PROCEEDINGS

of the

RADIO CLUB *of* AMERICA

Vol. I No. 4 June, 1920

R.C.A. SPECIAL NOTICES

We take pleasure in announcing the election of Mr. Minton Cronkhite, well known as an ardent Radio Club worker, to the office of Corresponding Secretary for remainder of 1920 taking the place of Mr. T. J. Styles now located abroad. Mr. Cronkhite has already assumed his new duties since the last Directors' meeting, and may be addressed at 115 Worth Street, New York City.

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The Radio art in general is standing at the threshold of C W transmission, and it may devolve on the amateur to successfully solve many of the problems met with in his work. Therefore we would like to have each member who is experimenting with C W sets tell the rest of the crowd his actual experience. We are all most interested in practical results not theories, therefore don't be reluctant in sending any of your ideas to the Chairman of the Committee on Papers, Mr. L. G. Pacent, 150 Nassau St., New York City. You will find him only too glad to see that they are properly set before the membership.

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This brings up another thought. Why doesn't the attendance at the meetings match up with our roster? Do you realize our active membership is now almost 150, and yet who would ever think so from the turnout of regular members at the meetings. The Radio Club of America stands in an unique position at the present time to be of real service to the amateur field. Are you doing your part with the rest to push the game?

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Recent Development of Radio Telephones

By Walter S. Lemmon, E.E.

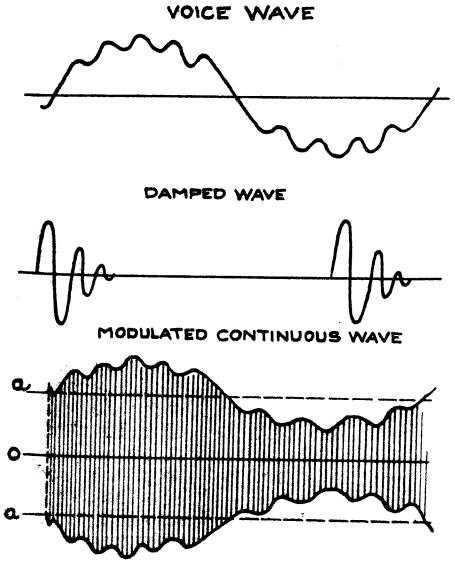
Presented at meeting of the Radio Club of America, Columbia University, February 20, 1920

SINCE the reopening of amateur stations there has been an increasing interest in the operation of radio telephones throughout the country, and it is the purpose of this paper to indicate the important strides accomplished during the war in this art, in order that the best forms of modern construction may be employed. Before proceeding to a discussion of the specific types developed it may be well to point out several fundamental features of the principles underlying the operation of this apparatus.

The transmission of radio speech is similar to that of radio telegraph signals, but, of course, the use of undamped waves is essential. This fact may be readily appreciated when it is remembered that in spark transmission a relatively long interval of time elapses between sparks or wave trains, and therefore any speech occurring between these wave trains would not be transmitted at all, as shown in Figure 1. Therefore it might be said that all present day apparatus utilizes a method of modulation or moulding of the continuously radiated wave by the voice frequency. The continuously radiated undamped wave will be referred to hereafter as the carrier, and the superimposed speech wave (of low frequency) as the voice wave or modulation.

In radio telephones, the receiving results do not depend entirely upon the total radiation of the transmitter, but upon how much this radiation is varied or modulated and also whether these variations closely respond to the pitch and amplitude of the voice wave to be transmitted. To receive radio speech the same general type of receiver is employed as is used for radio telegraph signals. It is important, however, to employ a detector which gives a response proportional to the received energy, and therefore a vacuum tube detector has been found to be excellent for this purpose. Another noticeable feature in receiving telephone signals is the sharpness of tuning required for clear speech. It must be remembered that the received signals consist not of a single wavelength, but of a narrow band of waves extending on each side of the carrier wave. This point mainly affects the reception of long telephone waves and may generally be disregarded for short wave work. Without digressing into theory too far it may be stated that this band extends about 1000 cycles (the limit of voice frequencies) on each side of the fundamental or carrier wave.

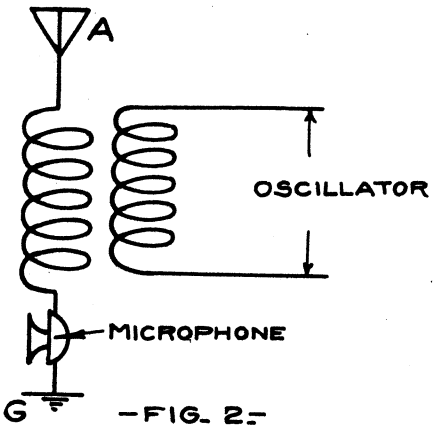
The question of modulation is perhaps at the present time the crux of radio telephone development, and is a problem which affords plenty of latitude for experimentation. Unfortunately for the amateur, the only satisfactory means of studying modulation in detail is the use of an oscillograph, although, for purposes of testing, the results of the received speech at nearby stations will give roughly quantitative results.



-FIG. 1-

The earliest method of modulating the radiated energy (applicable only to low powered sets) was to insert a microphone in the antenna or ground lead as shown in Fig. 2. Speaking into the microphone varied its resistance, hence the antenna current was also correspondingly varied.

However, the limited current carrying capacity and resultant heating of the microphone makes this scheme very wasteful of energy and it has long since been abandoned.

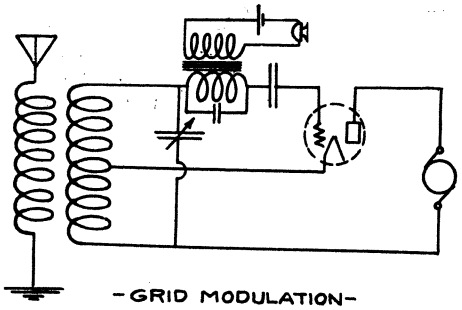


-FIG. 2-

With vacuum tube sets the fundamental principle has been to vary, by some means, the characteristics of the oscillating tube and hence vary its output. This, of course, may be accomplished by control either of the grid or plate circuits.

In grid modulation, illustrated in Fig. 3, the microphone and local battery are coupled to the grid by a small transformer. The secondary of this transformer is shunted by a condenser to bypass the radio-frequency oscillations. In this scheme the tube oscillates in the usual manner and the amount of this oscillation is controlled by varying the grid potential slightly in accord with the voice frequency currents from the microphone circuit. While this system is simple and requires but small microphone currents, in practice it is very delicate and tends to be unstable. Due to these bad qualities and lack of easy adjustment, this method has also been superseded.

The form of modulation finding strong favor through war development is the plate system, also generally known as the

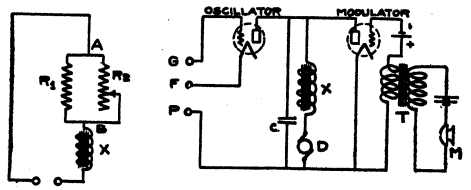


-GRID MODULATION-

-FIG. 3-

Heising system. The basic principle of this method is illustrated in Fig. 4-a. Let us suppose that R1 and R2 are resistances in parallel connected to a DC source through the large choke coil X. Now if R1 is held constant and R2 is suddenly decreased, the choke coil will prevent any momentary change of the total current drawn from the source. Therefore for an instant the current through the branch R2 will increase, and that through R1 will decrease. Similarly, if R2 is increased above normal value the current through R2 will decrease and that through R1 will increase. Of course there are also other effects, but this will serve mainly as an illustration of the modulation system to follow. In Fig. 4b the oscillator tube may be considered connected up to any standard form of oscillator circuit. In its plate circuit, however, in series with the plate generator D, is a large choke X. To by pass the radio frequency oscillations a small condenser C may be used. In parallel with the plate of the oscillator tube is the plate circuit of the modulator tube. The grid of the latter is kept at the proper normal negative voltage by the grid battery, and changes in its

-PLATE MODULATOR-



-FIG. 4a-

-FIG. 4b-

potential are produced by the secondary of the microphone transformer MT in accordance with variations of speech current in the microphone transmitter T.

Now when the grid voltage of the modulator tube is rapidly varied by the speech current in the microphone this causes the electron stream between filament and plate to vary and hence the effective resistance of the modulator tube plate circuit. Since, as in the above analogy, the total supply current fed to both plates is kept practically constant for short time intervals because of the choke coil X, the current through the oscillator tube branch varies corresponding to the modulator variations, and therefore the output of the oscillator is varied or modulated. Hence we may consider the modulator tube as a "speech operated resistance" in parallel with the oscillator tube. The choke coil X also has another function in this system which will be briefly touched upon here. Since it tends to prevent a sudden change in total current from the generator D, a counter

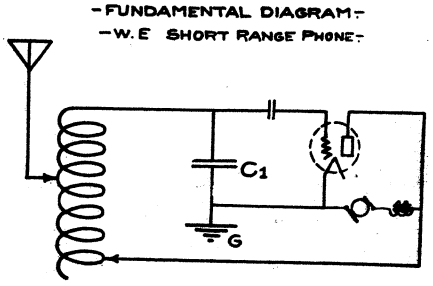


FIG. 5.-

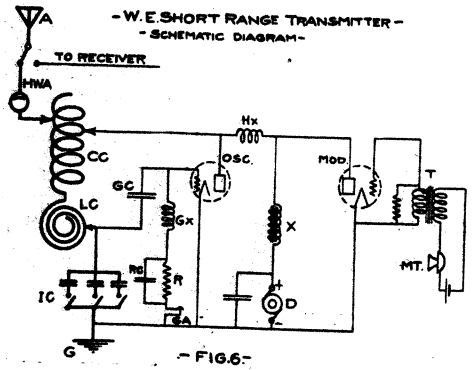
e.m f. is produced across it called the counter e.m.f. (or voltage) of self-induction. This voltage at one time is added to the generator voltage, and at another time opposes it, depending upon whether the generator current tries to decrease or increase. Now the radio output of the oscillator tube depends upon the total voltage momentarily imposed upon its plate, hence this normal output may be much increased by the use of a proper choke coil in the plate circuit. This important part played by the choke coil is taken advantage of in the practical design of radio telephone sets and forms a feature of this modulating system.

WESTERN ELECTRIC SHORT RANGE SETS.

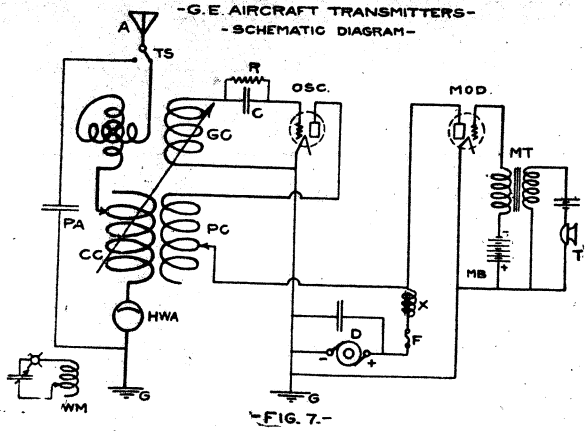
The latter part of this paper deals with a description of the important practical sets developed during the war period and will be confined to practical considerations of general interest. The apparatus developed for both the Army and the Navy was fundamentally similar although differing in construction and circuit details due to the special requirements of each service. Although the writer was directly connected with the Navy development, and hence more familiar with their construction, there is not the slightest intention to belittle the splendid encouragement and effort put forward by the War Department in perfecting this most valuable means of communication.

The short range radio telephone set developed by the Western Electric Co. for both services was known to the Signal Corps as the SCR-67 and 68, and as the CW-936 set to the Navy. Its principal use was for communication between airplanes and the controlling ground station in the Army, and for communication between submarine chasers and other craft in Naval squadrons. The shipboard type set illustrated in the photograph showed many exclusive features interesting to amateur construction, and hence will be briefly described herein.

The set was originally developed for rapid communication and exchange of commands between submarine chasers during manoeuvres, and despite its hasty development and severe service, gave an admirable performance over the required ranges. Since the antennas on these craft were all of small size, the set was designed to operate on low waves and was capable of quick adjustment to 256, 297, 300, 400, or 600 meters. Moreover, the antennas were well standardized and hence the sets were constructed for best operation on a standard antenna of approximately .0006 mfds. and a fundamental wave length of 190 meters, which corresponds closely to the size of the average amateur antenna used for transmitting. The same set with mechanical changes was later adopted for use on battleships, destroyers and transports, giving excellent communication over distances of 15 to 20 miles and in some instances exceeding 50 miles. All in all about two thousand of these sets were constructed for the Navy Department alone.

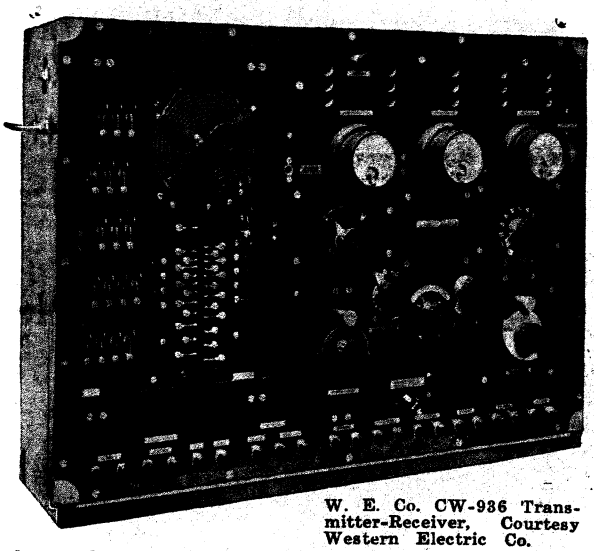


-FIG.6-



-FIG. 7.-

The transmitter is of the direct coupled type and employs one E type oscillator



W. E. Co. CW-936 Transmitter-Receiver, Courtesy Western Electric Co.

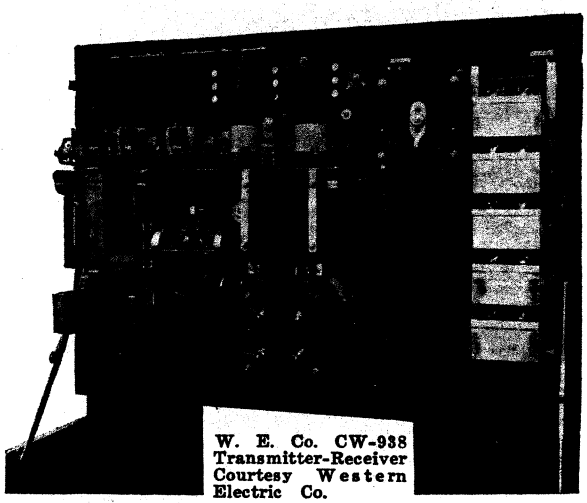
tube and a similar modulator tube, the output being about five watts. Although both transmitter and receiver were located in the same box, they will be described separately for the sake of clearness. The elementary connection of the transmitter is shown in Fig. 5. In the actual schematic diagram, Fig. 6, the circuits are separated into the antenna and oscillator, and modulator circuits. The antenna circuit consists of the antenna connection (A), ammeter (HWA), coupling coil (CC), a special spiral inductance loading coil (LC), and an input condenser (IC), in the ground lead. The coupling coil contains taps to vary the wavelength, while the small spiral loading coil enables positions between taps to be obtained. The function of the input condenser (variable by steps from 500 to 4000 microfarads) is to insure the proper voltage on the oscillator tube grid for the various wavelengths employed. The grid voltage is important and should be approximately 90 volts for proper oscillation.

Coupling between the grid and plate circuits of the oscillator is obtained by a second set of taps on the antenna coupling coil. A grid stopping condenser GC of small capacity prevents the plate voltage from reaching the grid. A special grid leak circuit consists of the resistance R, (10000 ohms) in series with which is placed the choke coil GX of 3 milhenries while in parallel with the leak resistance is the 750 MMF. condenser RC. The series choke and parallel condenser prevent high frequency losses in the grid leak circuit and should prove interesting to amateur constructors. A plug is also provided in the grid leak circuit, GA, in which a milliammeter may be inserted to note the operation of the set. For proper adjustment the grid leak current should be from 2 to 6 milamps.

For simplicity the filament connections will not be shown although it may be stated that all the filaments (including the receiving tubes) were operated in series from the 30 volt storage battery supply. When the set was operated for "stand by" receiving work the transmitter tubes were cut out and an equivalent resistance substituted to keep the total filament current constant thru the active tubes.

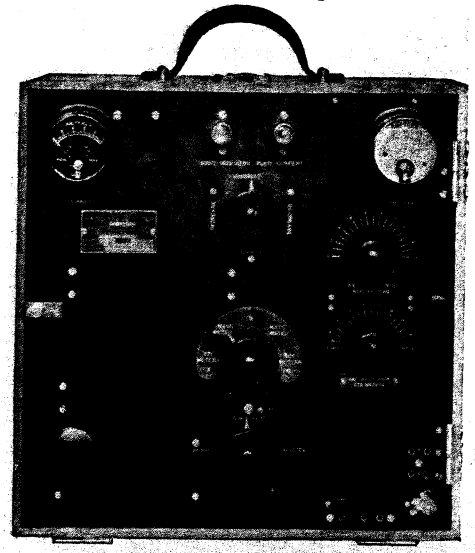
Voltage for the plate of the oscillator was obtained from a 350 volt dynamotor. The high frequency choke HX of 3 millihenries prevented high frequency from entering the modulator tube, while the main choke X of 1.3 henries acts as the modulation inductance. The modulator tube is connected as shown and also consists of an E type tube. Actually the voltage for its grid is obtained from the filament storage battery although it is here represented as a separate battery. The speech transformer has a ratio of 120 to 1 and consists of primary of low impedance with a secondary of very high impedance. Due to this high secondary impedance a resistance shunt is necessary to act as a grid leak for the modulator tube. The microphone is of a special type for low voltage operation.

The receiving set illustrated in the photograph does not contain any novel



W. E. Co. CW-938 Transmitter-Receiver Courtesy Western Electric Co.

features of particular interest and therefore will not be described in detail. It employs an aperiodic or untuned circuit for "stand-by" work with an ordinary loose coupler for actual operation cover-



Aircraft Radio Transmitter (Navy) Item 14, Type CG-1410, Courtesy General Electric Co.

ing a wavelength range from 200 to about 1000 meters. The receiver is not regenerative but employs a two step audio-frequency amplifier for ordinary work. Since these sets were installed to be distantly controlled from extension stations in the chart house or fire control stations, a special amplifier was also supplied to operate a "loud speaker", mainly for calling purposes.

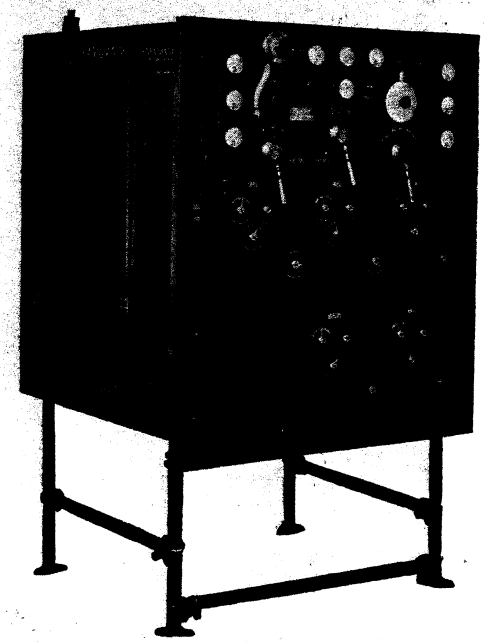
Considering the rapid development and severe service required, these sets operated, on the whole, remarkably well indeed. They allowed easy communication between commanders and other officers for the direct transaction of routine business while manoeuvering, and gave a personal touch and directness to such messages which was not obtained by telegraph. It may be interesting to know that in Brest harbor all communication between the dozens of transports, destroyers and other base craft was carried on by means of these small telephone sets which afforded flexibility and speed with minimum interference to high power traffic.

GENERAL ELECTRIC TELEPHONE SETS.

The many developments in this new art contributed by the General Electric Co. were mainly sets for use on Naval Aircraft and therefore contain many design features peculiar to this type of apparatus. On the whole it may be stated that the sets were of vacuum tube type somewhat similar in operation to the sub-chaser set just described. Therefore details of construction will be omitted except those pertinent or interesting to the experimenter.

The distinguishing feature of these sets is the use of inductive coupling of the oscillator to the antenna instead of direct coupling. The fundamental diagram of connections is shown in Fig.7 which is particularly applicable to the first small set known as the CG-1104. This transmitter was employed for communication between planes in flight and also to base stations over short distances of 25-30 miles with a trailing wire antenna. The apparatus is clearly shown in the photograph appended.

As will be seen from the fundamental diagram, Fig. 7, the antenna circuit consists of an antenna coupling coil CC provided with wavelength taps and a fine tuning variometer V. Since the wave length of the oscillator is set by the antenna circuit alone it is important to have the setting correct. To check up the radiated wave a small wavemeter WM is incorporated in the set and indicates by a small pilot lamp. The antenna coil is coupled to both the plate coil, PC, and the grid coil GC. The former coupling



3½ KW 5-Wave-Length Navy Set (R. L. Model) Radio Telephone and Telegraph Transmitter, Courtesy General Electric Co.

is fixed but the coil is provided with taps while the grid coil coupling is variable by rotation of a fixed amount of grid inductance wound on a cylinder. The absence of condensers makes the operating adjustment quite simple and the phantom antenna PA allows testing of the set with the antenna disconnected.

The oscillator tube gies an output of 5 watts (T tube) while two similar modulator tubes are employed to give complete modulation. The plate voltage is supplied by a 350 volt generator with the usual choke coil X and a protective fuse F to prevent excess plate current. The set is equipped with a microphone T for telephone work and also a buzzer, not shown, for telegraphy. The battery MB supplies the proper negative grid voltage for the modulator.

In a later model several improvements were made of a detailed nature. A larger set employing two "P" tubes (250 watts) and a plate potential of 1500 volts was also developed which operated on 1600 and 600 meters with separate coil systems for each wavelength. This arrangement is electrically most efficient and was typical of subsequent developments. For operation at base stations and on battleships, a long range radio telephone was next developed which gave an output of over 1 KW and good modulation.

A most interesting development with which the writer was fortunate to be intimately interested was in connection with the return of the President on the U.S.S. George Washington. A series of long range radio telephone experiments were carried on between the ship and New Brunswick, N. J., for several trips to determine the feasibility of "two way" communication. The installation at New Brunswick utilized the Alexanderson high power alternator with telephone control from the ordinary wire telephone line to Washington. On shipboard a special General Electric high power tube set was used employing a master oscillator of two "P" tubes (500 watts), the output of which was then amplified by twelve amplifier tubes in parallel. The actual output of the set to the antenna was somewhat over 3½ KW with rather complete modulation at full power. This was the first large set equipped for duplex operation, that is both transmitting and receiving could be accomplished simultaneously. Space does not permit the writer giving detailed results herein, but it may be stated that reception of speech from New Brunswick was attained from Brest harbor in France although midsummer static prevented the use of high amplification necessary to completely copy the conversation. From the ship conversation was clearly received on shore, over 2000 miles, and two way conversations with New Brunswick and Washington were interchanged up to 400 miles. These tests clearly showed the feasibility of radio telephone operation between ship and shore over moderate ranges and practically all conditions.

In conclusion the writer wishes to acknowledge with thanks the co-operation of the General Electric Co., the Western Electric Co. and the Navy Department for their kind permission to publish these details of the splendid developments which resulted from their united efforts during the recent World War.