In the right foreground are seen the radio frequency alternator and its driving motor and controlling rheostats. Directly back of these is a compressed air tuning condenser. On the table is shown a normal line telephone set connected to the high current relay which controls the outgoing energy. In addition, at the reader's left, on the table is placed a portion of the receiving set. On December 11, 1906, a demonstration of radio telephony was given from Brant Rock to Plymouth, Massachusetts, a distance of 10 miles (16 km.). Both speech and music were transmitted. In addition, speech was transmitted over an ordinary wire line to the radio station at Brant Rock, relayed automatically to the radiophone, transmitted by radio to Plymouth, and at Plymouth automatically relayed back to a wire line. Telephone experts present noted a remarkable absence of distortion of speech quality. In July, 1907, speech was transmitted between Brant Rock and Jamaica, Long Island, a distance of 180 miles (290 km.) over land, and by day. The antenna mast at Jamaica was 180 feet (55 m.) high. In this work, "the transmitting relays are connected in the wire line circuit in the same way as the regular telephone relay, except that in place of being inserted in the middle of the line, they are placed in the radio station and an artificial line used for balancing. There is no difficulty met with on the radio side of the apparatus, but on the wire line there are the well-known difficulties due to unbalancing which have not been entirely overcome. For the correction of these difficulties, therefore, we must look to the engineers of the wire telephone companies. At present, the difficulties are, if anything, less than those met with in relaying on wire lines alone."

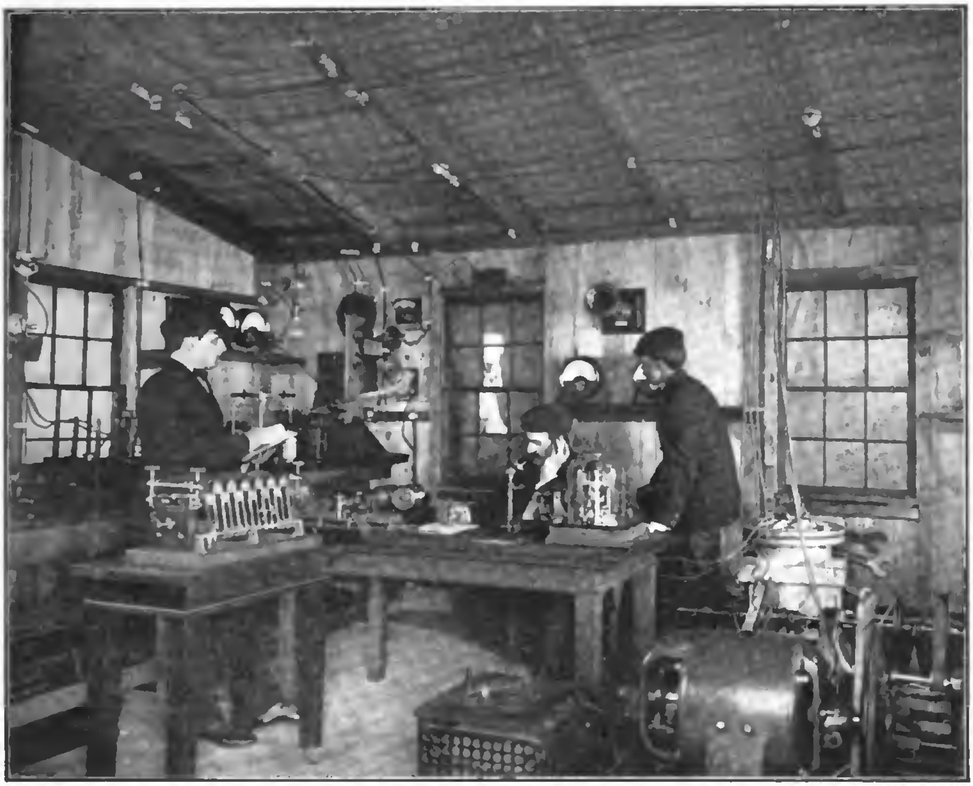


Figure 124—National Electric Signaling Company-Fessenden 2 K.W. radiophone transmitter

Another form of transmitter used by Mr. Fessenden is the condenser transmitter. This is not a carbon microphone at all, but a variable condenser with one (or more) fixed plates and one (or more) movable plates, the movable plates being brought nearer to or further from the fixed plates by the voice vibrations. In this way there are produced in this condenser changes of capacity closely proportional to the sound amplitudes. If such a condenser transmitter be connected between a high potential point of the antenna (e. g., the topmost point of the loading coil, *L* of Figure 125) and ground, it will have two effects when its capacity is varied by the sound waves. To begin with, it will detune the antenna by shunting the coil *L* and the radio frequency alternator *A* by a larger or smaller capacity (which capacity is, in effect, in parallel with the antenna capacity). This effect may be considerable if the antenna capacity is small, the antenna damping small, and condenser transmitter capacity variations large. Figure 126 depicts the curve of antenna current (ordinates) against frequency to which antenna is tuned (abscissas) with the alternator *A* run at con-

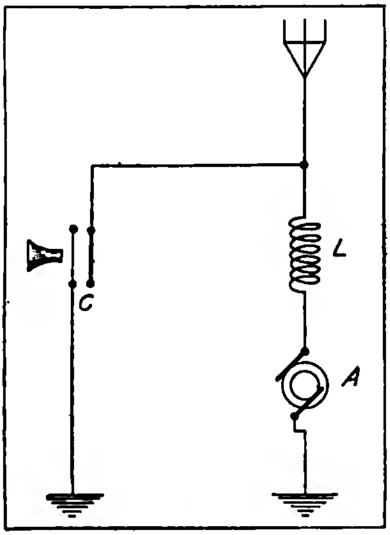


Figure 125—Fessenden condenser transmitter for radiophone work

stant frequency corresponding to the point *A* on the curve and the peak of the resonance curve. The proper point to work the antenna for such a system would be at some such point as *F* on one of the steeply falling branches of the resonance curve. Then, if the frequency were altered periodically between *OB* and *OD* by the condenser transmitter, the antenna current would similarly vary periodically between *EB* and *DG*. The second effect of varying the capacity of the condenser transmitter would be actually to "spill" energy from the antenna to ground through the transmitter capacity. These two effects should assist each other and the reader can satisfy himself by a little thought on the subject that this result can be secured by tuning the antenna system with the condenser transmitter in its undisturbed position to a *lower* frequency (that is, *longer* wave length) than that of the alternator. If the opposite is done, the two effects of the condenser may partially or entirely neutralize each other.

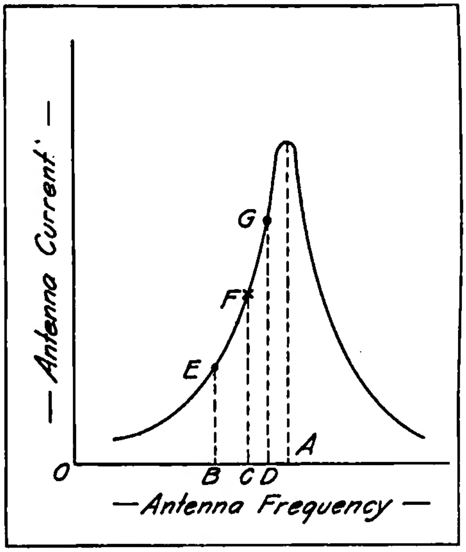


Figure 126—Detuning characteristic of radiophone transmitter

This is the tenth article of a series on "Radio Telephony," by Dr. Goldsmith. In Article XI, which will appear in the November issue, the consideration of high current microphones for modulation is continued. The type of telephone relay used by W. Dubilier is taken up and the high current transmitter used by the Telephone Manufacturing Company, that devised by C. Egner and J. .G Holmstrom and that used by R. Goldschmidt, are discussed. Methods of attacking the problem of high current microphones by using conducting liquid jets are also taken up. The article concludes with descriptions of radiophone experiments made by Dr. Alexander Meissner and those made by Mr. Round, of the Marconi Company.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912.

of The Wireless Age, published monthly, at New York, N. Y., for Oct. 1, 1917.

State of New York, County of New York, ss.

Before me, a Notary Public, in and for the State and county aforesaid, personally appeared J. Andrew White, who, having been duly sworn according to law, deposes and says that he is the editor of The Wireless Age, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Names of—	Post Office Address—
Publishers..Wireless Press, Inc.,	42 Broad St., New York, N. Y.
Editor..J. Andrew White,	42 Broad St., New York, N. Y.
Managing Editor—None.	
Business Manager—Alonzo Fogal, Jr.,	42 Broad St., New York, N. Y.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)

Wireless Press, Inc., 42 Broad St., New York, N. Y.

John Bottomley (851 shares), 233 Broadway, New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

J. ANDREW WHITE,
Editor.

Sworn to and subscribed before me this 25th day of September, 1917.

(Seal) HENRY SAUBER,
(My commission expires March 30, 1919.)
Bronx County Register Certificate 141.

A Convoy to Ward Off Submarine Attacks

An Efficient Method for Protecting Flotillas of Cargo Carriers

By Professor Francis B. Crocker of the Crocker-Wheeler Company.

Professor Crocker is a former president of the American Institute of Electrical Engineers and was for twenty years head of the Department of Eelectricity at Columbia University. For many months he has been working on the submarine problem and the following article embodies his solution.

THE submarine problem is still unsolved. Every week brings its formidable list of vessels that have been sunk—every week lives are lost and almost priceless cargoes destroyed. Occasionally there is a week when fewer vessels than usual are sunk, and our hopes rise, only to be dashed by the increased number of sinkings the next week. Seldom do we know the full toll, for the published figures usually cover only British losses, which are not much more than half of the total of all nationalities, and are based upon that vague phrase, "over 1,600 tons."

As yet no sure way of catching and destroying submarines has been devised, and until an absolutely effective means is created, the world must remain powerless before the undersea menace to shipping.

Several serious flaws appear in the present theory of preventing the loss of vessels merely by destroying submarines.

First, comparatively few submarines can do a lot of damage. Second, there is the human tendency of officers and crews to think that a near shot is a hit, and that submerging is sinking. Even when a periscope is struck, allowance must be made for the fact that the larger submarines have two or more periscopes, the submarine is therefore not fatally hurt, and can cruise under water by compass, coming to the surface now and then to make observations or to repair the periscope. Experts agree that it is hard to tell whether the damage is fatal, and doubt whether very many submarines have so far been destroyed. Third, Germany can probably build them as fast or faster than they are being destroyed.

And as we await the perfected destroying agency, precious lives, ships and cargoes are being wasted.

In the scheme here described, however, nearly all the ships involved are protected from torpedoes by two parallel lines of overlapping nets, each of moderate length and towed by its own vessel. This vessel may be a cruiser or destroyer having sufficient power to tow its net at the ordinary speed of convoyed steamers, say at ten or twelve knots per hour.

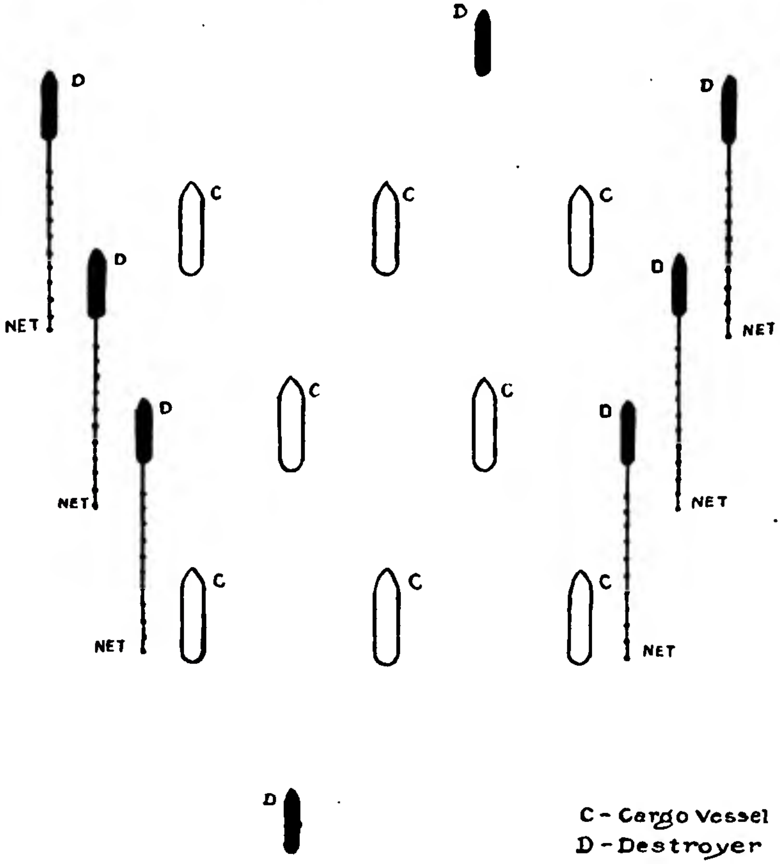
It is assumed that the merchant vessels and others needing protection from submarines would meet at a certain point outside the so-called danger zone, and when a sufficient number had gathered, would be convoyed to port.

For a vessel under way, especially on a voyage at sea, it is practically out of the question to protect it individually by nets, on account of the difficulty of supporting them. To give effective protection against torpedoes the nets around the vessel would have to be held out at a considerable distance from the hull, and the strain of dragging the nets along, especially if the sea were rough, would be enormous. The weight, cost and complication of the rigging required would be prohibitive. Moreover, the power of most merchant vessels is quite limited, and their ordinary speed of ten or twelve knots an hour would be reduced to a very low figure, seriously curtailing their efficiency as carriers.

In the scheme here proposed, a single net is towed directly astern, a method with which sailors are familiar. In bad weather there would be much less drifting and sudden, heavy strain on the towline than would be the case if one or several barges were being towed.

I have suggested nets 1,000 feet long and 25 feet deep, which is below the level at which torpedoes travel, for if the missiles' path were deeper than this they would fail to hit vessels of moderate draught, and would strike a glancing blow on most hulls of greater depth. Of course the nets may be made deeper, if desirable, or they may be varied in number and made longer or shorter than 1,000 feet, so as to be convenient for handling.

Each net is supported by a number of cigar-shaped buoys or floats of sheet steel, but these need not be large or numerous to support the necessary weight of net.



By proper construction the power required to tow the nets may be reduced to a reasonable amount. Nevertheless, this power will be large and each net should be towed by a high-powered destroyer or cruiser. Such a vessel, without the net, would run twenty-five or more knots an hour. When towing the net its speed would be reduced to ten or fifteen knots, which is the ordinary rate of convoyed steamers, so that the whole fleet could travel at the full speed of the slowest vessel.

Vessels need be convoyed only through the danger zone, which is 200 or 300 miles wide, so that the time occupied would be about twenty-four hours and a little slowing down for that period would not be serious. Certainly it is better than losing each week dozens of ships with cargoes. and many of their crews. At night, and in foggy or very rough weather, the formation of the convoy could be made more open, as the danger from submarine attack would be less.

Such a convoy would be formidable to a submarine for three reasons:

First, a line of nets on each side offers protection to nearly all the vessels, so that the chance of submarine attack is small.

Second, one or more destroyers or chasers, with full freedom of action, would be ahead and behind the fleet ready at the first indication of a submarine.

Third, other vessels of the fleet would be armed, so that shots from many directions would be concentrated on an attacking submarine.

Of course, all the ships would be on the lookout and therefore more likely to detect the submarine.

In spite of the general prejudice against convoys they seemed to work well in the recent sending of our troops to France.

One of the greatest difficulties in securing adoption, or even trial, of any plan is the fact that naval and scientific men—and, in fact, the public generally—expect an ideal solution of this most difficult problem. If mitigating methods, even though not 100 per cent. efficient, had been or were now being used, they would materially reduce the number of vessels sunk.

The fact that a torpedo fired at an angle of 45 degrees on either side could pass the nets either ahead or behind, might be an objection advanced to this scheme. It is obvious the nets may be extended further ahead or astern.

In the rear the opening is narrow and the vessels are going away, hence the danger is not so great. In front the convoy as a whole is very formidable and a submarine would not dare to take the chance of getting between the nets. Furthermore, at a distance, especially at an angle of 45 degrees, accurate shooting with a torpedo would be almost impossible. Torpedoes are usually fired as nearly as possible at right angles to the length of the ship to be attacked. Otherwise they strike a glancing blow and slide off or fail to explode. A net loose in the water, not stretched between supports, need not be so very strong to arrest a torpedo, for the same reason that a hanging cloth which will stop a moving body would be penetrated if stretched taut on a frame.

MARCONI'S BELIEF IN OUR INVENTORS

Guglielmo Marconi is quoted as having said on his arrival in Paris from this country that the United States will accomplish much to subdue the submarine.

"The Naval Consulting Board is not working vainly," he declared. "While no decisive means of combating the menace has been found, I have seen proved means of defence becoming daily more efficacious.

"The danger from submarines is decreasing daily. It is certain that future losses will diminish and thus Germany will first feel America's weight in the great war.

"I have seen many other amazing things in the American scientific domain, of which I cannot speak, but which will help us perceptibly toward the actual ending of the war. These things are now at the Allies' disposal."

It has been announced that in order to provide for what are known as "life and death" telegrams without disclosing the location of ships of the Navy, orders have been issued to all naval men directing then to inform their families that messages of the character mentioned are to be forwarded addressed to the ships in care of the Bureau of Navigation at Washington, D. C. These messages, it is understood, will be sent to the ships in many cases by wireless.

CAPTAIN FRITZ E. UTTMARK, NAVIGATOR AND EDUCATOR

FRITZ EMMERICK NILSON-UTTMARK, navigator and educator, was born September 4th, 1871, in Gothenburg, Sweden.

His father, a prominent merchant, doing business in Gothenberg under the name of Fritz Nilson & Co., and a man of excellent social standing, failed in business during a panic about 1884. He was one of the founders of the Royal Swedish Yacht Club.

Captain Uttmark was educated in Schiller's private college in Gothernburg, but his father's failure in business compelled him to leave college without receiving a degree. He entered a business firm in Gothenburg, and finding that pursuit distasteful, went to sea as an apprentice on the bark Gladon. He entered the Government navigation school at Gothenburg in 1890 and was graduated the following year. After he had obtained his certificate of competency, he was engaged as a navigator, being officer of several vessels sailing on all oceans. In his time he sailed under the Swedish, Norwegian, Danish, German, British, French, Chinese, Russian, and American ensigns.

He spent several years on the coast and in the interior of China. He was in command of several steamers there for a time, and later rceived an appointment as chief of a marine department in which capacity he organized a transportation service and constructed an adequate line of steamers, tugs, barges, pontoons, and wharves, in connection with important Chinese collieries and iron mines. He had headquarters at Hankow, with branches at various points on the Yangtse and An rivers.

Captain Uttmark passed examination for and obtained a British master's license at Hong Kong in 1903. He made various trips to the United States, but it was not until 1911 that he finally came here with the purpose of making the United States his permanent home, and became an American citizen.

His education and varied experience had endowed him with an excellent knowledge of navigation, and he determined to utilize this knowledge by teaching. He has since 1911 been teaching navigation, becoming proprietor of what is now Uttmark's Nautical Academy. Founded in 1882 by Captain Howard Patterson, and known successively as Patterson's Navigation School and New York Nautical College, the present name was adopted when Captain Uttmark became its proprietor. It is said to be the oldest nautical school in the United States.

Captain Uttmark is author of Uttmark's Guide to Examination for Masters and Mates and the Uttmark System of Navigation and Nautical Astronomy, and he is owner and editor of Uttmark's Nautical News. He is a member of the American Shipmasters' Club of New York, the Marine Transportation Association of New York, and the National Geographic Society of Washington, D. C. He is a fellow of the American Geographical Society.

His sea experiences would make an interesting book. During the Russo-Japanese War, he commanded the steamer Samson, having on board Bennett Burleigh, the famous war correspondent.

Finding Your Way Across the Sea

A Practical Instruction Course in Navigation

By CAPTAIN FRITZ E. UTTMARK

AMERICA has at last awakened to the urgent necessity for an adequate merchant marine, and as a result activities in her shipbuilding yards are greater than ever before. In past years the Yankee clipper-ship was known the world over and acknowledged to be superior to all others; the American flag was seen in every port of any importance on the seven seas, and the growth of many one time obscure places is due to the fact that they were visited by American vessels. The American skipper was known for his ability and zeal in navigating his ship, which enabled him to make the smartest passages from West to East and from East to West.

Later on, however, the merchant marine of this country fell into a period of comparative inactivity and other nations assumed the leadership of the seas.

Since the beginning of the world war the United States has felt the immediate need of strengthening her over-sea traffic in order to facilitate the transportation of her goods and passengers on her own bottoms. America requires ships and officers and men to handle the vessels. Consequently there are now excellent opportunities for able, clean cut young men to enter a profession that has many advantages.

To those who contemplate choosing the sea for their life work the following information will be of interest: The law calls for two years' experience in the deck department of steam or sail vessels before any candidate will be examined for a third officer's license; three years' experience is necessary in order to be eligible for a second officer's license. After that, with additional experience as junior officer, step after step is taken until a captain's license and command of a vessel are obtained.

As no headway can be made in navigation without a thorough knowledge of the subject, a series of articles for THE WIRELESS AGE has been written for those ambitious to study the problems which confront the practical navigator. This is the first article of the series.

CHAPTER I

Definition of Navigation—List of Instruments, Charts and Books Used by the Navigator.

DEFINITION

NAVIGATION is the science that teaches us to determine our position at sea and to conduct the ship from place to place; it consists of two parts, **Navigation and Nautical Astronomy.**

Navigation, according to the first term, enables us to determine our position by reference to the earth and is further subdivided into *a. Piloting* or *Coasting* when position is obtained by reference to visible objects on the earth or from soundings of the depth of water and the nature of the bottom; *b. Dead Reckoning* in which the ship's position is deducted from courses steered and distances run from a given point of departure.

Nautical Astronomy. This term is used for that part of the science which enables us to determine the ship's position by observations of the celestial bodies—the sun, moon, planets and fixed stars.

INSTRUMENTS

The necessary instruments, books, etc., used by the navigator are as follows:

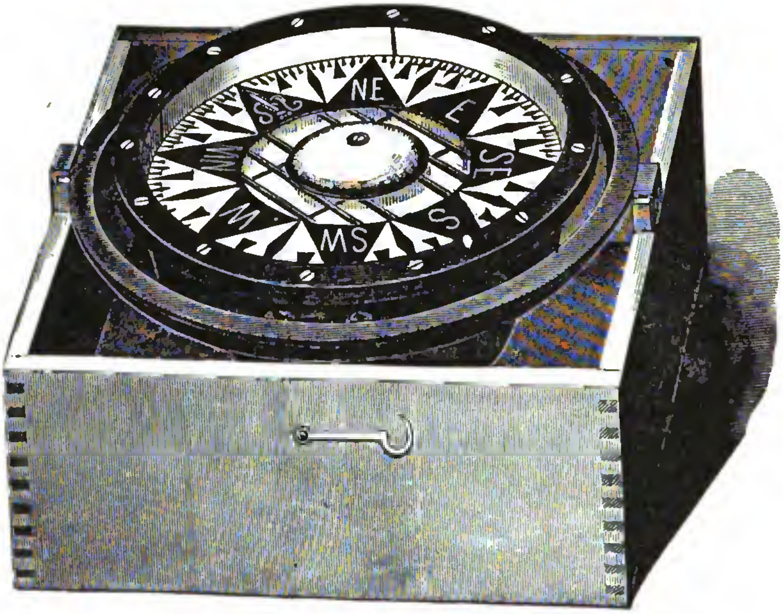
The mariner's compass, charts for the waters to be navigated, parallel rules, compasses or dividers, log and logline, log glass, lead and lead line, sextant or octant, chronometer, pelorus, sounding machines, binoculars, barometer, thermometer, bowditch useful tables, nautical almanac and azimuth tables.

CHAPTER II

The Mariner's Compass—Its Construction and Use

THE compass is the most important instrument used by the sailor and its principles and construction should be familiar to every navigator, whether he sails a small boat along the coast or navigates the largest steam or sail vessel across the ocean.

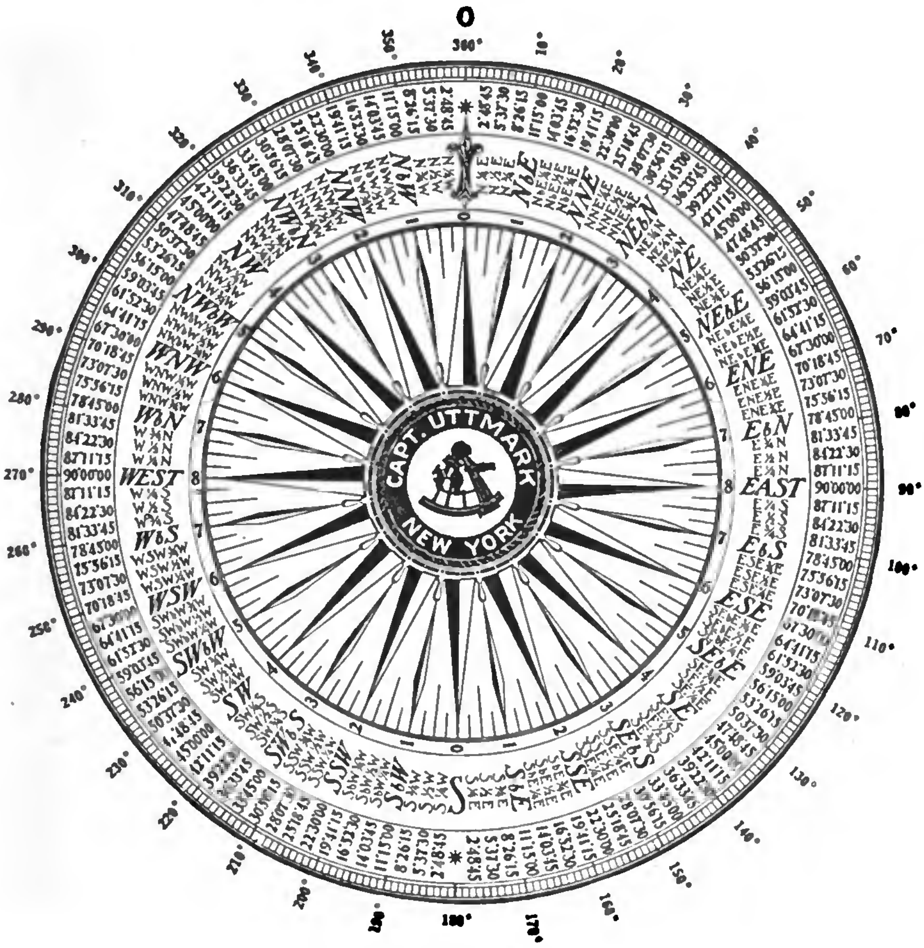
The mariner's compass consists of a non-magnetic metallic bowl in the center of which is fixed a pivot. A magnetic needle, or generally several pairs of needles, parallel with one another, are so centered and balanced on the pivot that they can freely swing in the horizontal plane and undisturbed by proximity of iron will come to rest in the magnetic meridian. A graduated card is fixed to the needles in such a position that the *North* marked on the card will point to the magnetic North pole on the earth. The ship's course is measured by this instrument, and bearings of objects on land as well as amplitudes and azimuths of the heavenly bodies are measured.



Compass card

The compass card is a circular disc the periphery of which is divided into 360 equal parts called *degrees* or in 32 equal parts of 11° 15′ each called *points.* These points are again subdivided into half points and quarter points. The compass card, as seen in an accompanying illustration, shows the various systems.

The process of naming the compass points in their proper order is known as "boxing the compass." The newest and most convenient way of numbering the degrees is from 0 (North), increasing righthanded up to 360 degrees. This system is now in use in the United States Navy and if universally adopted would be of great benefit and convenience to all navigators.



Mariner's compass

In the merchant marine, however, the older systems still prevail. North and South are here considered as zero (0°.) marks, East and West as 90 degrees. Intermediate degrees are read from the zero points, as for instance, midway between North and East would be N 45° E; midway between South and East S 45° E and so forth.

The oldest system which is still extensively used, on account of being most complicated should be memorized first of all. The card is divided into its thirty-two points with subdivisions. The four main points, North, South, East and West, are called the cardinal points; each one is at right angle or eight points from the adjacent one. Midway between these are the inter-cardinal points, which are named Northeast, Southeast, Southwest and Northwest. It is four points or forty-five degrees between each cardinal and the adjacent inter-cardinal point.

Beginning with North, the thirty-two compass points are named as follows: North, North by East, North-North-East, Northeast by North, Northeast, Northeast by East, etc.

In boxing the compass in half and quarter points, it is the custom in the United States to refer to these as follows: North quarter East. North half East. North three quarters East. North by East quarter East, etc.

The three systems are shown in tabulated form which also is conveniently used in converting one system into another.

CONVERTING POINTS INTO DEGREES AND VICE VERSA

Points	Old System	New System	Points	Old System	New System
North	0	0	South	0	180° 00′
N by E	N 11° 15′ E	11° 15′	S by W	S 11° 15′ W	191° 15′
N N E	N 22° 30′ E	22° 30′	S S W	S 22° 30′ W	202° 30′
N E by N	N 33° 45′ E	33° 45′	S W by S	S 33° 45′ W	213° 45′
N E	N 45° 00′ E	45° 00′	S W	S 45° 00′ W	225° 00′
N E by E	N 56° 15′ E	56° 15′	S W by W	N 56° 15′ W	236° 15′
E N E	N 67° 30′ E	67° 30′	W S W	S 67° 30′ W	247° 30′
E by N	N 78° 45′ E	78° 45′	W by S	S 78° 45′ W	258° 45′
East	N/S 90° 00′ E	90° 00′	West	S/N 90° 00′ W	270° 00′
E by S	S 78° 45′ E	101° 15′	W by N	N 78° 45′ W	281° 15′
E S E	S 67° 30′ E	112° 30′	W N W	N 67° 30′ W	292° 30′
S E by E	S 56° 15′ E	123° 45′	N W by W	N 56½ 15′ W	303° 45′
S E	S 45° 00′ E	135° 00′	N W	N 45° 00′ W	315° 00′
S E by S	S 33° 45′ E	146° 15′	N W by N	N 33° 45′ W	326° 15′
S S E	S 22° 30′ E	157° 30′	N N W	N 22° 30′ W	337° 30′
S by E	S 11° 15′ E	168° 45′	N by W	N 11° 15′ W	348° 45′
South	0	180° 00′	North	0	360° 00′

¼ point = 2° 48′ 45″ or approximately 3°
½ point = 5° 37′ 30″ or approximately 6°
¾ point = 8° 26′ 15″ or approximately 8°

(*To be continued*)

ELUDING SUBMARINES BY THE ZIG ZAG METHOD

Zig-zagging by commanders of vessels to elude attacks by submarines has a protective value which it did not possess before merchant ships were armed. Now that the tramp is apt to carry a rapid-fire gun of from three to six-inch caliber, the U-boat, once it has come within the effective range of the gun, must stay below. In the old days, a submarine with fourteen to seventeen knots speed, did not hesitate to run down its prey on the surface, and a large proportion of the victims were sunk by gun fire. But when merchant ships began to mount powerful guns with Navy-trained gunners behind them, the sinking, even of slow tramps, became a very difficult and hazardous task.

On sighting an approaching ship the submarine heads to intercept her course, submerges, and then takes an occasional look at her, bringing its periscope above water for a few seconds only. The U-boat commander estimates the speed and course of the ship, submerges and lays his own course by compass while below, so as to bring his boat within torpedo range, preferably forward of the beam.

Now, if while the submarine is below, the merchant ship changes her course, say through an angle of forty-five degrees, the former, on coming up for a few seconds' look at the ship, finds that, instead of converging to meet him, the merchant ship is sailing in a direction entirely different from that on which his calculations were based; his manoeuvre for getting into firing position goes for nothing, and he has to try again. Unless he is satisfied that his guns can greatly outrange the enemy, the U-boat commander does not dare to use his surface speed, and below the surface he has not sufficient speed to overhaul the merchant ship. One or two misjudgments of this kind will lose so much time that the ship will have a good change to pass him and steam beyond torpedo range.

"All in a Day's Work"

The Story of an American Operator who Sailed on the Steamship Navajo, Met and Vanquished a Submarine and Nearly Lost His Life in a Fire a Thousand Miles From Shore

By CLARENCE CISIN

TO the crew of the Navajo the Fourth of July came in like the proverbial lamb and went out as a roaring lion. And, incidentally, with a display excelled by no old-time celebration of that glorious day.

The sun was shining on a placid stretch of ocean that had all the peace and quiet, if not the exact aspect, of a street scene in Flatbush. Dinner was in progress and one of the men remarked that it didn't seem at all like the national holiday without the time-honored fireworks—

Had he been a prophet, gifted with the true foresight, his name would go down in history as the world's joker—

Almost immediately the alarm gong rang out its warning.

With a few choice words regarding the visions of over-zealous lookouts—for the pie was particularly appetizing—we rushed out on deck. And there was a submarine off our quarter, looking very business-like, with its gun crew on deck preparing to fire on us. The Captain immediately rushed to my cabin with the ship's position and my key snapped out the distress call instanter. A British destroyer answered, reporting that she was speeding toward us. Our gunners opened fire upon the "Sub" and after three shots from our guns she submerged. Whereupon we breathed a sigh of relief and anxiously awaited developments.

The patrol overtook us about an hour later, and convoyed us a short distance.

That night the machinations of submarines was a topic very seriously discussed. . . .

So was life insurance.

Early the next morning, July fifth, I was awakened by the sound of shots. The Captain came to my cabin and asked if I could hear any distress calls. I listened in, and picked up a distress call from a British ship, saying that she was being shelled by a submarine. In the middle of her message, as she was stating her position, the spark suddenly died out. It was a tense moment, as will be understood by all operators who are familiar with the peculiar appealing sound given out when an accident occurs to the transmitter.

Nothing more was heard from that ship. Then those on deck reported that a sailing ship about three miles ahead of us had apparently been struck by a shell, as she buckled midships and almost immediately went down.

Half an hour later the submarine appeared and commenced to chase us. I sent out our S O S and established communication with a French land station. The chase was well on when, a little over an hour later, an airplane came speeding toward us—it gave us the kind of a feeling a drowning man must have when he suddenly finds a life-preserver floating toward him. The plane circled round us and the U-boat promptly submerged. We no longer felt that the newspaper talk about submarines had been exaggerated.

Somehow or other, there was not a great quantity eaten at the noonday meal, despite the fact that we expected to arrive at the Port of Havre within a very short time, and all felt that the worst was over. But the subject of U-boats is one not given to easy speculation.

We were going full speed ahead, and although a heavy fog had arisen, the engineers kept the ship at its top. We were not breaking any "speed records" at that, for about nine and a half knots was our ship's best, even when pushed to the limit.

About three o'clock the same afternoon the fog lifted. There on our starboard side, a little over two miles away, was the ominous "Sub" with her gun crew on deck, ready to fire. They didn't lose any time about it, either. A peculiar whizzing, shrieking sound was heard, and a shell exploded about ten feet from us. A blue flame and a sickening thud—the whole ship rocked. The Captain immediately swung our ship around so that the stern of the vessel faced the submarine; then we opened fire.

I had started the distress call immediately upon sighting the submarine, adding the ship's position, which the first mate brought in a few minutes later. The wireless cabin was directly back of the after gun, and presented an excellent target for the U-boat. Shells were flying in all directions. One shell whizzed directly above my cabin, miraculously missing the masts of the ship, and landed a few yards ahead of us. Another shell exploded at about ten feet from one of the windows of my operating room, and a shower of water was thrown all around and upon the apparatus.

In the meantime I had picked up two British destroyers and a French land station. The destroyers sent encouragement, stating that they were steering toward us.

We expected to be struck any moment and we all knew that one shell would mean good-bye. For it would not only completely disable the Navajo, if it struck anywhere near the engine room, but would immediately set fire to the oil which we were carrying for fuel.

The battle lasted about fifty-five minutes, during which time the naval gun crew went about their business in the coolest manner imaginable. One young lad named Smith, a gun pointer, kept repeating, even with the shells bursting on all sides of us: "Those damned Germans can't hit us. Yeah! Give it to 'em, boys!" Our third mate had joined the gun crew and gave very valuable assistance. The trigger of the gun was out of order and he worked the lanyard which they had attached to it.

I realized that if one shell struck my cabin, pieces of wireless apparatus and wireless operator would be spread promiscuously about the ship. It was sort of comforting to realize that this separation would be instantaneous. Long before we entered the war zone I had decided just exactly what my procedure would be in case we were fired upon, but I little realized that, in place of self-preservation thoughts, there would come to me an overwhelming sense of duty to our glorious country, which would keep me at the key while it seemed every moment would be the last. I cannot see my action in a heroic light, for I stayed on the job without a thought of anything but the matter in hand. There must have been a guarding Providence watching over us, at that, for though shells were flying over and around us, missing us by a few feet, they *did* miss.

The twenty-fifth shot had been fired when the men, watching with every nerve strained, saw an explosion take place directly above the conning tower. Several of the enemy crew were seen leaping into the water as the submarine up-ended and sank. They had fired altogether twenty-three shells at us, and we fired twenty-seven.

When the guns ceased firing, the silence was just as it might be had you been standing close to Niagara Falls, and the falls were suddenly turned off. So great had been the vibration in my cabin the detector point had been jarred from the crystal several times during the battle. But we were through it successfully, and ready to call it "a day."

Then, just as all hands were breathing a sigh of relief, and I was about to light my pipe, the first mate rushed into the cabin and said, "Continue the 'distress,' another submarine is in sight!" There was to be no rest for the weary.

The engineers used all their energy in making the utmost speed, and the submarine which we had just sighted submerged within a few minutes. But not before one of the fragments of a shell had struck the stern of our ship, almost directly below my cabin, but above the water level. This required seventy-nine rivets when we arrived in France.

As I see the battle now, it is clear that with all the seriousness of the situation, there were still quite a few humorous incidents taking place while we were under fire.

Our carpenter, a Portuguese, when he heard the first shell whizzing by, looked out from the forecastle head and said "Sooter-marine!"—immediately thereafter disappearing. About three minutes later he appeared on deck, carrying his clothes done up in a bundle in one hand; a pair of old dilapidated shoes were dangling from the bundle and his set of tools were held in his other arm; his mattress was half slung over his back—he had everything but the piano. Thus encumbered, he rushed toward one of the lifeboats; but the first mate, seeing him from the bridge, ran down and grasped him by the collar, at the same time delivering some extremely well-aimed kicks, and saying, "I am spoiling a new pair of shoes kicking you!"—*bam! biff!*—"and if we get through this alive,"—*thump!*—"you will have to pay for them out of your wages."—*slam!* "Now get below, blankety-blank you, and help pass up ammunition!"

Another incident serves to illustrate how the habits of a lifetime dominate the excitement attending emergencies. When the first shot was fired, the first assistant engineer went below to call his chief, who had turned in for a nap. He drawled lazily, "I guess maybe you'd better get up, sir, we're being shelled by a submarine," while outside the cabin could be heard the Japanese, whom we had on board as steward, messmen, etc., running wildly from one cabin to the other in great excitement, and kissing each other fond farewells.

We arrived at Buxham, England, the same evening and anchored in the stream. A report of our encounter had preceded us and we were visited by several of the British officials. Later we received a letter of congratulation from the British Admiralty for sinking the U-boat.

That night we all sat around "chewing the rag" until about midnight. Had it been a religious gathering, it would not have been possible to have collected a more subdued and serious group of men; most faces bore an expression of heartfelt thankfulness for our miraculous escape.

About midnight we bade each other good night, apparently to turn-to. I went out on deck to have a final smoke before retiring, and about ten minutes later the third mate appeared, followed by two of the engineers; and there, before half an hour was up, we were all seated on deck, discussing the battle again.

The next evening we crossed the Channel with four other ships bound for Havre, and under the escort of a convoy. We arrived at Havre the following morning without further incident, and remained in that port a little over a week. During that time I had occasion to travel to Paris. There were about "fifty-seven varieties" of police inspectors who found it necessary to look at my passport and papers and it seemed as if everything and everybody was in uniform. A vast number of Americans, mostly from the Medical Corps and the Engineers Division, were in evidence. A civilian created as much curiosity as a man in uniform had had bestowed upon him a few years before the war.

Women were working as street cleaners, taxi-drivers, car conductors, and at practically every vocation of men in peace time. There was a ratio of about forty women to every man. Particularly pleasing were the car conductors, with their "kippy" little white hats and neat uniforms; a sight that would have cheered the pastels and paints of Howard Chandler Christy.

The French people surely know how to make strangers feel at home. A little incident of my train trip to Paris may be interesting, to show the attitude of all French people toward Americans. In the compartment in which I was riding there was a French soldier just returning from the front and a young lad who was studying aviation. They spoke very little English; my French was not quite as good; but we were able, by means of signs, gestures and a French-English dictionary, also by drawing little sketches, to converse with each other. I believe it was the best example of the pantomimic art on either continent—bar none.

When they grasped the fact that we had sunk a submarine, the soldier exclaimed, "Ah! *Americane!* My comrade!!" And he produced a bottle of wine from his kit. After which we were all little comrades together.

On July 14th, France's great national holiday (the fall of the Bastille) an immense review of the troops of the allied countries was held, headed by President Poincaire. Everyone for miles around who could secure a pass for the railway trip came to Paris for this event. The soldiers of the various countries marched by amid cheering and flag-waving of a spine-thrilling order. "Old Glory" was very much in evidence. I noted particularly, however, that among the soldiers were a great many lads apparently between the ages of seventeen and twenty, and, although the occasion was one of great celebration, there appeared a tired, dissatisfied, sort of longing-for-the-war-to-end expression on the faces of the majority of them.

When we sailed from Havre, we were acting as a convoy to twenty-three merchant ships. The Navajo steamed proudly ahead of this large procession, looking as if she were leading an exciting race—a thought which, however, immediately vanished when we remembered our unimpressive speed of eight and a half knots.

The next day we arrived in Fowey, England. Fowey is, indeed, the garden spot of the world. There are a hundred and one little nooks, shaded by gorgeous flowers, and the greenest of green trees, sending alluring invitations to all lovers of nature. All about are miniature hills, with dreamy bungalows perched on the summit, overlooking a stream dotted here and there with "skippy" little sailboats drifting along in a carefree, lazy fashion. Fowey would make a poet out of a Coney Island sideshow "barker."

We left this port with the whole town lined up to bid us farewell. The second day out, about 4 a. m., just as I was coming off watch, we sighted the body of a man lashed to a mast. The corpse was floating quite near us and the form was withered and apparently eaten away. It seemed like an ill omen.

The next morning at 5 a.m. we sighted a crowded life-boat. The people in it were waving to attract our attention. We overtook it, and saw twenty-three men—thirteen Chinamen and ten Englishmen. As we steamed past, they looked up at us with a pitiful imploring sort of expression as if they feared we would not stop for them. We did, however, and took them aboard, when we learned that they were from the British ship Glenstrae, torpedoed the evening before at about 9 o'clock.

The Captain immediately gave me a code message, asking that one of the destroyers relieve us of these men as we had but three life-boats, a number sufficient only for our own crew. I got in touch with a British patrol, and within a couple of hours it was alongside and took the shipwrecked men away.

A few days later, on August first, we had just about cleared the war zone. All hands were beginning to lose that strained constantly alert, half expectant, half dreading, expression that marks men who have reason to hold the submarine in great respect. A few of the men had decided to undress the next time they went to sleep. Someone even started a song about old New York town, and everyone joined in heartily. The spirits of the third mate rose and he washed his laundry which he had let accumulate since the beginning of the trip, because, as he said, "Clean laundry and 'dirty' subs are a poor combination."

Then it happened!

I was taking my noon siesta, and was suddenly awakened by sounds of running and confusion and shouting along the deck. Luckily, I had only to put on my slippers and rush out on deck to find out the trouble.

One glance was enough. The after-part of the ship was a dense mass of smoke, with flames shooting up at frequent intervals. Everyone was shouting, and running up and down. Someone said, "Try and heave that ammunition overboard." (We had 110 rounds of ammunition for our three-inch guns stored away, and about 2,000 rounds of machine-gun ammunition in my operating room.) The Captain bellowed down from the bridge, "Send out the S O S!"

I started the generator and one of the oilers came rushing in. "Sparks, the fire is uncontrollable," he shouted. "Keep the 'distress' going!"

I was already shooting it out, saying, "Ship on fire. Burning oil."

The fire was gaining such rapid headway that within five minutes the flames were licking in the windows of my operating room. Suddenly the curtains burst into flame. We had three life-boats on the after-poop outside my cabin, and they were being lowered away. It was impossible for any of the engineers to get below to the engine room, because of the fire and smoke, and the ship was going ahead full speed. I was still repeating the "distress" when I heard through my open window one of the naval lads shouting, "We're leaving, wireless!"

I was stunned for the minute. Then I grasped the import of that sentence. I grabbed the pup and ran from my cabin. Two of the boats were already away from the ship. I slid down the falls just as they cut away the last rope.

It was only good luck that kept us from capsizing, for the Navajo was going ahead full speed. But somehow we managed to get clear and rowed away from the swirl created by the propellers.

The fire had gained such headway that the whole poop was now a mass of flames. We were approximately 1,000 miles from land, and in an entirely unused ocean track and the only sign of a ship we had seen in the past four days was the patrol boat that had relieved us of the Glenstrae's survivors. It seemed probable that some time would pass before we stood any chance of being picked up.

These facts I had just grasped when the shells began to explode! First the ammunition for the rapid-fire gun went off with staccato reports; they sounded very much like the automatic trip hammers used in steel construction work; then came the deep boom of the large shells, followed by the peculiar whizzing sound as the projecticles shot out.

The whole after-part of the ship was one sheet of roaring flame and we expected to see the boilers go at any moment. The life-boat which I was in was in charge of the second mate; we also had the second assistant engineer and eight of the Portuguese crew. We knew that we had to make a quick get-away so everyone took a hand at the oars, everyone, that is, except one big Portuguese fireman. He was a man who must have been born on a rainy day; his ugly, crabbed nature had made him very much disliked while on shipboard; he had lost one eye in some manner, and the other eye had a ferocious, animal gleam in it; and there he sat, lounging back like a passenger, watching the rest row. I suggested to the second mate that this fireman relieve the second assistant engineer, who was an elderly man; and the second mate ordered him to do so. The fireman scowled, and replied, "No savvy." He savvied as well as anybody, but probably the combination of fright, laziness, and natural meanness, made him refuse.

I could see the second mate inwardly boiling with rage; he did not have his revolver with him, so in whispers he planned with me to use the end of an oar upon the fireman's head. A life-boat is no place for excess baggage, and this man was setting a dangerous example to the other Portuguese. We had but a limited amount of water and hard-tack aboard, and it was necessary to maintain strict discipline.

So, following instructions, I began edging over toward him with the intention of grasping his arms while the second mate utilized an oar on his head—when we saw the smoke of a steamship in the distance.

All grievances were immediately forgotten in the joy of the sight. No words can express with any degree of justice the feeling that ran through us.

Within an hour we were all safely aboard. The vessel which rescued us was the Greek steamer Iossifoglu—some name to pronounce, but a joyous sight for us, you can bet. We all felt like giving three cheers for Greece and all things "Greecy."

There were two American firemen aboard, and their first remark was, "Well, you sure have struck a hungry ship." And they were right. Meals consisted chiefly of potatoes and tea, with variety injected by reversing it to tea and potatoes. But we did not look a Greek horse in the mouth, for, compared to hardtack and water, the menu was indeed sumptuous.

I had a bunk above a Greek steward. He had, marching back and forth along the walls and over the bunks, the greatest collection of trained animals it has ever been my misfortune to encounter. Apparently they did not annoy him in any way, but I firmly believe that he must have spent considerable time in drilling them, as they would stand at attention, form in fours, fix bayonets and charge.

All through the first night aboard I occupied myself by striking the wall with resounding whacks. I connected with and killed the enemy—sometimes . . . . but not once did I miss my cuss phrase. About 2 a. m. the poor Greek steward knocked on my bunk and said, "What you mean, 'gol damn, gol damn' all night? What you mean?" I explained briefly, but to the point.

The next day we had a general hunt for shoes, socks, underwear, and various articles of wearing apparel, as some of us were shy everything, and most of us required something. We were bound for Limerick, Ireland, which was comforting, as was the fact also that the Greek ship was a neutral one. We did not feel very much uneasiness while going through the "zone."

On August fifth we steamed up the River Shannon, where the country is rugged, hilly and green, with a scattering of thatch-roofed huts dotting the hillsides. We arrived at our destination in the evening and once again we were very much touched by the hospitality shown us.

The far-famed ready wit of the people is indeed justified. One of our men, while getting a shave was cut, and angrily asked the barber why he didn't learn his business, whereupon the tonsorial artist replied, "Kape your mouth shet, if you want to be shaved. Shure 'tisn't my fault if your face is made wrong."

The waiter in our hotel would have been called an exaggerated type on any vaudeville stage. Upon being sarcastically informed that he was never born to be a waiter, he replied, "Sure and I knew that long ago. I was born to be a Prince, it's only circumstances that makes me a waiter."

After seven days we left Ireland and sailed from Liverpool on the American liner New York, arriving at an Atlantic port in the United States without incident.

I have just received a letter from a wireless operator at the land station at Bleville, France. I met this chap while in Havre, and as he had picked up our distress calls we had quite a feeling of intimacy. His letter reads:

> My dear Mr. Cisin:
>
> I'm really happy to have the honor to know you, but very sorry that you did not stoped a long while to Le Havre.
>
> I think that was not last times see you, it will be for another.
>
> Don't wish receive any S. O. S. of S. S. 'Navajo' like this on the last 5 July at 11 a. m. and 4 p. m. (Very constantly)
>
> Your devoted new friend.
>
> (Signed) H. C.
>
> P. S. Excuse, please, my America writing, it is my first letter of this language.

The owners of the steamship company have mailed me a very liberal gift, accompanied by a kind letter of appreciation, and everything has ended very happily.

Maybe I'll have another story for THE WIRELESS AGE soon, for I expect to be on my way across again within a short time. Because of the necessity of supplying our troops with food and ammunition, the game is worth the candle.

Signal Officers' Training Course

A Wartime Instruction Series for Advanced Amateurs Preparing for U. S. Army Service

FIFTH ARTICLE

By MAJOR J. ANDREW WHITE

Chief Signal Officer, Junior American Guard

IN preceding articles of this series, the reader has been given the principles of individual drill instruction for the recruit and the marching evolutions of the squad.

On the assumption that the Signal Corps units following this course are not yet recruited to full numerical strength, so that drill regulations by section and company can be employed, instruction in signaling by flag is the next logical instruction step.

Communication of military intelligence by hand flags is best taught in squads or small groups. Recruit instruction should begin with the two-arm semaphore, using the flags illustrated in the lower portion of the drawing.

The following extracts from "Military Signal Corps Manual" will be found of value in learning two-arm semaphore flag signaling.

Hand flags are authorized for general use by the Army, though on account of their small range they are of limited application and are chiefly serviceable for use within organizations, within fixed positions, or for incidental signaling. The range with flags of the usual size is of course dependent upon light and background, but it is seldom more than one mile with the naked eye. This system of signaling has been highly developed in the Navy, and on account of its rapidity and simplicity is of use to the Army and should be familiar to all soldiers. It is limited to visual signaling work and not adapted to general signaling as is the General Service Code. It will be found useful under many circumstances and is adapted to special work when rapid communication for short distances is needed. This method is also used to advantage for interior signaling within batteries of the field artillery and within regiments of infantry, and at times is convenient to the cavalry.

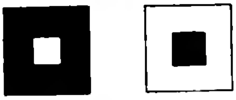
The semaphore hand flags for service use are 18 inches square divided diagonally into two parts, one of red and the other of white;* the staffs are 24 inches long.

The hand flags of the Navy are from 12 to 15 inches square, of blue with a white square, or red and yellow diagonally, the colors to be used depending upon the background. The flags are usually attached to a light wooden staff about two feet in length.

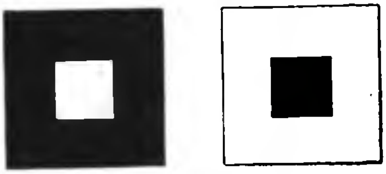
In calling a station, the signalman faces it squarely and makes its call. If there is no immediate reply he waves the flag over the head to attract attention, making the call at frequent intervals. When the sender makes "end of the message" the receiver, if the message is understood, extends the flags horizontally and waves them until the sender does the same, when both leave their stations.

Recruits should be taught that the letters of the alphabet and conventional signals shown on the accompanying plates are indicated by definite positions of the arms and that these must not be assumed carelessly. An excellent plan of instruction is to face the beginner toward a clock or a disc divided into seven parts. The eight radial positions for the flags are then indicated by the clock's hour hand at 6:00, 7:30, 9:00, 10:30, 12:00, 1:30, 3:00 and 4:30 o'clock. The flags are moved in the same direction as the hands of a clock.

SIGNAL CORPS TWO FOOT FLAGS



SIGNAL CORPS FOUR FOOT FLAGS



SEMAPHORE HAND FLAGS

The method of instruction varies with the teacher, but a schedule which has worked out satisfactorily for the writer in teaching novices quickly is a division of the alphabet into sections as follows: (1) Letters A to G and numerals 1 to 7 inclusive; when these have been thoroughly mastered instruction is begun on (2) Letters H to N (omitting J) and the numerals 8 and 9; the instruction then being pursued in the rotation following: (3) Letters O to S inclusive; (4) Letters T U and Y; (5) Letters J and V and numeral 0; (6) Letters W, X and Z.

Contrary to the usual instruction in code telegraphing, flag signaling progress is more rapid if the beginner learns to receive first. If he starts his instruction with sending he has an opportunity to stop and think of the letter before taking the position. When facing a skilled signalman, however, the letters must register instantly on his mind or the message will be lost.

As the letters of each division in the six given are made familiar, simple words should be signaled containing these letters. When the alphabet has been completely covered, words may be expanded into phrases and gradually

---

*For the field and the coast artillery there has been temporarily issued a semaphore hand flag of orange with a scarlet center and scarlet with an orange center, one of each constituting a kit. The flags are 18 inches square, the centers 9 inches square, and the staffs 24 inches long.

into sentences and complete messages. The soldier should then become familiar with the letter codes which follow:

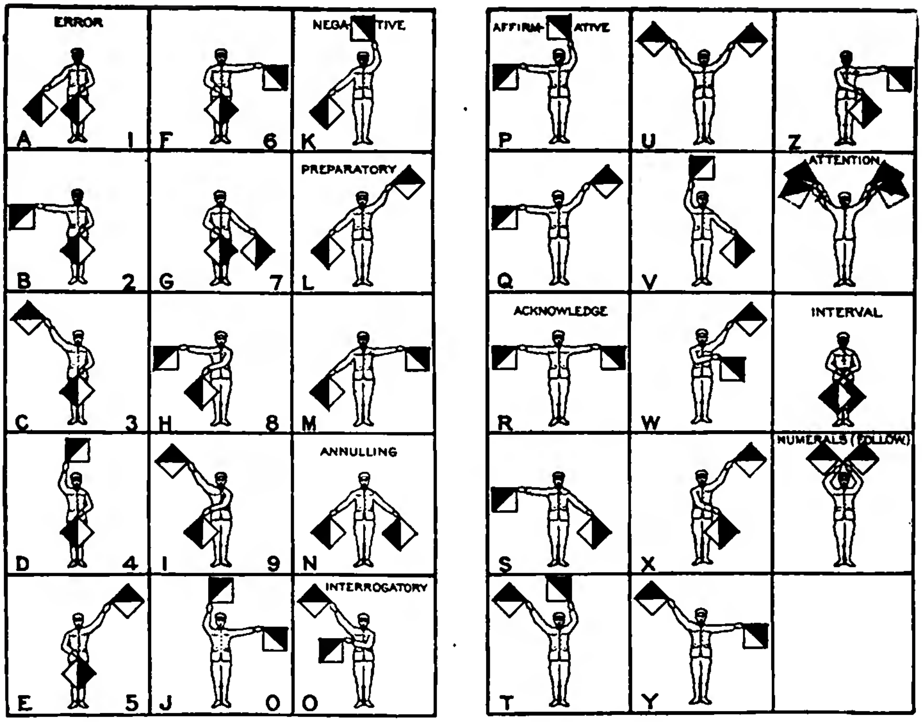
LETTER CODES

INFANTRY

For use with General Service Code or semaphore hand flags.

Letter of alphabet	If signaled from the rear to the firing line	If signaled from the firing line to the rear
A M	Ammunition going forward	Ammunition required
C C C	Charge (mandatory at all times)	Am about to charge if no instructions to the contrary
C F	Cease firing	Cease firing
D T	Double time or "rush"	Double time or "rush"
F	Commence firing	
F B	Fix bayonets	
F L	Artillery fire is causing us losses	
G	Move forward	Preparing to move forward
H H H	Halt	
K	Negative	Negative
L T	Left	Left
O	What is the (R N, etc.)?	What is the (R N, etc.)?
(Ardois and semaphore only)	Interrogatory	Interrogatory
. . — — . . (All methods but ardois and semaphore.)	What is the (R N, etc.)? Interrogatory	What is the (R N, etc.)? Interrogatory
P	Affirmative	Affirmative
R N	Range	Range
R T	Right	Right
S S S	Support going forward	Support needed
S U F	Suspend firing	Suspend firing
T	Target	Target

Recruit instruction in semaphore signaling by flags



Alphabet of two-arm semaphore with flags

CAVALRY

For use with General Service Code or Semaphore hand flags.

AAA—Ammunition going forward (if signaled from the rear to the front).
—Ammunition required (if signaled from the front).
CCC—Charge (if signaled from the rear to the front).
—About to charge, if no instructions to contrary (if signaled from the front).
CF—Cease firing.
DT—Double time, rush, or hurry.
F—Commence firing.
FL—Artillery fire is causing us losses.
G—Move forward (if signaled from the rear to the front).
—Preparing to move forward (if signaled from the front to the rear).
HHH—Halt.
K—Negative
LT—Left.
M—Bring up the horses (if signaled from front to rear).
—Horses going forward (if signaled from rear to front).
O—What is the (R N, etc.) ?
. . — — . . What is the (R N, etc.) ? Interrogatory (all methods but ardios). and semaphore).
P—Affirmative.
R—Acknowledgement.
RN—Range.
RT—Right.
SSS—Support going forward (if signaled from the rear to the front).
—Support needed (if signaled from the front to the rear).

Signal Corps camp of the Eastern Division, U. S. Army

SUF—Suspend firing.
T—Target.

FIELD ARTILLERY

For use with General Service Code or Semaphore Hand Flags.

........—Error (all methods but ardois and semaphore).
A—Error (ardois and semaphore only).
AD—Additional.
AL—Draw ammunition from limbers.
AKT—Draw ammunition from combat train.
AM—Ammunition going forward.
AMC—At my command.
AP—Aiming point.
B (numerals)—Battery (so many) rounds.
BS (numerals)—(Such.) Battalion station.
BL—Battery from the left.
BR—Battery from the right.
CCC—Charge (mandatory at all times). Am about to charge if not instructed to contrary.
CF—Cease firing.
CS—Close station.
CT—Change target.
D—Down.
DF—Deflection.
DT—Double time. Rush. Hurry.
F—Commence firing.
FCL (numerals)—On 1st piece close by (so much).
FL—Artillery fire is causing us losses.
FOP (numerals)—On 1st piece close by (so much).
G—Move forward. Preparing to move forward.
HHH—Halt. Action suspended.
IX—Execute. Go ahead. Transmit.
JI—Report firing data.
K—Negative. No.
KR—Corrector.
L—Preparatory. Attention.
LCL (numerals)—On 4th piece close by (so much).

LOP (numerals)—On 4th piece open by (so much).
LT—Left.
LL—Left from the left.
LR—Left from the right.
LE (numerals)—Less (so much).
MD—Move down.
ML—Move to your left.
MR—Move to your right.
MU—Move up.
MO (numerals)—Move (so much).
N—Annul, cancel.
O—What is the (R N, etc.)? Interrogatory. (Ardois and semaphore only.)
..——..—What is the (R N, etc.)? Interrogatory. All methods but ardois and semaphore.)
P—Affirmative. Yes.
PS—Percussion. Shrapnel.
QRO—Send faster.
QRS—Send slower.
QRT—Cease sending.
R—Acknowledgement. Received.
RS—Regimental station.
RL—Right from the left.
RR—Right from the right.
RN—Range.
RT—Right.
S—Subtract.
SCL (numerals)—On 2d piece close by (so much).
SOP (numerals)—On 2d piece open by (so much).
SH—Shell.
SI—Site.
SSS—Support needed.
T—Target.
TCL (numerals)—On 3d piece close by (so much).
TOP (numerals)—On 3d piece open by (so much).
U—Up.
Y (letter)—Such battery station.

The selection of the site for a visual signal station is governed by choice of a point perfectly in view of the communicating station, the exact position in which the flagman is to stand being arranged, if possible, so that he will have behind him for every signal a background of the same color.

Secrecy in communication is vitally important. Even though the code used may not be known to the enemy, the waving flag or other means of visual signaling will inform the enemy that he has probably been observed; stations should therefore be located where they will be most difficult of discovery. If there is reason to believe that signals are seen by the enemy, they should be made in cipher and extraordinary care be taken in transmitting messages. Where practicable, they should be repeated.

The distant station is the best judge of background, and it should indicate the color of flag wanted.

The following table shows how far an object at sea level can be seen:

Height of the eye above sea level (in feet)	Distance (in statute miles)
10	4
15	5
20	6
30	7
40	8
50	9
60	10
70	11
85	12
100	13
115	14
130	15
150	16
200	18
230	20
300	23
350	25
500	30
700	35
900	40

Hence, an observer whose eye is 30 feet above the sea can distinguish an object 7 miles distant, providing it is at the sea level; but if the object itself is 15 feet above the sea he can make it out $7 + 5 = 12$ miles off.

In visual signaling over a distance the telescope is used. In locating the signalman at any known station, some prominent landmark is noted with the unaided eye and the telescope then directed upon the place and the country near the marker scaled until the signalman is found. When the compass bearing is known the telescope is aligned with the proper compass bearing and the telescope moved slowly from side to side until the whole country in that direction has been scrutinized.

The magnetic bearing of all communicating visual stations is always carefully noted. In addition, guide lines may be established by driving two stakes firmly into the ground and close to each other. A line through the center of these should point the direction of the distant station. If more than one station is being communicated with, the various names should be written under the lines which mark each one.

A signal officer should provide himself and those working under him with the latest and most accurate topographic maps of the country. The location and call letters of all stations and the personal signals of his subordinates should be recorded and made known to all under his jurisdiction.

The called station should respond at once when its particular signal is shown.

A continuous watch for signals should be kept and assignments recorded so that responsibility for neglect to promptly answer calls may be determined.

When a station has sent all messages on hand, the signal "Cease signaling" should invariably be made. When nothing more is to be sent from either station, both make "Cease signaling."

If a signal station asks another to move its station to the right or left, both stations appoint a signalman to hold a flag above his head. The station asking for the change lowers its flag immediately when the proper background is found.

Attempts to attract the attention of a station must be persistent. They should never be abandoned until every device has been exhausted, and should be renewed and continued at different hours.

How to Become an Aviator

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

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

INDICATIVE of the giant strides made in the development of aeroplanes is the announcement that the United States is considering the delivery of its vast air fleet to the European battlefields by direct flight, instead of ship transportation. Equipped with engines which can maintain a speed of eighty miles an hour, and built to carry several tons of fuel, the new aircraft through which we hope to strike the crushing blow to Germany can well be conceived making the cross-ocean flight in safety within twenty-four hours.

The air dream of yesterday is today's reality.

Navigation has been up to now considered one of the greatest obstacles to trans-Atlantic flight, the danger of the pilot losing his way, say, between Newfoundland and the Azores, having long been of serious concern to those who have plotted ocean routes. In wireless will the solution be found, however. The direction finder, or radio goniometer, a familiar instrument to readers of THE WIRELESS AGE, is to be the basis of the new air navigation instruments, according to present plans. With this instrument pointing the way to a sending station in the Azores, or similar objective point, the danger of the aviator losing his way will be reduced to the minimum. More and more each day, aviation and wireless, the two arts giving mastery of the air, are becoming more closely allied.

Better than any letter of introduction is knowledge of wireless for readers of THE WIRELESS AGE who have in mind enlistment in the aviation sections of our military establishment. Since a large proportion of our aviators must be radio operators, qualification for wartime service in our flying section is thus made easier, for less instruction of the pupil is required.

But, as in the study of radio communication, the prospective aviator must be thoroughly grounded in the fundamentals. Both safety and common sense demand that the aviator know more of hismac hine than the mere manipulation of the conerols.

It is this study of fundamentals which will now be taken up in the series.

Military aeroplanes will of course be given first consideration. Some aeronautical generalities are necessary, however, in dealing with design and construction, but these will be treated briefly.

The aeroplane is but one form of flying machine. Leaving balloons of various types entirely outside the question, there still remain three types of heavier-than-air machines. We will devote all our study to the aeroplane, but passing reference should be made to the other two types before proceeding. These are:

The Helicopter—a machine which employs the principle of direct lift by means of an air screw propeller operating on a vertical axis. This is not a practical type of flying machine and little has been done with it.

An aeroplane of the "tractor" type, so called because the propeller is attached to the front, pulling the machine through the air

The Ornithopter—a machine which derives its name from the bird, its principle being the creation of flapping wings given a reciprocal motion somewhat similar to rowing, the forward push intended to exactly counterfeit that of the bird's wings. These machines are not yet successful.

The reader may be fascinated by the possibilities of research into the field represented by this latter type, but considering the present efficiency of the aeroplane, it is safe to assume that time will be better spent in utilizing its man-discovered principles of flight, rather than in following a new line of thought on the assumption that Nature never makes a mistake and the bird is therefore the best model.

It must be remembered that flying is but an incident in the life of a bird, just as walking is to a man. The famous aviator Santos-Dumont drew a parallel which disclosed the folly of blindly following Nature, when he pointed out that such a procedure would have resulted in locomotives being built with huge iron legs and steamships with the flapping fins and lashing tail of the whale. Sir Hiram Maxim further blasted the bird-flight theory by noting that "in order to build a flying machine with flapping wings, to exactly imitate birds, a very complicated system of levers, cams, cranks, etc., would have to be employed, and these of themselves would weigh more than the wings would lift."

Without further comment, therefore, we will confine ourselves to the aeroplane, the most successful type of aircraft and the best developed means of navigating the air.

The aeroplane is sustained by the upward push of the air flowing past it; it therefore is composed of (a) lifting surfaces, (b) power for propulsion.

Propulsion through the air is effected by a propeller, identical in principle though not in appearance, to the screw on a boat. An engine drives this propeller at the required velocity. The propulsion produced by the propeller is called the *thrust*.

When the propeller is attached to the front, pulling the machine through the air, the aeroplane is called a *tractor*.

If the propeller is back of the wings, or main lifting surfaces, the aeroplane is called a *pusher*.

The tractor type, with a single propeller, is generally acknowledged the most efficient all-around machine, although pushers with two air screws have distinct values in gun-carrying machines.

An aeroplane with two wings, one above the other, is known as a *biplane*.

The single wing type, with but one lifting surface, is called a *monoplane*.

The *tractor biplane* is the type which is more nearly standardized and will be principally considered here.

The main lifting surfaces are planes, or "wings," which present their widest dimension across the line of flight and create the air compression on their surfaces which produces flight.

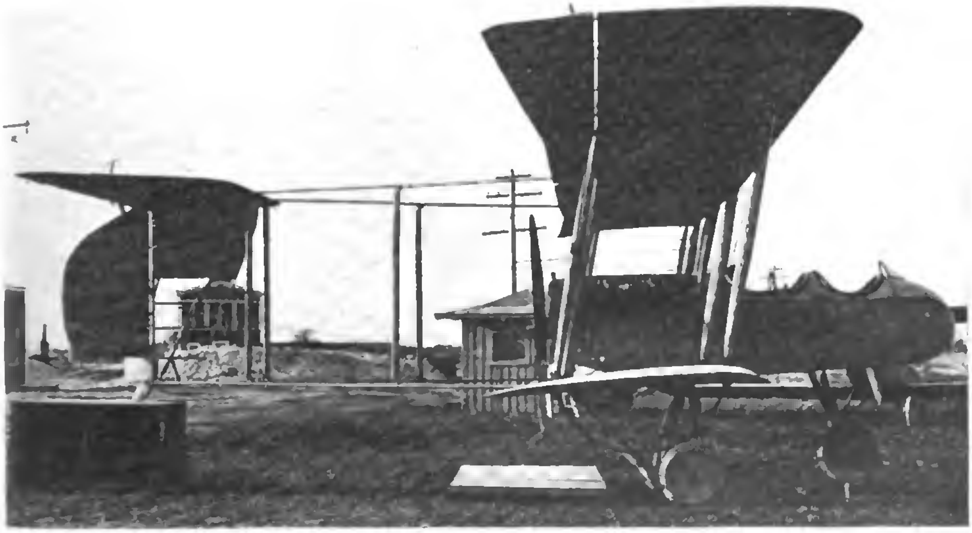
The body to which these planes are attached is known as the *fuselage*, the engine and seats mounted in it being enclosed to lessen the resistance of the wind.

Since the aeroplane "sails" through the free air, it has three axes of rotation.

(1) It may ascend or descend. This is known as **pitching**, and is controlled by depressing or elevating an *elevator* by means of suitable controls.

(2) It may change its direction of travel, or steer to right and left. This is called *yawing*, and is made possible by the operation of a rudder.

(3) It may tip over to either side, a movement termed *banking* or *rolling*. This lateral motion is offset by three means of control which give a difference in angle to the two sides of the wing surface, causing one side to lift more than the other. The controls are: (a) *ailerons*, small planes set at each side, between and independent of the main lifting surfaces; (b) *wing flaps*, which are hinged portions of the main planes; (c) *warping*, or twisting the main lifting surfaces to simultaneously lessen and increase the angle of inclination to the wind as required on both sides.



A "pusher" biplane with the propeller back of the wings or main lifting surfaces

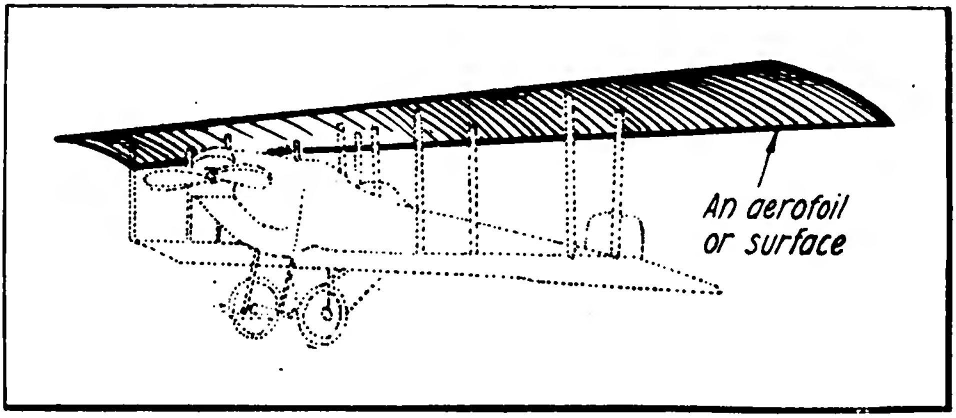


Figure 1—A lifting surface

THE PRINCIPLE OF FLIGHT

The upward air pressure against its main wing surfaces enables the aeroplane to fly, when these wing surfaces, or planes, are set at an angle inclined from the direction of motion, the pressure being supplied by the speed at which the planes are driven by the propeller.

AIR--Air is attracted by the mass of earth, or the gravity force, and therefore has **weight**. A cubic foot of dry air, at sea level and 32 degrees Fahrenheit temperature, weighs 0.0807 lb. Its density decreases with altitude, until at a mile above sea level it weighs 0.0619 lb., and at five miles, 0.0309 lb. per cubic foot.

Air also has **motion**, which must be taken into consideration by the aviator, and **resistance**, due to density and intensity of motion, or wind. Air resistance comprises:

Inertia—Its tendency to remain at rest, if still; in motion, if moving.

Elasticity—Its tendency to reoccupy its normal amount of space after being disturbed.

Viscosity—The tendency of particles of air to resist separation.

Inertia gives the propeller its "hold" in the air; elasticity, when air is compressed under the surface of the plane, aids the lift; viscosity creates fricton, which is minimized by using polished surfaces and stream-lining aeroplane parts.

THE SURFACE

A wing surface is meant by this expression (see Figure 1). It has a strictly aeronautical designation, viz.:

THE AEROFOIL

This term is seldom used bv aviators, but is commonly employed by aeronautical engineers to differentiate between an ordinary surface and one inclined at an angle to the direction of motion, having thickness, and curved to secure a reaction from the air for lifting.

CAMBER

This is the term which designates the curvature of the surface, or aerofoil.

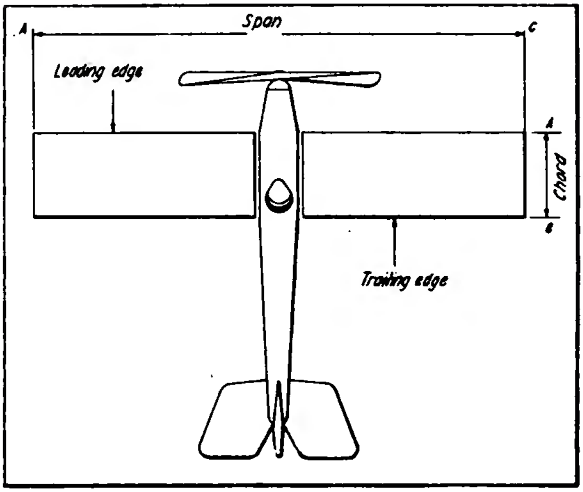


Figure 2—The chord and span of a wing surface

THE CHORD

This is the dimension of an imaginary straight line from the front edge of the aerofoil, or surface, to the rear edge, as shown by A—B, in figure 2.

The front edge of the wing is known as the **leading edge,** and the rear as the **trailing edge.**

SPAN

This is the dimension of the surface across the direction of motion, indicated by A—C, in figure 2.

THE ANGLE OF INCIDENCE

This is the angle of inclination of the chord to the air stream.

In practice this is the angle of inclination of the chord to the line of the propeller thrust. If the leading edge of a surface is above the trailing edge when driven through the air, the angle of incidence is **positive.** A surface with the trailing edge presented above the leading edge, or negatively to the air flow, would bring the air pressure to the top of the surface and constitute a **negative** angle.

LIFT BY AIR PRESSURE AND SUCTION

Having considered the aeroplane wing as a surface, its action upon the air will be described.

Air, or the atmosphere, has characteristics similar to water, the atmosphere being an ocean of definite extent and pressure at different altitudes, and flowing past an object either in stream lines, or in broken up eddies due to disturbances in its flow.

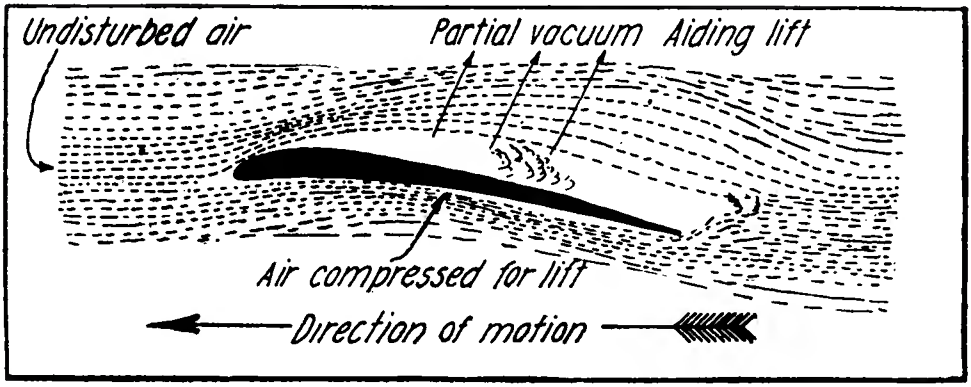


Figure 3—Action of air on the aerofoil

The nature of the air pressure when encountering the aerofoil is shown in the drawing, figure 3.

The under face of the aeroplane wing compresses the air, resulting in a positive force.

At the same time a suction is caused by the air flowing past the upper face, causing a partial vacuum, tending to draw the surface upward.

The value of this suction is about three-quarters of the total pounds force of the air's action on the aerofoil. The factors of this air reaction are:

(a) The mass of the air.

(b) The velocity of the aerofoil.

The reaction increase is as the square of the velocity.

The air reaction has two values:

LIFT—opposed to gravity, or the aeroplane's weight.

DRIFT—opposed to the thrust of the propeller.

The lift is opposed by the drift, which must be overcome by the thrust supplying velocity great enough to produce air reaction sufficient to produce flight.

Drift is of three kinds: (a) **active drift,** produced by the velocity of the lifting surfaces; (b) passive drift, the resistance of other parts of the aeroplane, such as struts, wires, tank, fuselage, hood, etc.; (c) **skin friction,** or the air resistance on roughness of surface.

LIFT AND DRIFT

It has been shown how the air pressure is created on a surface inclined at a positive angle to the direction of motion, and that this pressure exerts a lifting force.

The air pressure is inclined upward and to the rear of the direction of motion in a ratio equal to the variance of the angle of incidence of the wing plane.

The vertical action of the air pressure is a force capable of lifting weight but its horizontal component of air pressure represents resistance to motion.

Thus, while

LIFT is a vertical air pressure.

DRIFT, its horizontal component, is resistance.

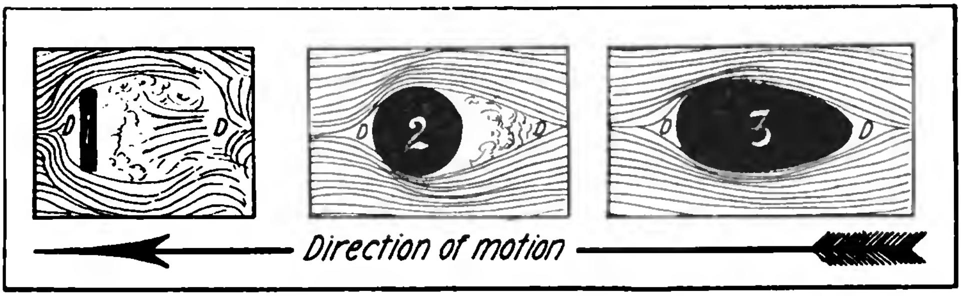


Figure 4 *Figure* 5 *Figure* 6

LIFT-DRIFT RATIO

Flight is maintained by the proportion of lift to drift being sufficiently great to overcome the force of drift, the characteristics of the wing surface being designed for the greatest lift with the smallest consequent drift, so that minimum power supplies maximum capacity for load carrying.

The factors to be considered in determining lift-drift ratio are **velocity, angle of incidence, camber** and **aspect ratio.**

VELOCITY

Drift increases to lift proportionately with increase of velocity.

Active drift, formed by the wing surfaces, is a component part of the air reaction which creates the lift, and therefore increases as the square of the velocity. At all speeds the efficiency of the aeroplane would remain the same, but for the

Passive drift, or the resistance of the aeroplane parts other than the lifting surfaces, which also increases as the square of the velocity, yet adds nothing to the lift. Thus by adding its resistance to the active lift, it prevents the aeroplane's ratio of lift to drift from increasing proportionately with the increase of the thrust. In other words, the efficiency of the aeroplane would not decrease with added velocity, if it were not for the passive drift. This factor prevents, so to speak, doubling the speed or lift by doubling the thrust.

To diminish the passive drift all parts of the aeroplane are given **stream lines,** or a form offering least resistance as they pass through the air.

Head resistance is a term formerly employed to describe passive drift. It has been largely discarded, however, for its inaccuracy of description of the effect of the action of parts in air reaction. Passive drift is due more to the action on the rarefied area behind the object than to the head or forward part of hood, struts, wires, etc.

FLOW OF AIR

Figures 4, 5, 6 illustrate the flow of air around three objects of varying form.

In figure 4 the rarefied area, or drift, is represented by D—D, and is of marked extent.

In figure 5, this area, indicated by the same symbols, has decreased, the air flowing closer to the spherical body.

Figure 6 shows the rarefied area still further diminished, the shape of the body being conducive to closer air flow.

These three figures illustrate the importance of stream-lining parts on the line of flight.

As the head resistance is increased by the rarefied area in the rear of the object, the thrust required increases proportionately.

The action of air on objects of different shapes and propelled at varying velocities is determined by visualizing the air in laboratory research with wind tunnels.

ANGLE OF INCIDENCE

This is the angle of inclination of the chord to the air stream. Its efficiency varies and is determined by what is desired in thrust, weight-carrying capacity, and ratio of climb to velocity.

It may be accepted as a general premise that the greater the velocity the smaller should be the angle of incidence, so that the rarefied area may be kept to stream-lines and the eddies of air reduced to a minimum. These eddies represent drift, since they have no lift, and when produced by too great an angle of incidence, the power required to produce them is wasted, with consequent loss in efficiency of the aeroplane.

Wind tunnel research largely determines the best angles of incidence.

CAMBER

The purpose of the camber, or curve, in a lifting surface is to decrease the active drift, horizontal component of the lift.

Camber of lower face—The horizontal air reaction from a flat surface would be considerable and increase the drift. Curving the wing surface compresses and accelerates the air from the leading edge to the trailing edge. If this air action is not uniform the drift will be increased.

With a fixed upper face, an increase in the camber of the lower face does not greatly vary the relation of lift to drift, but lift increases with camber increase. Most of the lift is furnished by the upper face, however, and the camber increase of the lower does not produce sufficient effect on the upper to compensate for the lessened depth of spar allowed when a rather flat surface is used. Increased depth of spar permits a weight reduction in the framework of the wing without sacrifice of strength. It is for this reason that lessened camber for the under side is allowed.

Camber of upper face—The top surface is curved to produce the least possible eddies of air resistance behind the trailing edges, the rarefied area produced being given the best obtainable stream line to lessen the drift in the lift-drift ratio.

Velocity, angle of incidence and thickness of aerofoil, or surface, determines the camber of the upper face. In general, the camber and angle of incidence should decrease proportionately with velocity increase.

On an aerofoil with a *flat* under face the maximum lift increases with the upper face cambered up to 1/15, beyond which it decreases. Improvement of the lift-drift ratio is steady up to 1/20 camber, thereafter showing decrease in value with deeper cambers.

With the under face *cambered* the increase of upper face camber above 1/15 shows little variation in lift, but steady increase of drift.

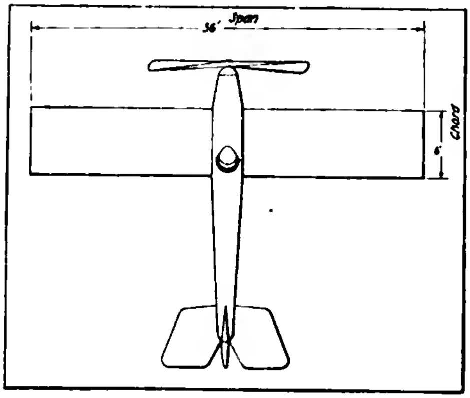


Figure 7—High aspect ratio

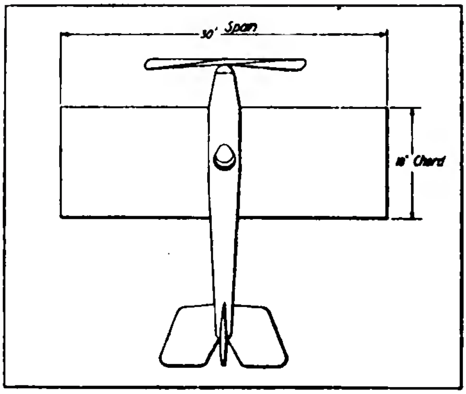


Figure 8—Low aspect ratio

ASPECT RATIO

The proportion of span to chord is the aspect ratio. The total span divided by the chord of the wings is the "aspect" of aeroplane.

In figure 7 the span is 36 feet, the chord is 6 feet, the aspect ratio is therefore 6 to 1.

At a given velocity and given wing area, the reaction increases with increase in aspect ratio. The reason for this is that a greater mass of air is engaged with a wider span, the reaction of air being partly the result of the mass of air engaged.

An average aspect for an aeroplane is 6, but in deep cambered planes an aspect of 9 is considered practicable by designers.

In a general way it may be said that the higher the aspect ratio, the better is the lift-drift ratio. But with decrease of chord the deepening of the camber requires added thickness of aerofoil, or surface, and in practice the reduction of chord required for an extremely high aspect ratio makes prohibitive the use of the thickness of surface which would give the best camber.

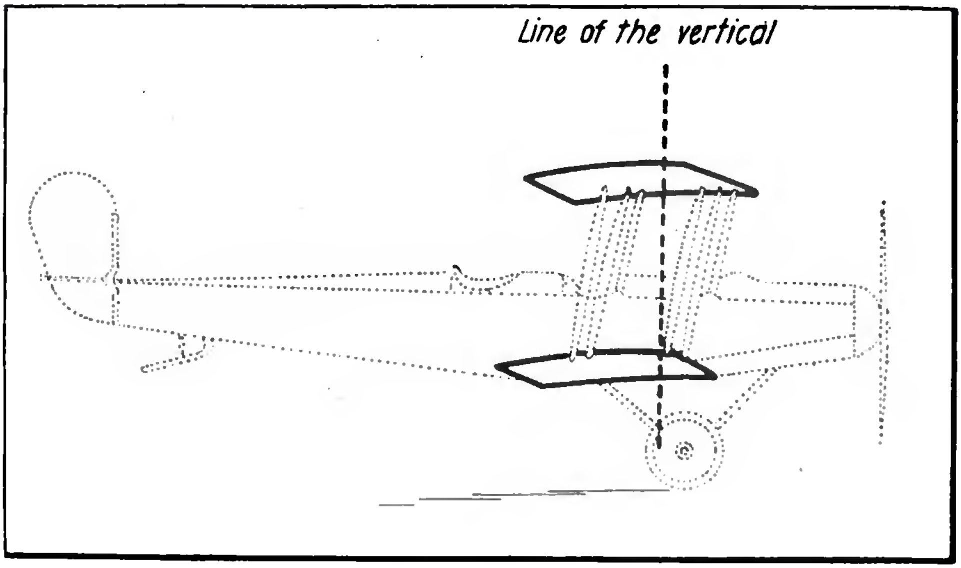


Figure 9—The upper plane placed in advance of the lower, or staggered

STAGGER

When the top surface of a biplane is placed in advance of the vertical with relation to the lower wing surface, the term stagger is used.

See Figure 9.

By staggering the upper plane ahead of the lower plane it is removed from the area of action of the lower aerofoil and engages undisturbed air.

Without stagger, the confusion of air reaction could be obviated by increasing the gap between upper and lower planes a dimension equal to 1½ times the chord. But the length of struts and wires required for this opening increases the drift, making it impracticable to have a gap much greater than the chord.

Minor considerations of construction and balance, and visibility for pilot and observer, govern the proportion of stagger, although, theoretically, the upper plane should be advanced a distance about equal to 30 per cent. of the chord, small variations being further governed by velocity and angle of incidence.

The telegraph room, showing members of the Signal Corps at practice

Training Signal Corps Men at Pratt Institute

Drill, Military Discipline and War Wireless Instruction in Halls of Learning

THE customary silence which prevails in the spacious halls and grounds of Pratt Institute, Brooklyn, N. Y., gave way during the past Summer to the martial tread of many feet; staccato commands sent alert khaki-clothed figures hurrying here and there; a military air pervaded every nook and corner; in a word, the Institute was turned into training quarters for a detachment of Depot Co. H, United States Signal Reserve Corps.

Among those preparing themselves to serve their country were representatives of many walks in life. One man left an important post with a widely-known banking firm to join the Corps; another came from among the tried men in a great industrial corporation; here and there were amateur wireless men learning to put to practical use the knowledge which they acquired during their spare hours. Commercial wireless men and students from technical schools were also found in the detachment.

The detachment was organized by First Lieutenant John A. Zimmerman, First Lieutenant Grover Pipkin of the United States Army being placed in command. It was divided into two sections which alternated in the following daily program:

The men were awakened at six o'clock in the morning, roll call taking place ten minutes afterward, after which came a run of about a quarter of a mile and setting-up exercises. Mess time was set for half-past seven o'clock, two hours of drill following. The electrical class met at half-past eleven o'clock and at twenty-five minutes to twelve o'clock the men sat down at the mess table. From fifteen minutes after one o'clock till fifteen minutes after two, conversational French lessons were given. This instruction was provided through the Y. M. C. A. At half-past two o'clock the section returned to the telegraph room, remaining there for an hour, when it took up work in the laboratory. At half-past four o'clock telegraph practice was taken up. This lasted an hour and at six o'clock the men again sat down at the mess table.

In the telegraph room a service buzzer and the regulation pack set were used, the buzzer current being obtained by induction. Instructions in receiving were given in the morning and transmitting was taught in the afternoon. The room was in charge of a master signal electrician, the instructors being alternated in order to obtain a diversity of method teaching. Examinations were held once a week to determine the progress made by each member of the classes.

There is considerable diversity in the training. This is a photograph of the men receiving instruction in the laboratory

Considerable attention was paid to assembling and tearing apart the pack set, which is of the regulation ¼ K. W. type.

The training quarters were recently moved to the College of the City of New York, New York, where the work begun at Pratt Institute is being continued.

The activities of the Signal Corps men told of in this article are part of the plan of Brigadier-General George O. Squier, chief signal officer, United States Army, to use educational institutions throughout the country as training camps. How well the plan is succeeding is attested by the fact that many of the men in the detachment of Depot Co. H who were unfamiliar with wireless telegraphy before July 2d, when their training began, are now able to copy wireless messages at excellent speed.

Wireless Instruction for Military Training

A Practical Course for Radio Operators

ARTICLE VI

By Elmer E. Bucher

Instructing Engineer, Marconi School of Instruction

Editor's Note.—This is the sixth 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.

THE DYNAMO AND THE MOTOR

THE DYNAMO

(1) We have shown how a coil of wire placed in a magnetic field of varying strength will have an electric current induced in it, and it is immaterial whether the field is of varying strength and the coil is stationary or the field is of constant strength and the coil is moved through it. So long as there is relative motion between the coil and the field, an E. M. F. will be generated in the coil, the magnitude of which will be proportional to the rate of change of flux.

(2) We have already remarked that the machine built on the principle of revolving a coil or a number of coils of wire through a magnetic field, for the production of electromotive force, is called a dynamo or generator; and a dynamo may generate direct or alternating current. An alternating current dynamo is frequently called an alternator.

(3) We may define the **dynamo** as a machine for the conversion of mechanical energy to electrical energy.

(4) A dynamo consists in the main of a powerful set of **electromagnets,** an armature, collector rings or commutator, and brushes for conducting the electric current away from the armature coils.

(5) The coils of the armature are generally wound in slots on an iron core, and as the armature revolves (driven by an external mechanical source of power) they are filled and emptied with magnetic lines of force. At the moment that a given coil is completely emptied of lines of force, the maximum induction takes place, i. e., the current induced in the armature coil reaches its maximum.

(6) Stated in another way, when a conductor revolves through a magnetic field, the current induced therein will attain its greatest amplitude when the conductor moves at right angles to the field.

(7) When a dynamo is constructed to generate alternating current, the current is collected from the armature by brushes making contact with two brass rings which are mounted on the same shaft with the core, but if it is designed to generate direct current, a device known as a **commutator** is mounted on the shaft of the armature. The function of the commutator is to change alternating current to direct current.

(8) Dynamos are designed to have special operating characteristics according to the nature of the service in which they are employed. Direct current dynamos may have **series, shunt** or **compound** field windings. (To be explained further on.)

THE ELECTRIC MOTOR

(1) The armature of any direct current dynamo if fed with electricity from an outside source will revolve as a motor. The motor may be defined as a machine to convert electrical power into mechanical power.

(2) There is essentially no difference in the construction of a D. C. motor and a D. C. generator.

(3) Motors, as we have previously declared, are employed principally in wireless telegraphy to drive alternating current generators, and when the two units are coupled on the same shaft, the complete machine is called a **motor generator.** A motor generator therefore makes available an alternating current from a direct current source of supply, or vice versa. Occasionally, an **alternating current motor** is employed to drive an alternating current generator simply to change the frequency of the current supply. Such machines are called frequency changers.

(4) Motors may have **series, shunt** or **compound** windings according to the service in which they are employed.

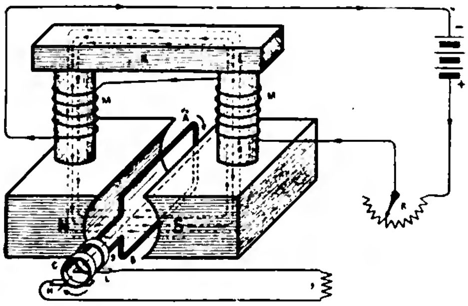


Figure 30

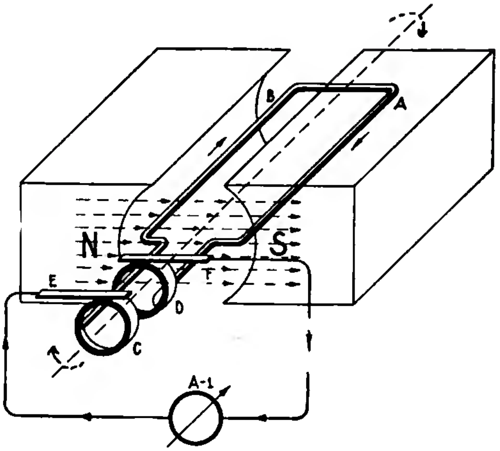


Figure 31

OBJECT OF THE DIAGRAMS

To show the fundamental working principle of the alternating current dynamo or alternator.

PRINCIPLE

A copper conductor (or a series of conductors) if rotated through a magnetic field will have an E. M. F. generated in it, and if the conductor forms a closed circuit, a current of electricity will flow.

This current will reverse its direction periodically, the number of reversals increasing as the number of north and south poles, or as the speed at which the coil rotates.

DESCRIPTION OF THE APPARATUS

In Figure 30, an electromagnet, K, with poles N and S has the windings, M, M, which are connected to a source of direct current, either a battery or storage cells or a small direct current dynamo.

A rectangle or a coil of wire, A, B, is assumed to be mounted on a shaft supported on bearings so that it can revolve clockwise through the field created by the N and S poles. The rectangle is in the neutral magnetic field.

The terminals of the armature coil, A, B, are connected to two copper or brass rings mounted on a driving shaft, but insulated from it. Two copper or carbon brushes make contact with the rings, and the external circuit, therefrom, is completed through the load, F.

In Figure 31, the rotating coil is shown in the position of maximum induction; that is to say, the A side of the rectangle is under the S pole, and the B side under the N pole. Current now flows in the external circuit in the direction shown by the arrows.

OPERATION

The coil, A, B, may be driven by a steam engine, gas engine or by an electrical motor whereupon an alternating current will be induced in the coil, which will continually reverse through the external circuit. The number of reversals per second will vary as the speed of rotation.

SPECIAL REMARKS

(1) If the coil, A, B, cuts through 100,000,000 lines of force per second, an E. M. F. of one volt will be generated.

(2) The armatures of commercial alternating current **generators** or **alternators,** as they are sometimes called, are composed of several loops of wire instead of the single loop shown in Figures 30 and 31.

(3) These loops or coils are mounted in slots on an iron core, the core revolving between the field poles, N, S.

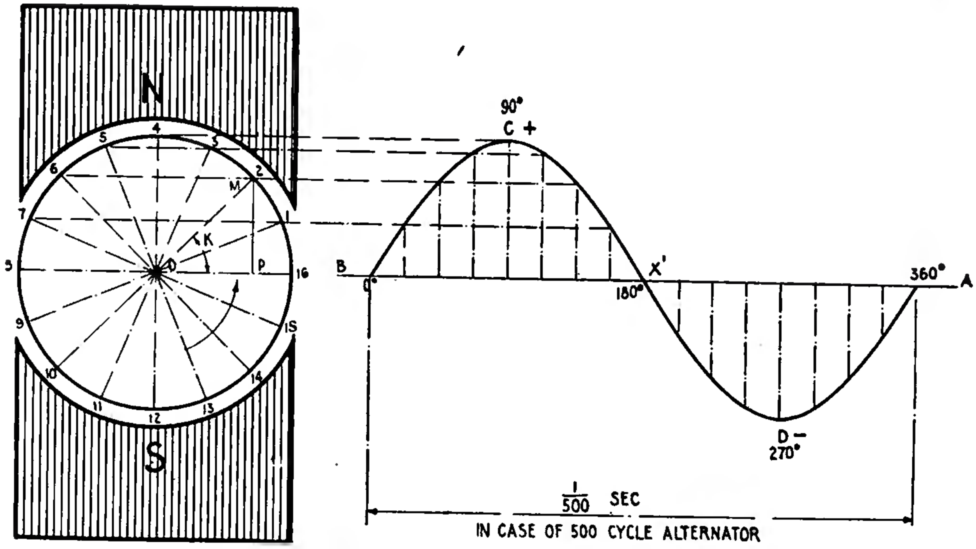


Figure 32

OBJECT OF THE DIAGRAM

To show graphically the rise, fall and reversal of an alternating current in a dynamo armature.

PRINCIPLE

The amplitude of the current generated in a dynamo armature is proportional to the sine of the angle of revolution.

DESCRIPTION OF THE DRAWING

The circle within the field poles, N and S, with the consecutive numbers 1, 2, 3, 4, 5, etc., is assumed to represent a dynamo armature having several coils mounted thereon as in modern commercial machines.

The horizontal axis, B, X′ A, is divided into fractions of a second, and the vertical axis (not shown) is scaled to represent the amplitude of the current at successive positions of the armature coil during a complete revolution.

Assuming that the armature rotates clockwise, then the position in which the rectangle, A, B, of Figures 30 and 31 will receive the minimum induction is that of the line, 16-8, and as shown by the horizontal axis, B, X′ A, the current is zero. The amplitude of the current increases gradually as the side of the rectangle takes the successive positions, 1, 2, 3, 4, the maximum cutting taking place in the position, 4-12. This corresponds to point C on the curve and represents the maximum amplitude of the positive alternation.

As the armature coil continues to revolve, taking up the positions 4, 5, 6, 7, 8, the current gradually reduces to zero, that is, in the position, 8-16. As the armature continues the revolution, a second increase in current takes place, but in the opposite direction to that of the previous maximum position, maximum induction taking place in the coil when it attains the position, 12-4, and as the coil continues to revolve, the current drops to zero when the coil is in the position, 16-8.

In the ideal case, the current thus rises and falls uniformly and the current continually reverses its direction.

SPECIAL REMARKS

(1) Not all commercial alternating current generators possess the genuine sine wave form. The maxima of the curves may be decidedly "peaky" or be more or less flat, depending upon the design of the machine.

QUES.—How are the number of reversals of current per second designated in alternating current circuits?

Ans.—By the term frequency.

QUES.—How is the frequency of an alternating current generator determined?

Ans.—In multiplying the number of field poles by the speed of the dynamo armature per second and dividing the result by two. The frequency can also be measured directly by a frequency meter.

QUES.—What effect has an increase of speed of an alternating current dynamo upon the frequency?

Ans.—The frequency will increase directly with the speed.

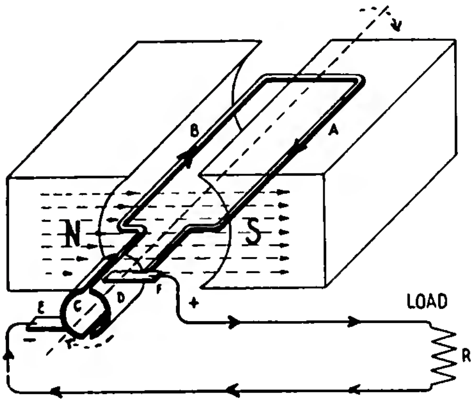


Figure 33

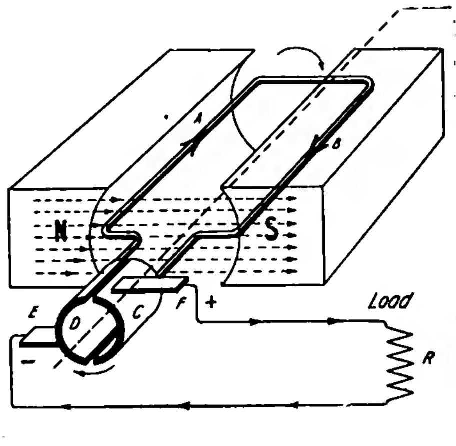


Figure 34

OBJECT OF THE DIAGRAMS

(1) Figure 33—To show how direct current can be obtained from a dynamo.
(2) Figure 34—To show the function of a simple commutator.

PRINCIPLE

By placing an appropriate device known as a commutator on the end of an alternating current dynamo armature shaft, the alternating current can be converted into a direct or uni-directional flow of current.

DESCRIPTION OF THE APPARATUS

An armature coil A, B, with the commutator, C, D, is assumed to be mounted on a shaft and to rotate in a magnetic field, as in the previous diagrams.

The commutator, C, D, revolves with the coil, A, B, and in reality consists of a split brass or copper ring mounted on the shaft and insulated from it. Brushes F and E make contact with the commutator.

In Figure 34, the coil, A, B, is shown in just the opposite position to that of figure 33.

OPERATION

If the coil, A ,B, rotates clockwise, then in the position shown in Figure 33 the current will flow towards the front in A and towards the rear in B. The brush, F, makes contact with the commutator segment, D, and the current induced during the revolution of the coil flows in the external circuit in the direction of the arrows.

As shown in Figure 34, when A, B, attains just the opposite position to that shown in Figure 33, the current flows toward the front in side B and towards the rear in side A, but commutator segment C now makes connection with brush F and brush F is therefore positive as before. Current will now flow in the same direction as previously.

SPECIAL REMARKS

(1) Commutators of commercial generators have a great number of segments which are insulated from each other by fibre blocks. The segments of the commutator, are of course, thoroughly insulated from the shaft of the dynamo.

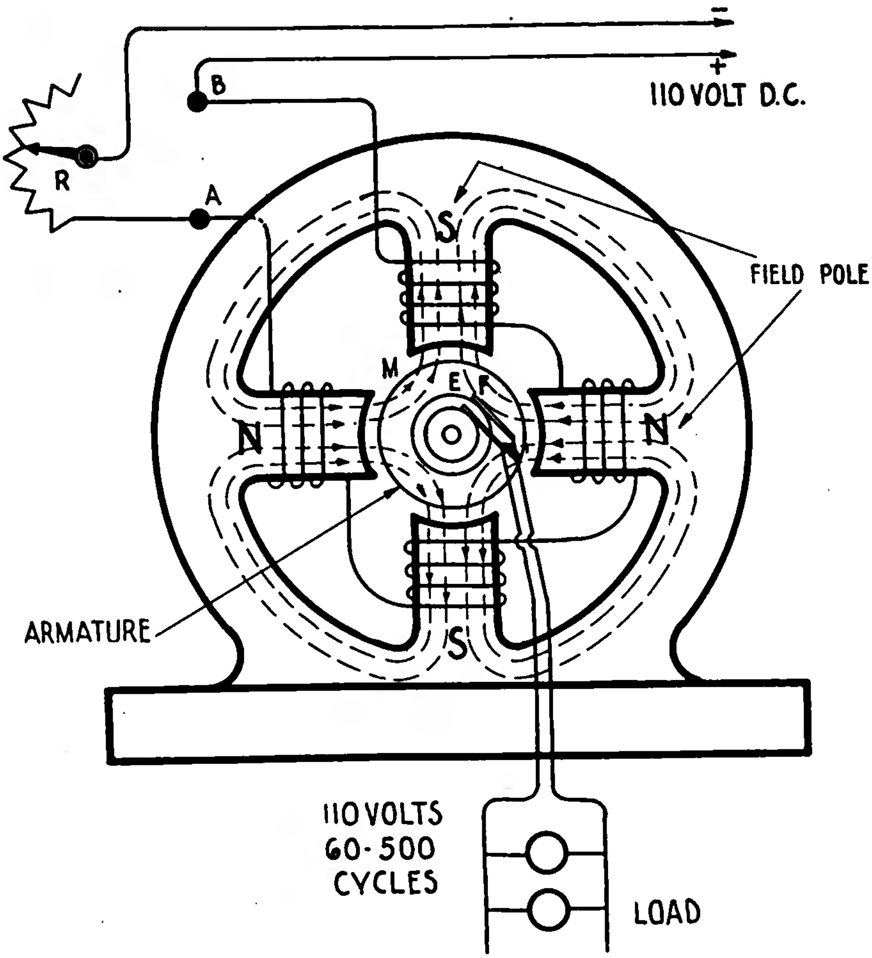


Figure 35

OBJECT OF THE DIAGRAM

To indicate the fundamental electrical and magnetic circuits of a multi-polar alternating current generator.

DESCRIPTION OF THE APPARATUS

An iron frame has the magnetic poles, N, S, N, S, which are wound alternately in opposite directions, the final terminals, A, B, being connected to a direct current source of electricity. A regulating rheostat, R, is connected in series with the field coils to control the flow of the field current The armature is indicated at M, and it is assumed to consist of a soft iron core upon which are mounted copper conductors.

OPERATION OF THE APPARATUS

When the armature, M, revolves at a uniform rate, an alternating current is induced in its coils, which is collected by the brushes, E, F, in contact with two collector rings mounted on the end of the shaft.

The armature, M, is assumed to be driven by an external source of mechanical power, either by belting or by direct coupling.

The voltage developed at the terminals of the armature varies as:

(1) The strength of the magnetic field;
(2) The speed of the armature M.

If, for instance, the armature revolves 1,800 R. P. M., and the E. M. F. is 110 volt and the speed of the armature is then doubled the E. M. F. will increase to 220 volt The voltage can likewise be increased by running the armature at a constant spee increasing or decreasing the strength of the field current at the rheostat, R. A pra tical limit would be encountered in such regulation because, as previously mentione there is a limit to the number of lines of force which can be stored up in an irc core.

SPECIAL REMARKS

(1) If the armature of Figure 35 revolves at a speed of 1,800 R. P. M., corre ponding to thirty revolutions per second, there would be 4 x 30 or 120 reversals current per second; and since **two alternations of current constitute one cycle,** th frequency of the current would be said to be 60 cycles per second.

DIRECT CURRENT DYNAMOS

(1) We have seen from previous discussions that an alternating current ge erator requires a source of direct current for excitation of its fields. Generally a sma direct current dynamo known as an exciter is employed for this purpose.

(2) It is possible, although it is not often done, to place a **commutator** on o end of an alternating current armature shaft and thus commutate or rectify a portic of the alternating current into direct current. The terminals of the field winding a then tapped across the brushes resting on the commutator, the rectified curre flowing to the field windings.

(3) The direct current dynamo or generator, once in rotation, can supply its ow field current. It is then known as a **self-excited generator,** and if the terminals the field windings are shunted across the armature brushes, it is termed a **shun wound self-excited generator.**

(4) The field coils of the dynamo may be conected in **shunt** or in **series** with tl armature, or for special purposes a dynamo may have both **shunt and series** fie windings. In this case the machine is called a **compound wound dynamo.**
(Note: The following diagrams will illustrate 3 and 4.)

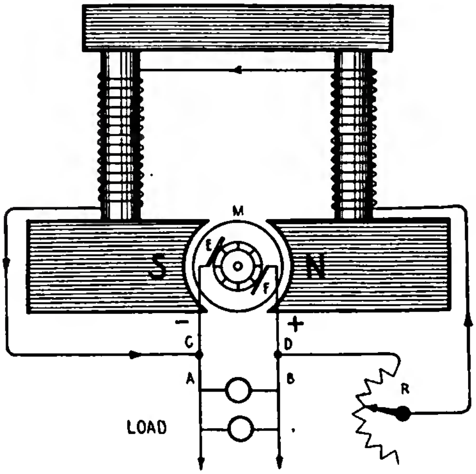


Figure 36

OBJECT OF THE DIAGRAM

To indicate in a general way the circuits of a two-pole shunt-wound direct current dnyamo.

PRINCIPLE

A portion of the current generated in a D. C. dynamo armature may flow to its field windings for purposes of excitation.

By careful regulation of the strength of the field current, the E. M. F. generated by the armature can be closely regulated.

DESCRIPTION OF THE DRAWING

A two-pole self-excited dynamo has the fieldpoles, N and S, the armature, M, and the commutator on which rest the brushes, E and F.

A variable resistance coil, R. called a **field rheostat,** is connected in series with the circuit from the armature to the field windings.

OPERATION

The generator armature, M, is assumed to be set into rotation by an external source of power.

To adjust the voltage according to load, the rheostat, R, is carefully regulated, and the brushes, E and F, set in the position of "no sparking." The latter adjustment must have particular attention, for otherwise the commutator or perhaps the armature coils will be burned.

QUES.—How is the current built up in self-excited dynamos?

ANS.—This is accounted for by the fact that a piece of iron which has once become magnetized does not, when the magnetizing influence is removed, become completely demagnetized. A small number of the lines of force remain in the core. These are known as the residual lines of force, i. e., the field poles of the dynamo are said to possess residual magnetism.

When the armature is first set in rotation, its coils cut through the residual field and thereby generate a weak electro-motive force which in turn sets up a feeble current in the field windings. This increases the strength of the magnetic field from pole to pole, which in turn generates increased E. M. F. in the armature coils. This process continues until the normal voltage of the dynamo armature is obtained.

QUES.—How can the voltage of a shunt wound dynamo be increased or decreased?

ANS.—The E. M. F., for instance, can be increased:

(1) By increasing the speed of the armature.

(2) By increase of the strength of the exciting or field current, i. e., by cutting out the resistance at the field rheostat, R.

The reverse operations noted in (1) and (2) will effect a decrease in voltage.

QUES.—What is the limit to which the two foregoing operations can be carried out?

ANS.—The speed of the armature is limited by mechanical considerations such as a safe-bearing speed and safe-centrifugal speed of the armature.

The field current in a given case is limited by the degree to which the iron will saturate, and once this degree of saturation is obtained, an increase of field current will have little or no effect upon the E. M. F. of the dynamo.

QUES.—What proportion of the current generated by the armature flows to the field windings?

ANS.—A very small proportion of the current generated by the armature is taken by the field coils. The requisite magnetizing flux for a given machine is obtained by providing a field winding of a great number of turns through which flows a weak current.

To illustrate: A 2 K. W. 110 v. D. C. machine will have a field current varying from one to three amperes, according to the load. The armature will deliver for external work approximately eighteen amperes.

QUES.—In the case of a shunt wound generator, what effect upon the voltage has an increase of the external load?

ANS.—The voltage will have a tendency to drop off as the load increases.

QUES.—How may this be compensated for?

ANS.—By an increase of the field current through the reduction of the resistance of the rheostat, R, i. e., the handle of the rheostat should be turned in such direction as to reduce its resistance. This result may be obtained automatically by a special winding known as a compound winding.

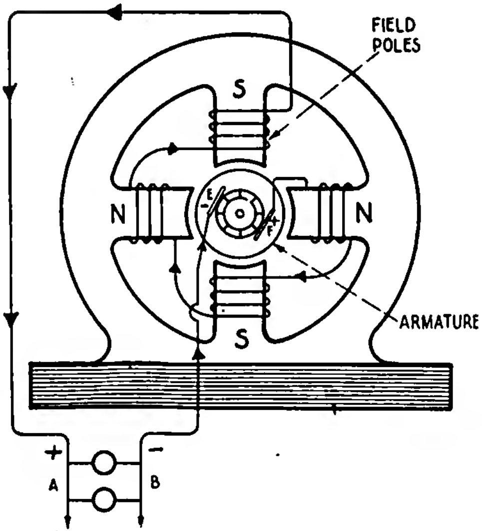


Figure 37

OBJECT OF THE DIAGRAM

To show the general circuits of a series wound dynamo.

PRINCIPLE

By causing the current generated by a dynamo armature to flow through its field windings, the dynamo can be designed to increase its E. M. F. with increase of load.

DESCRIPTION OF THE DRAWINGS

A four-pole generator with the poles N, S, N, S, has the brushes E and F, which rest on a commutator. The circuit from brush F continues through the series winding to the external circuit through the lamp and back to the brush E.

OPERATION

When the armature is in rotation, current flows from brush F through the series winding to the external circuit, provided the external circuit is closed, the circuit continuing to the negative brush, E. If the resistance at A and B be diminished the current through the entire circuit increases. Therefore the field windings will be more strongly magnetized and hence the armature will generate increased E. M. F.

The E. M. F. will increase with the load up to a certain point or until the field is fully saturated. If the load is then greatly increased, the voltage will fall off because the increase of magnetizing flux of the field will not be sufficient to compensate for the drop in voltage.

SPECIAL REMARKS

(1) A series wound generator is particularly desirable for series arc lighting where a constant current is desired with increased voltage as more lights are turned on.

(2) The voltage of a series wound generator may be regulated by cutting in and out turns at the series field winding through the medium of a multi-point switch, or by placing a regulating resistance in shunt to the series winding, thus diverting a portion of the field current.

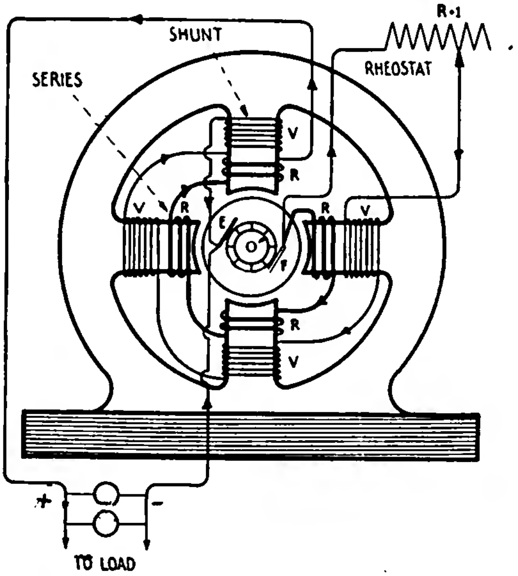


Figure 38

OBJECT OF THE DIAGRAM

To show the fundamental circuits of a compound wound generator or dynamo.

PRINCIPLE

The operating characteristics of the shunt and series wound generator may be combined in one machine.

DESCRIPTION OF THE DRAWING

A four-pole generator has a set of series coils, R, and a set of shunt coils, V, the current circulating in both windings in the same direction.

The shunt winding is tapped across the brushes of the armature and the series winding is connected in series with the brushes of the armature.

A field current regulator or rheostat, R-l, is connected in series with shunt field winding, C, for initial adjustment of voltage.

OPERATION

The initial current for field excitation is supplied by the shunt field coils. As the load on the external circuit increases, there will be a tendency with a shunt winding alone towards a drop in the voltage, but this is counteracted by the series winding. As the load increases, increased current flows through the series winding and the field flux is increased accordingly.

DYNAMO AND MOTOR ARMATURES

(1) The construction or design of dynamo and motor armatures varies widely, according to the nature of the service.

(2) It is not possible in the scope of this course to go over these windings in detail, but a few fundamental facts will be presented showing in a general way the method of winding armatures.

(3) The basic idea underlying the construction of a dynamo armature is to place its coils so as to utilize the north and south magnetic fields, connecting the armature coils in such a way that the **E. M. F. of one coil will be added to that of the remaining coils.**

(4) There are two general types of dynamo armatures.

1. **The ring wound armature;**
2. **The drum wound armature.**

The former type is now practically obsolete.

(5) In the drum type of armature the conductors lie lengthwise on the core O (Figure 38), but in the ring wound type they are wound around a circular iron frame (Figure 39).

(6) The windings of alternating current armatures are generally continuous, two final terminals being connected to collector rings.

(7) It is essential that the cores of dynamo or motor armatures be made of thin sheets of iron carefully insulated from one another, for otherwise considerable current will be induced in the iron as well as in the armature conductors. Armatures built up of thin sheets in this way are said to be **laminated.**

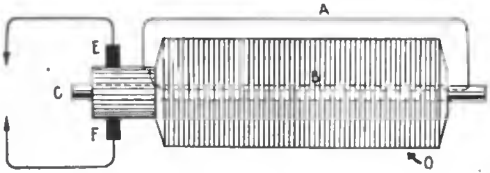


Figure 39

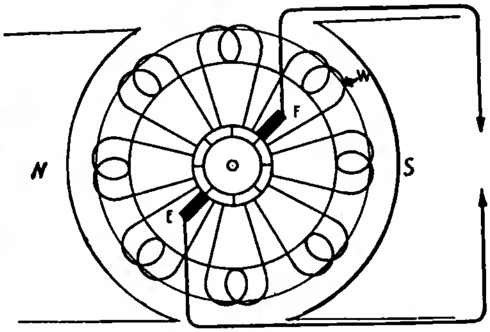


Figure 40

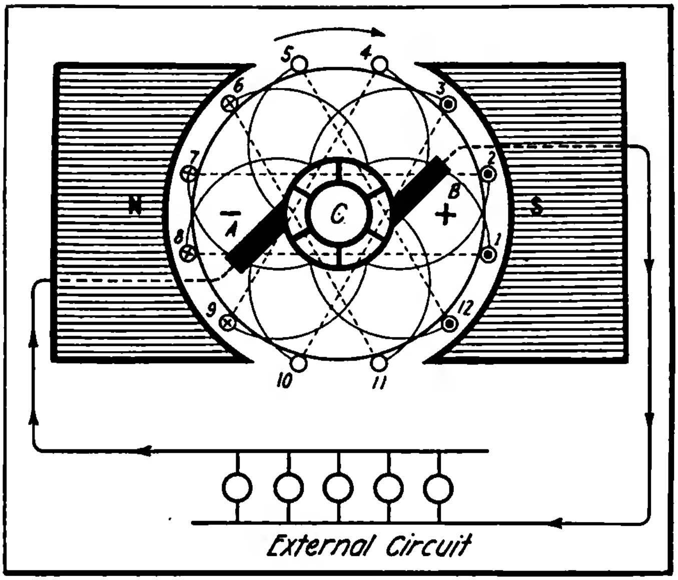


Figure 41

OBJECT OF THE DIAGRAMS

(1) Figure 39 To show the disposition of the coils upon the drum wound armature.

(2) Figure 40 To outline in a general way the construction of the ring wound armature.

(3) Figure 41 To show the actual connections of a simple drum wound armature such as may be employed in a direct current generator.

DESCRIPTION OF THE WINDINGS

(1) In Figure 39 the general shape of the core of the drum wound armature is shown at O. This core consists of a number of sheets of soft iron, properly slotted, which are mounted on the shaft C. The brushes E. F. make contact with the commutator on the left hand end of the shaft. The notations A, B show how a single coil is placed on the armature core The coil is in reality placed lengthwise in a slot cut in the iron.

(2) In Figure 40 the general disposition of the coils on a ring wound armature is shown, a single coil being indicated at W.

(3) In Figure 41 the connections of a drum wound armature are shown for a winding of twelve conductors. Brushes A and B make contact with the commutator C, the external circuit being completed through the bank of lamps.

OPERATION

(1) The following explanation applies to Figure 41. In this diagram conductors 6, 7, 8 and 9 are underneath the north pole, and conductors 3, 2, 1 and 12 underneath

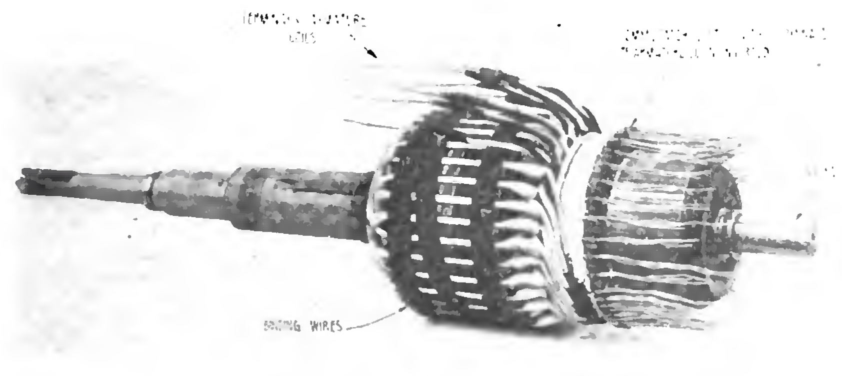


Figure 42

This photograph shows the general construction and disposition of the coils on a direct current dynamo or motor armature of the Crocker-Wheeler type. The terminals of the coil are placed in slots on the end of the commutator bar previous to being soldered. Although the coils on this armature have the general shape shown in Figure 43, *they consist of double layer windings rather than single windings, as in Figure* 43. *These armature coils lie lengthwise in slots cut in the soft iron core and are held in place by the binding wires shown.*

the south pole. If the armature revolves in the direction of the arrow, then the current flows in conductors 6, 7, 8 and 9, to the rear, and in conductors 3, 2, 1, 12, to the front.

(2) Wires 5, 4, 10 and 11 are in the neutral field, and therefore they are not acted upon inductively.

(3) It will be noticed in this diagram that all coils in each half of the armature are connected in series in such a way that the E. M. F. of one coil is added to that

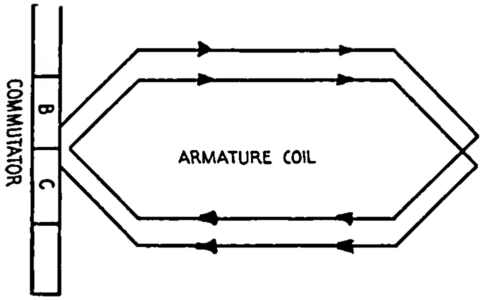


Figure 43

This diagram shows how the terminals of a single armature coil are connected to commutator segments. The complete coil, in fact, consists of two turns, and the current is seen to circulate in the same general direction throughout the coil. Frequently, two sets of such coils are placed in a single set of slots in the dynamo armature.

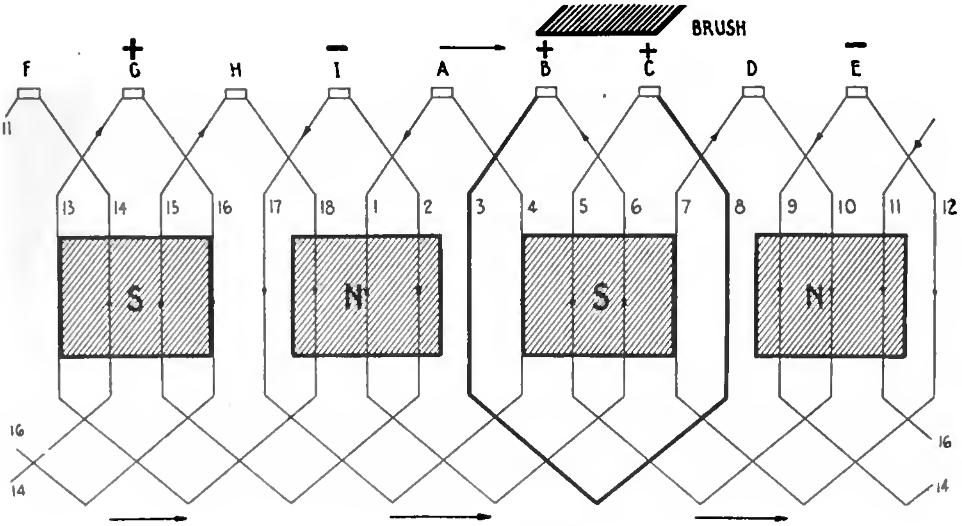


Figure 44

Showing the general outline and connections of a lap-wound direct current dynamo armature. The field poles are represented at N S, N, S, the conductors of the successive coils being numbered 1, 2, 3, 4, *etc. This armature consists of* 18 *conductors, revolving in a four-pole field. Coil* 3, 8 *is in the neutral field.*

We may trace out the direction of the induced current by starting from commutator segment 1, *one path being through conductor* 17, *through* 4, *to commutator segment A, through conductor* 1 *and* 6, *to commutator segment B. The other path is through conductor* 2, *through conductor* 15, *to commutator segment A, through conductor* 18, *through conductor* 13, *and out at commutator segment B. The current is thus seen to take two paths from the negative brush, through the armature coil, to the positive brush. A similar path is taken from commutator segment E, two paths to the brush D and to the brush G, being indicated.*

---

of the next; that is to say, the wires are joined together in such a way that the circuit is continuous. This can only be accomplished by selecting as a pitch (for the connection) a number which is one greater or one less than one-half of the total number of conductors. In this case we have selected as a pitch 5. The connections of the armature conductors at the rear are indicated by the dotted lines.

(4) The circuit may be traced out as follows

Front: wire 8 is joined to wire 3.	Front: wire 2 is joined to wire 9.
Rear: wire 3 is joined to wire 10.	Rear: wire 9 is joined to wire 4.
Front: wire 10 is joined to wire 5.	Front: wire 4 is joined to wire 11.
Rear: wire 5 is joined to wire 12.	Rear: wire 11 is joined to wire 6.
Front: wire 12 is joined to wire 7.	Front: wire 6 is joined to wire 1.
Rear: wire 7 is joined to wire 2.	Rear: wire 1 is joined to wire 8, the latter being the wire at which we began.

The next point to be observed is that this winding is in reality composed of two windings in parallel from brush to brush, as we shall presently see.

(5) Beginning with the negative brush, we may trace the circuits in two directions; one path leads to wire 5, the other to wire 10.

The following paths will be noted:
5-12-7-2-9-4 positive brush;
10-3-8-1-6-11 positive brush.

(7) That is to say, the current flows in the armature coils in both paths away from the negative brush and towards the positive brush.

(8) It is well to keep in mind that this diagram represents the simplest possible type of drum wound armature and that many other types are in commercial use. Careful study of this diagram will reveal the function of the commutator.

(*To be continued*)

A Digest of Electrical Progress

The Experiments of Marconi's Predecessors in Attempting to Establish Wireless Communication and How Marconi Found the Road to Success—Early History of Land Line Telegraphy and Cable-Laying—Using a Pliotron Oscillator for the Production of Large Currents at Radio Frequencies—The Movement to Establish the American Academy of Engineers

WIRELESS AND EARLY SYSTEMS OF TELEGRAPH COMMUNICATION

IN an article entitled "Wireless Points and Pointers," in *The Railroad Man's Magazine,* Samuel W. Beach shows that although many scientists conducted investigations with a view to establishing communication without wires, none succeeded until Marconi announced his discovery of electric wave telegraphy. The experiments of his predecessors were mainly confined to earth current and electrostatic induction systems, and although Hertz in his early work proved the existence of electrical waves, his apparatus could by no means be applied to communication, even over distances of a quarter of a mile.

The writer asserts that Hertz not only did not grasp the true value of his work, but he actually smiled at the suggestion made by the engineer, Huber, that his electrical waves might be harnessed and employed for signalling through space.

After citing experiments made by other investigators, among them Maxwell, Lodge and Branley, he says:

> "What Sir Oliver Lodge failed to get, another man there was who eagerly grasped it. He was just a youth, looking none too healthy, and with a nervous temperament. He was an Italian immigrant—born in Bologna, April 25, 1874, of Irish-Italian parentage. It is said that he looked like anything other than a great inventor when he wandered into the office of Sir William Preece, in England, and introduced himself as Guglielmo (William) Marconi.
>
> "Fortune not only smiled, but literally laughed upon this wonderful man from the very start. With the willing assistance of Preece, Marconi's ideas and apparatus grew apace so rapidly that it stuns the mind to read of it."

The writer declares that on September 12th, 1901, Marconi and an assistant, Kemp, received at a station at Signal Hill, St. John's, Newfoundland, the letter S many times repeated sent by a station at Poldhu, Cornwall, 1,800 miles distant across the Atlantic ocean. He says:

> "So rapidly did wireless advance that at eight o'clock on the morning of December 9, 1916, the big wireless station at Arlington, Virginia,

> distinctly heard Japan working with Honolulu. The distance lacks but a few degrees of being half-way around the globe.
>
> "Marconi first spanned the big pond without wires. Other inventors, plenty of them, such as Fessenden, deForest, Slaby, and Shoemaker, have done wonders; but the name of Marconi shall outlive them all."

Mr. Beach declares that Morse's supposed priority in the invention of land line telegraphy is generally misunderstood. He says that the wire telegraph system first saw the light of day at Geneva, Switzerland, some two or three years before the battle of Bunker Hill, and at least twelve telegraph lines are said to have been in fairly successful operation in Europe when Morse sent his famous message to Washington in 1844. But notwithstanding the fact that Morse's apparatus was built from theories already advanced, it so outclassed the apparatus of his predecessors that all other schemes sank into oblivion.

The cable laid by Cyrus W. Field was not the first to span the Atlantic, Mr. Beach asserts. He declares that the cities of Dover, England, and Calais, France, have the distinction of having been the terminals of the first submarine cable, which was laid in 1844. It was approximately twenty-five miles in length, and was operated for almost twelve years before repairs were necessary. Field's first cable between Trinity Bay, Newfoundland, and Valencia, off the coast of Ireland, ceased to work after it had been in operation sixteen days, but its usefulness was thoroughly proven, for one cablegram alone during this period saved the English government more than $250,000.

Among the humorous instances of attempted telegraphic communication, that of the eminent Spanish electrician, Don Francisco Salva, in 1795, is perhaps the most amusing. Salva advocated the construction of a telegraph line between Barcelona and Mataro, which was to consist of forty-four wires, that is, twenty-two complete metallic circuits. Mataro was to be the receiving station, and twenty-two men were to be stationed there, each grasping the broken end of the metallic circuit. Each circuit stood for a particular letter of the alphabet and the signals were to be sent by discharging a Leyden jar into whatever circuit bore the particular letter to be signalled. This was expected to throw a shock into the human sounder at the distant terminal, who bawled out the letter which had been apportioned to him.

It is generally recorded that Professor C. A. Steinheil of Munich first discovered the feasibility of using the earth for the return circuit in wire telegraphy. But it is fully established that the conductive properties of the earth were known many years before Steinheil's work. In fact, Aldini, as early as 1803, used the waters of Calais harbor for the return circuit.

A PLIOTRON OSCILLATOR FOR THE PRODUCTION OF LARGE CURRENTS AT RADIO FREQUENCIES.

STUDENTS of radio communication are thoroughly familiar with the use of the pliotron evacuated bulb of the General Electric Company as a detector and amplifier of radiotelegraphic signals. They are also aware that such bulbs may be employed to convert direct current into alternating current of any desired radio frequency, but they rarely have an opportunity to see published a detailed diagram of its connections or the constants of the circui specially suited for a given service. Especial interest, therefore, attaches to recent article by William C. White in the *General Electric Review.*

The writer points out that in a resonance circuit the current will rise unti the losses become equal to the input energy, but with practical circuits the lowe limit of power-factor obtainable is about one-half of one per cent. This permit the maximum resonance current produced to be about 200 times the value o the true energy current fed into the resonance circuit. In consequence, i large currents are desired from a small quantity of energy, the total volt-ampere of the circuit must be kept small. This condition requires that for such a resonance circuit, a large capacity and small inductance must be used. Again, i the amount of electrical energy which can be furnished by a certain source i limited by the definite amount of primary power available, or by the losses i transmission, it is important that the resistance of the load be adjusted to th voltage so that the energy will be economically utilized. This implies that th resistance of the heavy current circuit must give an apparent value most suitabl for insertion in the pliotron anode circuit.

Two methods are shown by which a single pliotron bulb can be made t generate either a heavy current or a high voltage current at radio frequencie for calibration purposes.

In Figure 5, the complete circuits of the pliotron bulb are shown inductivel coupled to a resonance circuit, including a calibrated ammeter, A, and a secon Ammeter, A^1, which has been inserted for calibration, and as usual the frequency of the circuit, L 3, C 3, A^1, A, is determined by the usual resonanc equation:

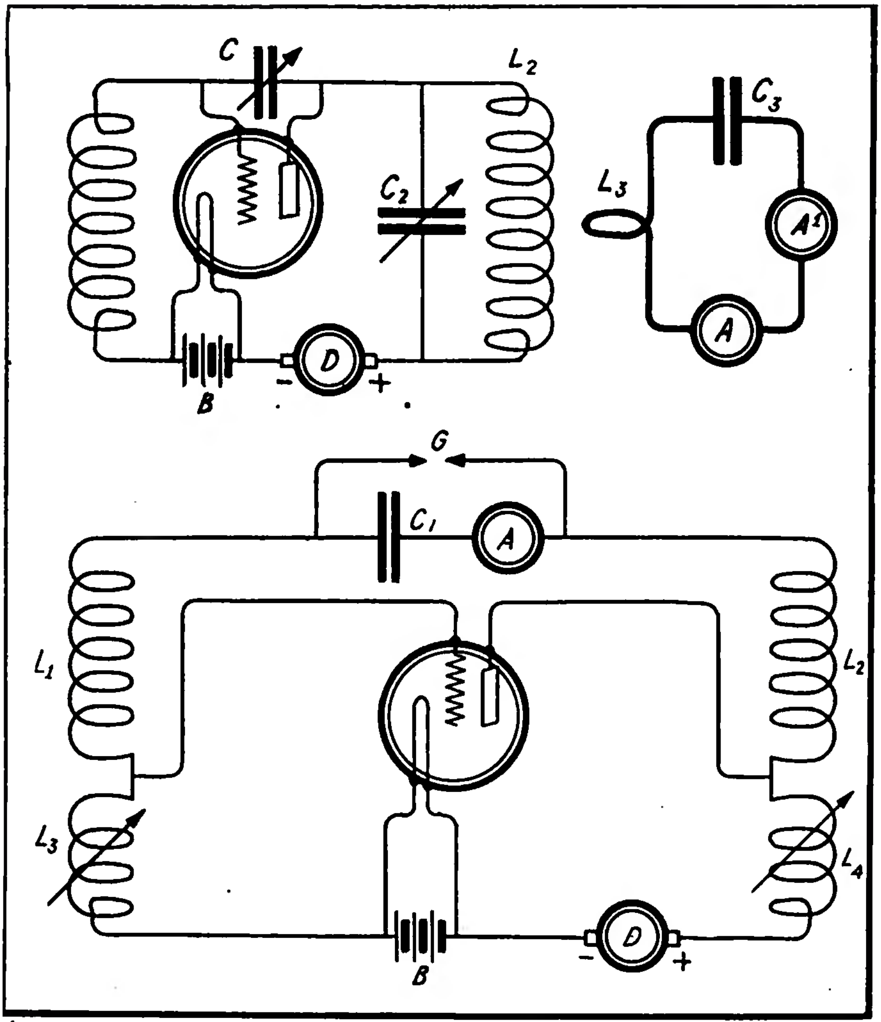
$$N=\frac{1}{2\,\Pi\,\sqrt{L\,C}}$$

It is important in a case of this kind that the inductance value of L3 b made the minimum possible; usually it consists of one or two turns of heav conductor and, therefore, the value of the condenser, C3, must be of the orde of 0.1 microfarad.

By proper adjustment of the inductance of L1, L2, and the capacity o the condenser C1, the pliotron circuit of Figure 5 can be made to set up a hig frequency current having a frequency corresponding to the period of the heav current circuit. Because of the relative values of the inductances, L2 and L3 the apparent resistance in the plate circuit is greatly multiplied, but this is no sufficient to absorb all the available energy, and to increase this apparent resistance further, a variable capacity, C2, is shunted about the inductance L2.

The output of the circuit indicated in Figure 5 is dependent upon th voltage of the direct current source, and the useful range has been found to b between 200 and 750 volts. With this arrangement, current can be obtaine at frequencies of from 100,000 to 1,000,000 cycles per second. It is declare that pliotrons may be operated in parallel to produce a current larger than tha obtainable from a single bulb.

The circuits of the pliotron oscillator for the production of high voltage at radio frequencies are shown in Figure 6. Here the inductances, L-1 and



Figures 5 *and* 6

L-2, are approximately eight millihenries each. Inductances L3 and L4 are of approximately 2.5 millihenries. They should be, if possible, of the variometer type, but a simple coil fitted with a number of variable contacts will be satisfactory. As usual, the direct current dynamo is indicated at D, the high voltage condenser at C1, and the spark gap at G. The capacity of C1 should lie between twenty and 200 microfarads for a frequency of 100,000 cycles. Through use of a hot wire ammeter, A, and knowledge of the frequency, the voltage produced across the condenser, C, may be simply calculated.

If the values of the inductance and capacity are properly proportioned for a frequency of 100,000 cycles, and the voltage of the dynamo lies between 200 and 750 volts, voltages up to 12,000 may obtain. It is further mentioned that two metal plates, 10 inches by 10 inches, placed approximately ½ inch apart, will afford a condenser having a capacity of approximately forty microfarads.

It is difficult to say in how many ways the pliotron bulb will lend itself to practical application, but present indications point to the fact that it will be an indispensable adjunct to the laboratory of the modern radio experimenter.

THE AMERICAN ACADEMY OF ENGINEERS

IN order that the United States Government may have an able body of engineers to act in an advisory capacity as occasion arises a bill recommending the incorporation of an institution to be known as the American Academy of Engineers was recently considered in the United States Senate. The establishment of this body has been under consideration for eight years, and due to the present national crisis, its immediate organization was urged by prominent engineers throughout the country.

The objects of the organization may be summed up as follows:

1. To render loyal and effective service to the United States Government so far as lies within its power.

2. To advance in every legitimate manner the interests and welfare of the engineering profession in all its numerous branches.

Limited to a membership of 200, we find among the names of the fifty original incorporators, such men as Dr. John J. Carty, chief engineer of the American Telephone and Telegraph Company; Howard E. Coffin, vice-president and chief engineer of the Hudson Motor Company, and member of the Naval Consulting Board; Dr. John J. Hammond, past president of the American Institute of Mining Engineers; Herbert C. Hoover, food administrator of the United States Government; Dr. Elihu Thomson, past president of the American Institute of Electrical Engineers; Dr. M. I. Pupin, member of the National Academy of Science and Professor at Columbia University; Frank J. Sprague, past president of the American Institute of Electrical Engineers; Dr. William Barclay Parsons, consulting civil engineer, New York City.

One of the articles of incorporation specified:

> "That the American Academy of Engineers shall, whenever called upon by any department or establishment of the government, investigate, examine, experiment, and report upon any subject of engineering science or art, the actual expenses of such investigation, examination, experiment, and report to be paid from appropriations which may be made for the purpose; but neither the Academy as a body or any of its committees shall receive any compensation whatever for any service to the government of the United States."

Dr. C. O. Mailloux, past president of the American Institute of Electrical Engineers, wrote a stirring letter to Congress, saying that an institution developed in France along similar lines, known as the Academy of Agriculture, had been established with beneficial results to the government. During the last two years, he said, efforts have been made to establish in France a federation of engineers, architects, and technologists with the object of insuring a better co-ordination of and co-operation among the different branches of applied science. So far the efforts to bring together this organization had not borne fruit.

From and For those who help themselves

Experimenters' Experiences.

FIRST PRIZE, TEN DOLLARS

Instructions for Designing a Step-Down Transformer

No wireless amateur who wishes to succeed can limit himself to the construction of a wireless telegraph equipment alone. He should, in fact, investigate other branches of electrical practice, because as he will see sooner or later, the operation of modern wireless telegraph apparatus is based on certain fundamental electrical principles. Moreover, the commonly used wireless telegraph equipment is made up of certain parts which were well known to the electrical trade previous to the advent of wireless telegraphy.

One of the pieces of apparatus for which the average electrical experimenter often has great need is a step-down transformer, but to date very little data giving instructions for its construction have been published. The purpose of this article is to describe such a transformer in terms simple enough to satisfy the most inexperienced amateur. Moreover, this transformer, when completed, will have a wider range of power, that is, it will be more flexible than the type ordinarily supplied to the amateur market. Its cost will also be less.

In calculating the frequency of a transformer, it is necessary to take into account numerous factors, either contributing to or against perfection. A far-reaching discussion of this point is beyond the scope of this article, but after considering the sum of all the defects in the average amateur-built instruments, it is safe to predict an operating efficiency of ninety per cent., that is to say, the secondary winding will give ninety per cent. of the total energy taken in at the primary winding.

The transformer is designed to have a maximum output of 250 watts (¼ K. W.) and it is clear that in order to have an efficiency of ninety per cent. the total required input will be 275 watts. It is expected that this transformer will be connected to a 110-volt supply of alternating current; therefore, to determine the size of wire necessary to carry the primary current, without heating, the simple formula amperes=watts÷volts is used.

If we assumed 275 watts as the input, then the required current would equal 275÷110 which is 2.5. To determine the size of wire to carry this current, we must multiply by 1,000, that is, 1,000×2.5=2,500 which is the cross sectional area of the copper wire required to handle the current of 2.5 amperes. By reference to a standard wire table, we find that No. 16 wire has the requisite current-carrying capacity.

In calculating the size of the secondary winding, identically the same method is employed. If the builder expects the transformer to have a maximum output of 250 watts, with the highest step giving fifty volts, he will have to wind the secondary with wire large enough to carry five amperes, because 250÷50=5. Multiplying five by 1.000 equals 5.000 circular mils which is the cross sectional area of the required wire. Again, referring to the wire table, it will be found that No. 13 wire is called for.

We have mentioned that in order to obtain an efficiency of ninety per cent. an input of 275 watts is required; therefore the difference between this and the output or twenty-five watts must be lost somewhere in the process of transformation. This loss is due to eddy currents, hysteresis in the iron core and heating of the windings.

Laboratory investigations have shown that about forty-five per cent. of the total or 11¼ watts, are due to the first two of these losses of which seventy-nine per cent., or 8.89 watts, are accredited to hysteresis alone. This latter loss, 8.89 watts, is called the iron loss and the core must have sufficient volume to dissipate this amount. The standard practice is to allow 0.15 watt loss to each cubic inch of core. Therefore, to find the required volume of iron we divide 8.89 by 0.15, which gives fifty-nine cubic inches. This loss is calculated upon the presumption that the core was built up of shellac insulated iron laminations.

The writer's attention has been called to the fact that some of the large manufacturers of transformers place their iron in a brine solution in order to put a coat of rust on it. This is a simpler method and should give as good results. In the construction of transformers it has been my custom to use No. 28 stove pipe iron for the core. This can be picked up in any tin shop out of the scrap. The shellac, or rust, is used to prevent excessive losses due to eddy current being induced in the core.

No hard and fast rules can be laid down for designing the core, but it must be made long enough to accommodate the windings and wide enough to prevent the coils touching in the center space. The core should not be extremely long as it would tend to increase the reluctance of the magnetic circuit, although it would require an excessive number of turns on the winding which is detrimental to efficient operation. A good plan is to keep the core nearly square, never allowing the length to exceed greatly the width. A convenient size for the transformer under discussion is 9 inches by 7 inches outside dimensions, with a cross section of 1½ inches by 1½ inches. The core will then have a total volume of 58½ cubic inches.

In assembling the core of the transformer, start with the long leg, that is, the pieces 9 inches by 1½ inches. Then place on this a piece 6 inches by 1½ inches, leaving a space of 1½ inches at each end. This space will take the ends of the short legs which are laid crosswise. Lay up enough pieces alternately 9 inches by 6 inches until a pile of 1½ inches is obtained. These should then be pressed tightly together with a clamp, and wound with two layers of friction tape.

One half of the total number of turns of wire in the primary is wound on each leg. The required number of turns is found by using the formula:

$$\text{Turns} = \frac{\text{Voltage} \times 10^8}{4.44 \times F \times f}$$

where 4.44 and 10^8 are constants. In this case, the voltage is 110, the frequency, f, is 60 cycles. F refers to the flux or the number of magnetic lines of force passing through the core. This quantity is obtained by multiplying the cross sectional area of the core (1½ inches by 1½ inches) by the maximum flux per square inch. The standard flux for sixty cycle work is 30,000 lines per square inch. Then 1½ by 1½ by 30,000 =67,500. Substituting in the above formula, we have

$$\text{Turns} = \frac{110 \times 100{,}000{,}000}{4.44 \times 67{,}500 \times 60} = 612$$

Care should be taken to wind the primary coil on each leg so that the current will travel around the core in the same direction; otherwise the current in one leg will oppose that in the other, and the transformer will not work.

In my estimation the best way to wind a transformer by hand is to clamp the core in a vise, fastening one end of the wire on the core and leaving a lead about 1 foot in length. The core should then be wound to the right. Both legs are wound in the same direction. After the primary and secondary windings are made complete, the core construction is completed by adding two short legs. The inside or the starting leads of the primary winding are then connected together.

We have stated that No. 13 wire was required to give an output of fifty volts and five amperes. Theoretically, a different sized wire could be used for each step in voltage to keep the ampere high enough to give the maximum output in watts. This is done, however, only in special cases. In this design the output in watts is divided by the highest step in voltage, and the same sized wire is used throughout all steps.

The next step in the order of construction is to find the number of turns for each step in voltage and output from the secondary. This is obtained by the following formula:

$$\frac{\text{Volts input}}{\text{volts output}} = \frac{\text{turns on secondary}}{\text{Turns on primary}}$$

substituting, we have

$$\frac{110}{50} = \frac{612}{X}$$

therefore X=279 turns.

This is the total number of turns required to give an output of fifty volts and five amperes. Whatever voltages the builder requires may be figured out in the same way, taps being taken off the windings to include the number of turns shown by the calculation.

The number of turns for a very good run of voltages are given in the following table:

Steps	Turns	Volts
1 to 5	279	50
1 to 4	223	40
1 to 3	167	30
1 to 2	139	25
2 to 5	140	25
2 to 4	84	15
2 to 3	26	5
3 to 5	112	20
3 to 4	56	10
4 to 5	56	10

Before winding the secondary, the primary should be covered with two layers of empire cloth. Also it should be noted that half of the secondary is wound on each leg over the primary. It should be wound so that the number of turns will work out so that the inside or starting end on one leg will be connected to the inside end on the other leg. This transformer can have a special winding for a particular amperage by winding a separate coil on the short legs.

I am sure that an amateur building a transformer after this design will have one that will give perfect satisfaction.

J. E. MacGregor, *Michigan.*

SECOND PRIZE, FIVE DOLLARS

Novel Capacity Tuning Which Has Proven Successful

The article in the July issue of The Wireless Age on "Novel Design in Receivers," interested me considerably because I have been working along similar lines. My developments originated from another experimenter of New York City and I have further amplified their use in conjunction with regenerative vacuum valve circuits. The scheme has proven very efficient both in selectivity in tuning and in amplifying radio-frequency currents.

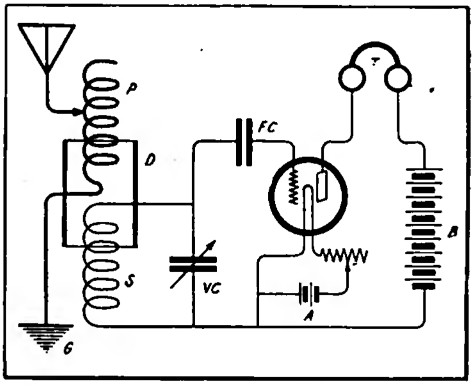


Figure 1—*Second prize article*

A wiring diagram similar to that of Elmer E. Bucher's was used, but it did not seem to increase the audibility of signals as mentioned in the article referred to. For this reason another arrangement of circuits was adopted, i. e., the principle of capacity coupling was utilized for coupling the wing circuit to the grid circuit of the valve. Accompanying this article is a photograph of the capacitively-coupled tuning coil which has been used in these experiments, and in addition three circuits which have proven very satisfactory. The explanation for each individual circuit will be gone over for the benefit of those who desire to investigate further.

The first of these circuits is shown in Figure 1. The metal disc, D, placed

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over the two windings of an inductive coupler, travels back and forth at a distance from the coil by mounting it over a sliding rod, as shown in the photograph. The inductive coupler used in this experiment consisted of two windings, each wound side by side on the same core. It was found that by tuning the primary of the coupler to the required wave-length of the received signal and then carefully coupling the two circuits electrostatically that is, adjusting the metallic disc, D, between the two circuits, increased strength of the signals was obtained. This was probably due to the increase of coupling between the circuits, thus increasing the energy transformation.

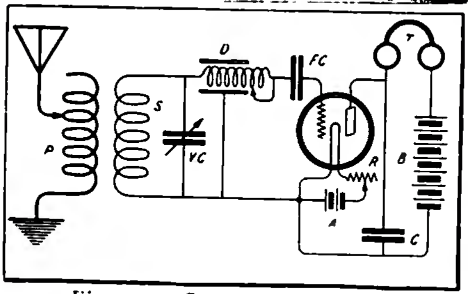

Figure 2—Second prize article

This circuit was found to be of considerable value in preventing interference. Arc light disturbances were lessened to such an extent that the circuit is strongly recommended to those who are constantly experiencing this interference.

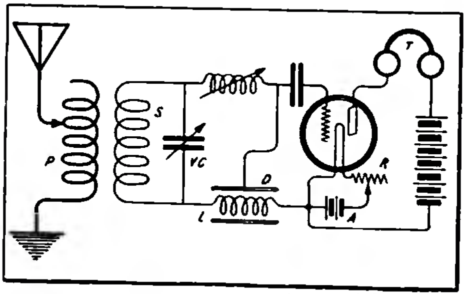

Figure 3—Second prize article

If a regenerative circuit is employed, such as shown in Figure 2, it is found that by placing a metallic disc, D, over the tuning coil, L, the adjustment for the oscillating condition could be more readily found. It was further observed that outside capacity efforts were unable to disturb the oscillating condition of the system, as is frequently found to be the case in ordinary regenerative circuits.

A circuit somewhat similar is shown in Figure 3, where the tuning coil, L, is linked in series with the filament terminal of the valve. Although this scheme did not prove to be an efficient amplifier, it was an excellent oscillator and was therefore used mostly for undamped wave reception. The usual metallic slider, D, was employed.

It is hoped that these circuits will some day find their way into the modern amateur's station. He will certainly find them of great assistance in long-distance reception.

A photograph of the tuning coil used in the experiments described in the second prize article.

SAMUEL COHEN, *New York.*

Editorial Note.—Fully appreciating the writer's early work in this direction, we suggest that he note the date of the specification granted to Elmer E. Bucher on electrostatic tuning.

The conditions brought about in the amateur field as a result of the war provide contributors to this department with excellent opportunities to evolve ideas for articles.. It is fairly well established that in the battle fields abroad emergency apparatus must be constructed of whatever material may be available. The ingenuity displayed by experimenters in putting together apparatus should not only give valuable suggestions to signal men, but there may appear in these pages at some time the exact solution of a problem confronting the soldier in the field.

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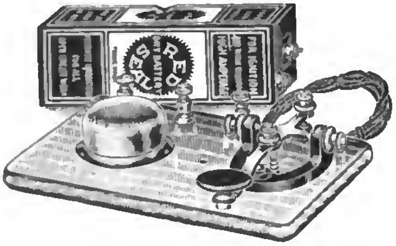
IT is within the range of possibility that the uninformed amateur experimenter may unintentionally violate the President's executive order in regard to dismantling his wireless apparatus. The following communication from the United States Navy Department calls for attention on the part of the members of the N. A. W. A.:

> It has come to the notice of the Navy Department that the President's executive order which called for the dismantling of private radio stations, has been misinterpreted by many experimenters, publishers, and amateurs.
>
> By dismantling is meant *the complete disconnection of all pieces of apparatus and antennae, and the sealing and storing of same.* Apparatus which is not dismantled as outlined above is subject to confiscation.
>
> A number of articles have been published urging experimenters to use phantom antennae for experimenting and improving their equipments. In order to do this the experimenter must connect up his apparatus and this is contrary to the dismantling order.
>
> Will you please bring this to the attention of your large number of readers in order to enlighten them as to what is meant by the President's order relative to the closing of all private radio stations.

The precautions taken by the Navy Department to prevent hostile radio communications are entirely in order, and it behooves all experimenters to co-operate with the Government and comply with the President's order to the smallest detail. It is clearly evident that amateurs who attempt to rebuild or improve their apparatus take the risk of meeting with punishment and having their equipments confiscated. Note that by dismantling is meant "the complete disconnection of all pieces of apparatus and antennae and the sealing and storing of same." Obviously, apparatus under construction comes within the scope of this order. Therefore the members of the N. A. W. A. and other experimenters are not only directed to discontinue the construction of such apparatus, but they are also urged to avoid building apparatus that is in any way suggestive of a radio telegraph set.

There is nothing in this order of the Navy Department, however, which prevents the amateur from studying wireless from a practical or engineering standpoint. In fact, as we have repeatedly brought to our members' attention,



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present conditions offer them an unusual opportunity for improving their knowledge of the art. They are advised to follow the instructional articles appearing in this magazine and to purchase text books bearing on the subject. Not only will they be better equipped to operate their own apparatus when the time comes, but in the event that emergencies demand it, they will be able to serve their country better as wireless telegraphers.

The Army and Navy Departments require hundreds of expert radio telegraphers—men who have the ability to co-ordinate theory and practice. Some have natural ability along these lines, while practice is required to develop it in others.

Military affairs are engaging the attention of N. A. W. A. members more than ever, and it would seem from the communications received that the rating of army and navy officers is one of the least understood subjects. The ranks of the various officers in relation to each other are shown as follows:

Army.	*Navy.*
General	Admiral
Lieutenant-General	Vice-Admiral
Major General	Rear-Admiral
Brigadier-General	Commodore
Colonel	Captain
Lieutenant-Colonel	Commander
Major	Lieutenant-Commander
Captain	Lieutenant
First Lieutenant	Lieutenant (Jr. Grade)
Second Lieutenant	Ensign

No one at present in the United States Army holds the rank of general. This rank exists only when specially created by Congress, and so far has been filled but four times in United States history. The title of admiral was only conferred once, when it was given to George Dewey by special act of Congress.

Since the President's declaration of war, schools of wireless instruction have been opened in numerous cities. Some were instituted by private individuals and others were established under government supervision. While amateurs throughout the country constitute a great part of the students of these schools, many who enrolled had not heretofore been engaged in signalling work of any sort. The land line telegrapher, too, while quick at the telegraph key, is frequently unable to grasp the technical details of radio apparatus. He finds that although knowledge of land line telegraphy is by no means unimportant, the wireless operator's curriculum includes considerably more than ability to manipulate the telegraph key.

One of the errors made by some students is their attempt to master the manipulation of wireless apparatus without knowledge of elementary electricity and magnetism. Others, possessing more foresight, take up elementary work and slowly but surely master the rudiments of the art; thus working on a solid foundation they find themselves easily able to qualify as operators.

The student located far from a training school is at a disadvantage. He does not find it difficult to master the transmission of the code signals; in fact, he could learn to send the code characters with two or three days' practice, but when it comes to the matter of receiving, he will find himself in need of a second student who will send to him slowly until he is able to recognize the characters transmitted. In case such a helper is not available, an automatic sender can be resorted to, but the difficulty with a transmitter of this type is that one soon becomes familiar with the words on the record, and consequently can form the complete word or sentence before it is finished. This does not give actual practice, but, of course, if a number of records are available, the difficulty can be partly overcome.

Experience teaches that once the experimenter has gained a certain speed, the services of a competent instructor are necessary if further progress is to be attained. It should not be difficult for the average student to find a land line telegrapher who, with a few days' practice, can master the Continental code characters and send to the student for hours at a time until the latter becomes proficient in receiving signals. Steady application and daily practice over a period of, say, five months should qualify the average student to become a capable Continental code telegrapher.

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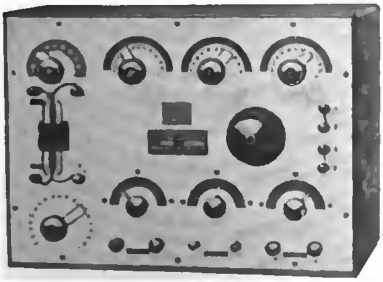

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Positively no Questions Answered by Mail.

N. A., Philadelphia, Pa.:

We do not clearly understand your communication of recent date with reference to the proposed method of varying the inductance of the secondary winding of a receiving transformer. It is not absolutely necessary to adjust the inductance of this circuit by single turns. In fact, if a shunt secondary condenser is employed, taps can be taken from every tenth or fifteenth turn. Whether or not your device has merit we cannot say unless we see a detailed diagram showing how it functions.

* * *

H. J. H., Atlantic City, N. J., inquires:

Ques.—(1) What size wire do you consider to be the best for connecting up transmitting and receiving apparatus for wireless telegraphy?

Ans.—(1) The low voltage alternating current power circuits should be connected up with No. 12 or No. 14 single braid rubber covered wire. The circuits of radio-frequency such as the condenser, spark gap and oscillation transformer should be connected together with stout stranded copper wire or copper tubing. The receiving apparatus may be wired up with rubber covered annunciator wire which possesses sufficient conductivity for this work. The connections from the oscillation transformer to the earth lead of the transmitting apparatus should be made of copper ribbon, if possible.

Ques.—(2) Will a flat top antenna have greater efficiency in sending and receiving if it is slanted a few degrees out of the horizontal?

Ans.—(2) It is doubtful whether slanting it will make any difference.

Ques.—(3) Please explain how a wave-meter can be used to tune receiving apparatus.

Ans.—(3) This method is fully described in the textbook, "Practical Wireless Telegraphy." A wave-meter is set into excitation by a buzzer and battery and its inductance coil is placed in inductive relation to the earth lead of a receiving set. The wave-meter now becomes a miniature transmitting set which acts inductively upon the receiving set. The wave-meter is then set at a particular wave-length, following which adjustments are made of the inductances and capacities of the receiving set until maximum response is obtained. The wave-length of the receiving set obviously is that of the wave-meter. To make such calibrations with a fair degree of accuracy, the coupling between the wave-meter and the circuit under measurement should be as loose as possible.

* * *

K. R. A., Newark, N. J.:

The best electrolytic interrupters are made by immersing a lead plate with a piece of platinum wire in a diluted solution of sulphuric acid, the amount of acid employed depending upon the voltage of the current and the rate of interruption desired. It is customary to insert the platinum in a porcelain tube and provide means whereby the amount of platinum exposed to the acid can be carefully regulated, that is to say, the electrode can be raised or lowered by a thumb screw adjustment.

One concern manufactured, several years ago, a very satisfactory interruptor, which, instead of employing a platinum rod for the anode, used a long piece of German silver wire. This was fed through the porcelain sleeve by a long spiral spring and at the bottom of the tube the German silver wire rested upon a porcelain button. The amount of German silver exposed to the action of the acid was governed by a small regulating screw which raised and lowered the porcelain sleeve.

Two disadvantages arise in the use of the electrolytic interruptor, one being that it will become overheated unless it is water jacketed, and the second that it is somewhat dangerous to operate. In several instances violent explosions have occurred, due to the accumulation of hydrogen gases, but if the interruptor is placed in a closet at a distance from the apparatus being operated, safety is assured. It is possible to secure an extremely high rate of interruption with this device, particularly when di-

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rect current is employed, but the electrolytic interruptor will not function well on voltages of less than eighty volts.

* * *

A. C., Paris, France, inquires:

Ques.—(1) You will note from the diagram of a receiving set accompanying this query that a telephone transformer is shunted around the blocking condenser in the local circuit, and the secondary winding of the transformer is connected to a telephone. Would this arrangement increase the strength of signals? If so, please state the dimensions of the transformer suited for this purpose.

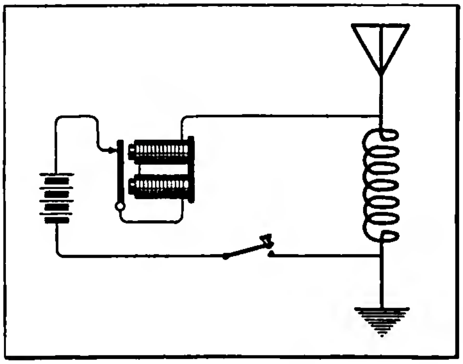

Figure 1

Ans.—(1) The step-down telephone transformer will only increase the strength of signals in the event that a high resistance detector is employed and a low resistance telephone only is available. In such a case, increased strength of signals would be obtained, but if a high resistance telephone having sufficient ampere turns to give a resistance of 3,000 ohms is employed, better signals will be obtained without the step-down transformer. You, of course, understand that there are certain energy losses in transformation in any type of transformer, and, therefore, no benefit would be derived in adopting a step-down transformer except under the conditions mentioned.

Ques.—(2) I have frequently heard the statement and have also seen it published in your magazine that an ordinary bell buzzer can be employed for radio transmission. What would be the normal transmitting range of such a buzzer, and how should it be connected to be most effective? Is a condenser necessary?

Ans.—(2) Two methods of connection for this buzzer are shown in Figures 1 and 2. In Figure 1 the circuit of the bell buzzer is completed through a coil of fifteen turns of annunciator wire connected in series with the antenna circuit. In Figure 2 a .005 microfarad condenser is connected in series with the antenna and in shunt to the vibrator of the buzzer. Connected in either way, the antenna will be charged at a rate depending upon the speed of interruption of the vibrator.

The actual range of such apparatus depends upon the sensitiveness of the receiver. It has frequently been possible for battleships to communicate at sea over distances of thirty miles when the receiving station was equipped with a triple vacuum valve amplifier.

We do not quite understand the drawing accompanying your third query, which apparently shows two tuning coils, A, B, in parallel and both in series with the antenna circuit. We see no advantage in this arrangement whatsoever.

Answer to fourth query: We have made some calculations on your antenna which, by the way, is rather difficult to calculate on account of its irregular shape; but if it consisted of four wires, its capac[illegible] be about .0022 microfarad. If you wish to calculate the capacity of wireless telegraph antennae, and you have sufficient knowledge of elementary mathematics to carry out the work, you should secure a copy of the book entitled "The Calculation and Measurement of Inductance and Capacity," by W. H. Nottage, which can be purchased from the Wireless Press, Ltd., Marconi House, Strand, London, England.

Answer to last query: The actual size of the antenna wire does not make much difference provided it possesses sufficient current-carrying capacity for the power of the transmitter employed. It is customary in the United States to employ a conductor made of seven strands of No. 19 silicon bronze wire. This wire is not employed because it possesses a particularly high degree of conductivity, but because it possesses great tensile strength which is highly important when we consider the span of the antenna on many ships. We consider your antenna too long for the reception of signals around 600 meters, but for the copying of signals from high-power stations, he antenna you mention will be satisfactory.

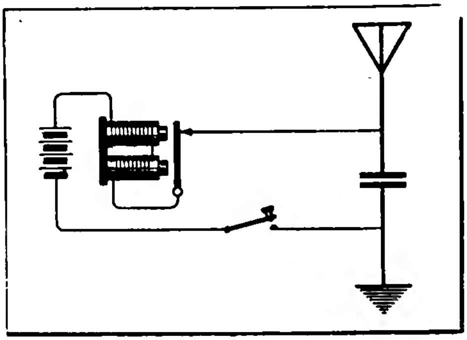

Figure 2

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