# PROCEEDINGS

*of the*

# RADIO CLUB *of* AMERICA

Vol. I No. 9 February, 1921

# R.C.A. SPECIAL NOTICES

To the Membership:—

Entering the New Year, the Radio Club of America once again stands at the position of particular service in the development of Amateur Radio. During the past year we have enjoyed many papers which dealt with the application of the recent War's research to present day problems. The Club hopes to have a most interesting series of papers presented during the next few months which will assist the members in perfecting their new equipment for C.W. work.

* * * * * * * *

If in the construction of new apparatus, or in the remodelling of old sets you should find any items of general interest to amateurs, why not spread the good news around? Even though you may consider the idea of little value, it may be "great stuff" to some fellow member who is looking for that very stunt. The proper medium of exchange for these ideas is through discussion at the meetings and through these Proceedings. So just draw up a sketch, add a brief description, and pass it along to the Editor—ideas are always welcome.

* * * * * * * *

The returns of the election of officers for the coming year are not yet at hand. However they will appear in the next Proceedings.

* * * * * * * *

Office of the Editor of Proceedings—319 West 94th Street, New York City
Walter S. Lemmon—Editor
Ernest V. Amy
Austin Lescarboura
Lester Spangenberg

# 2ZM's Radiophone and C. W. Transmitter

*By L. Spangenberg*

**Presented at Meeting of Radio Club of America, Columbia University, May 28, 1920**

THE following is a brief description of a Radiophone and C.W. Transmitter which was constructed by the writer and which has been in use for the past four months at his station on an antenna having a fairly low resistance and a natural period of 250 meters, with quite satisfactory results.

An attempt has been made to show the design of this set by photographs, Fig. 1, 2, and 3, which together with the wiring diagrams and cuts, I believe will show same quite clearly.

It was found that for phone or buzzer transmission using two tubes as oscillators, only one tube was needed as a modulator to give almost perfect modulation, although the set is arranged to use two tubes as modulators if found necessary. It is also so arranged that all four or part may be used in parrallel as oscillators for C.W. Transmission.

The antenna current on different stages of transmission is as follows: Radiophone and Buzzer Transmission using two tubes as oscillators, with all circuits properly adjusted, six-tenths ampere; when using all tubes as oscillators for C.W. Transmission, an antenna current of 1.5 amperes may be obtained. The wave length used when the above results were obtained was 325 meters, that being one of the wave lengths called for in station license, but may add that on shorter wave lengths almost the same results can be obtained and on longer, still better. The set has a range of from 200 to 425 meters.

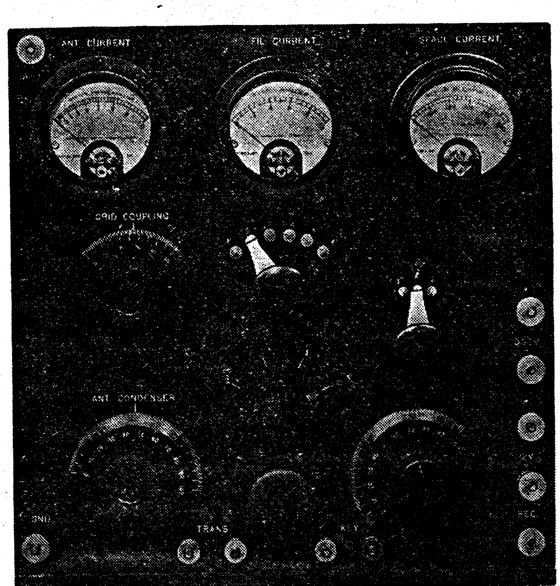


Fig. 1.

The bakelite panel on which the meters and different parts are mounted is 12" x 12" x ¼" and fastened to a wooden base 12" x 8" x" ⅜, well seasoned, and braced to panel as shown in Fig. 2 and 3. It will be noticed that almost all of the parts are of a standard make and may be purchased from any supply house handling radio equipment.

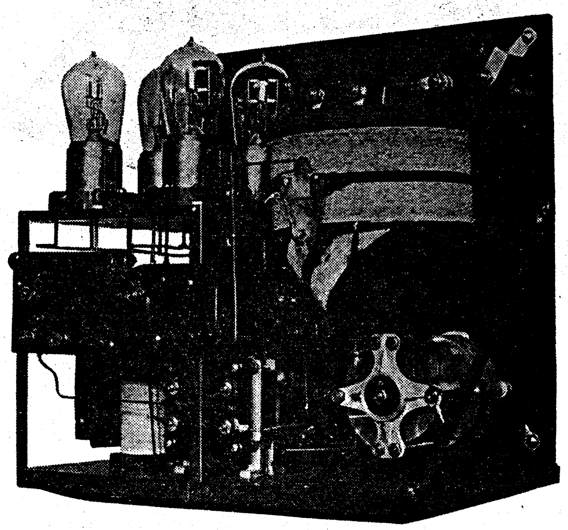

Fig. 2.

The schematic wiring diagram, Fig. 4, shows the circuit used and a simple way of changing to radiophone, buzzer or C.W. transmission by the means of a DPDT switch, with the aid of a SPDT switch to change from radiophone to buzzer transmission while the DPDT switch is in the first position. The diagrammatic wiring plan, Fig. 5, shows the actual circuit of this set, using a standard make of five-contact drum switch which replaces the DPDT switch and performs other duties, such as closing the filament circuit, high voltage circuit and changing the antenna from sending to receiving, also having a neutral position for all circuits. By using this type of switch the operator can very readily change to any type of transmission, and then back to the receiving position, at the same time opening both the filament and high voltage circuits.

The rheostat regulating the filament current may be of a standard make, but when using four tubes (the current being too heavy for the wire) it was found necessary to divide the resistance, making

It will be noticed that a C battery of about 40 volts is used as a biasing battery in the grid circuit of the modulating tubes as shown in the wiring diagram.

The type of tubes used is the well known VT-14 and on which the above results were obtained. By using the VT-2 type of tubes, 25 percent better radiation may be obtained on all kinds of transmission.

The plate voltage is obtained from a ¼ H.P. 110 v. A.C.—500 v. D.C. motor-generator, and the proper voltage required obtained by placing an adjustable rheostat in the field circuit—350 volts being the voltage used at all times.

The filament current is supplied from a 12-volt storage battery and regulated by the filament rheostats.

The microphone transmitter is an essential part of the outfit and the best that can be obtained should be used; that is, wherein the resistance is varied with the voice very freely and over a comparatively wide range.

(Concluded on last page)

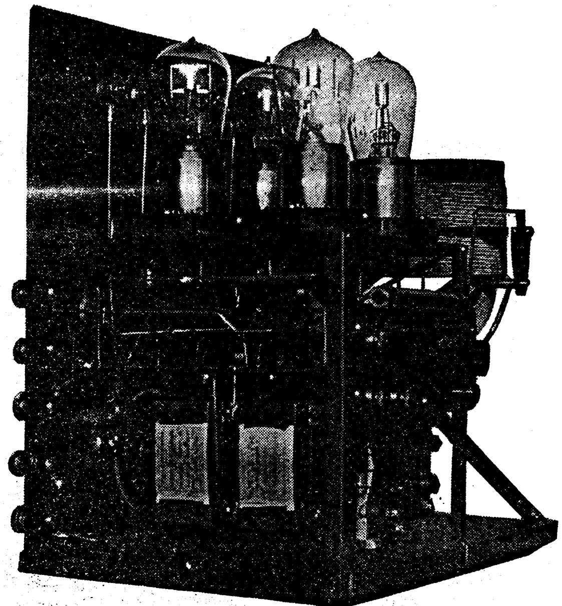

Fig. 3.

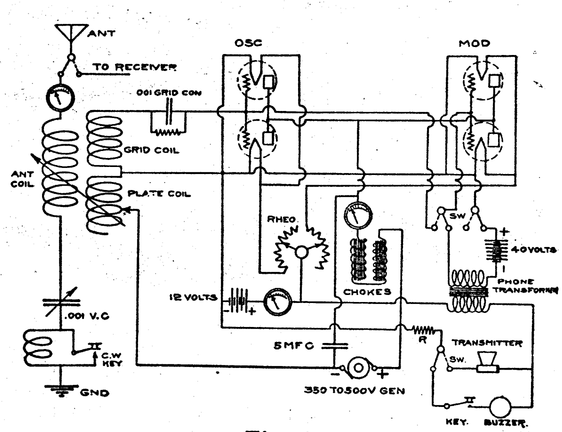


Fig. 4.

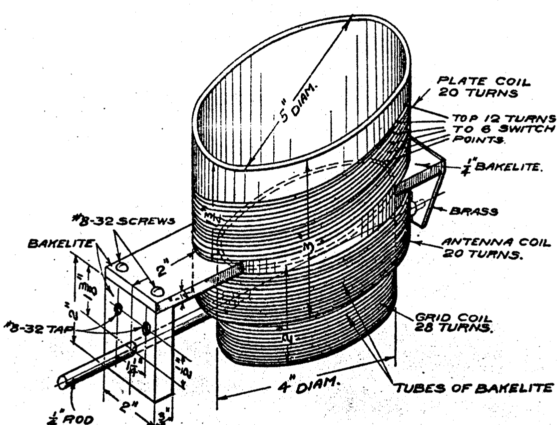


Fig. 6.

two variable resistances, one for the two oscillator tubes and one for the two modulator tubes, as shown in the wiring diagrams, adjustable independent of each other (by the double-knob control located in lower right hand corner of the panel, Fig. 1.—Ed.)

The filter arrangement using two coils and two ¼ mfd. condensers is shown in Fig. 7 and is self explanatory.

The Inductance is shown quite clearly in Fig. 6 and may be mounted on back of panel as shown in photographs. (Note: The inductance forms are circular in cross-section, not oval.—Ed.)

The microphone transformer is a standard make of the closed-core type and works quite satisfactorily.

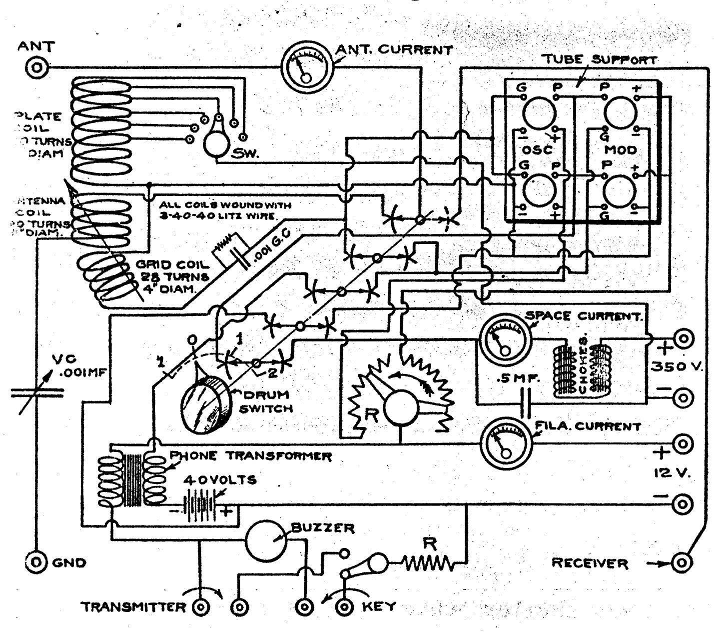


Fig. 5.

# Determination of Resistance, Inductance and Capacity by The Wheatstone Bridge Method

*By Julius G. Aceves*

**Research Assistant to Dr. M. I. Pupin, Columbia University**

Presented before the Radio Club of America, October 22, 1920

IN order to understand the behaviour of circuits, such as used in wireless telegraphy, the first step is to ascertain the constants of the various pieces of apparatus of which the circuit is made up, and their combinations, so that the laws of action and reaction may be properly applied.

In alternating current circuits there are two reactions against the applied E.M.F.; the dissipative, and the conservative reaction. In the first case, energy is transferred in or out of the circuit, and in the second case, energy is merely stored in the electro-static or electro-magnetic fields. The first kind is the result of a RESISTANCE and the second one of a REACTANCE. It is our aim to show how these can be measured in a very accurate and convenient manner.

At the bginning of the Twentieth Century, Dr. M. I. Pupin of Columbia University suggested and used the Wheatstone Bridge with alternating current to determine resistance and reactance and we use it now at this research laboratory as the standard method for measurements with currents of from 20 to 200,000 cycles.

This method of measurement requires three principal devices:

I. A Wheatstone Bridge.
II. A Source of Alternating Current.
III. A Detector that indicates when the bridge is balanced.

### I. The Bridge.

The theory of the bridge tells us that in order to have the difference of potential across the detector D (Fig. 1) at all times equal to zero, the resistances and reactances must satisfy the condition

$$\frac{R_a}{R_b} = \frac{R_s}{R_x}, \text{ and } \frac{R_a}{R_b} = \frac{X_s}{X_x}$$

where $X = 2\pi f$ or $\frac{1}{2\pi fC}$, produced either by inductance or capacitance. The subscripts denote the bridge arm to which they belong, s meaning standard and x the unknown.

There are various methods of balancing a bridge, but we shall only show the most important ones.

I. Balancing an unknown impedance against an adjustable standard resistance and reactance.

II. Balancing against a fixed standard reactance and adjustable resistance, varying the ratio arms of the bridge.

III. Balancing a reactance by a standard one of opposite sign by a resonance bridge.

IV. Substituting in the bridge already balanced the unknown by adjustable standards.

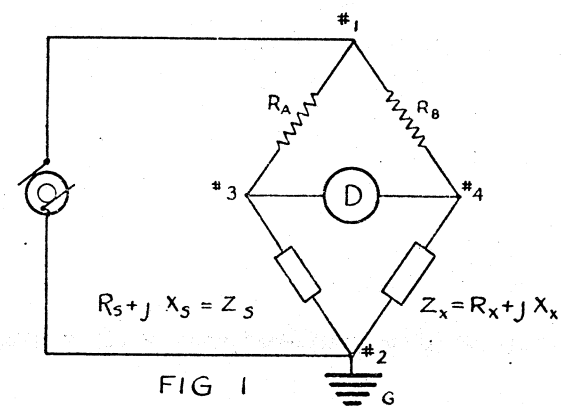


FIG 1

Examples of carrying out each respective method shown above follow:

I. This is a very simple method and accurate when the power factor of the unknown Z is about 70%, that is, X = R.
Example: To measure a 2 milihenry coil at 25,000 cycles, having about 300 ohms resistance. A variometer is connected with a resistance in arm S as per Fig. 2.

II. When an adjustable standard coil or condenser is not available, then use a fixed one and adjust the ratio $\frac{R_a}{R_b}$ and the resistance $R_s$.
Example: To measure the effective capacity and resistance of a cable, having a 0.1 mfd. condenser, connect as per Fig. 3 and vary alternatively the ratio $\frac{R_a}{R_b}$ and the value of $R_s$.

III. If a coil or condenser has a very low power factor, say of 2%, then very serious errors are usually made when using methods I and II without a great many precautions. Then a non-reactive bridge will give excellent results.

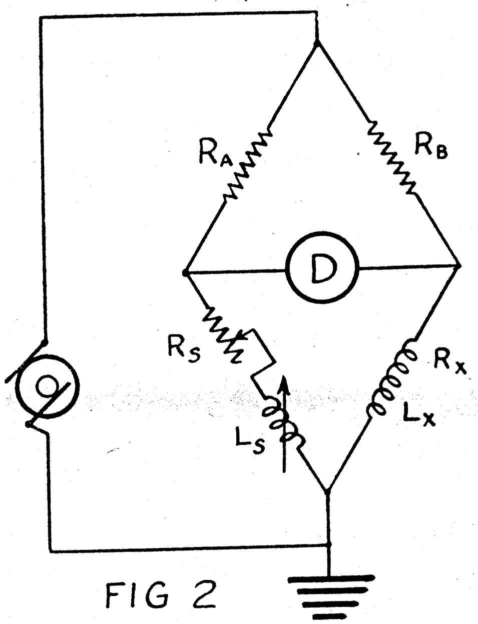


FIG 2

Example: To determine the inductance and resistance of a "duo-lateral" coil. Connect as per Fig. 4, using a standard mica or air condenser. Then

$$L_x = \frac{1}{(2\pi f)^2 C}, \text{ and } R_x = R_s \frac{R_b}{R_a}$$

If f is not known, a standard $L_o$ is substituted for the unknown and the bridge rebalanced with a capacity of $C'_s$, when

$$L_x = L_o \frac{C'_s}{C_s}$$

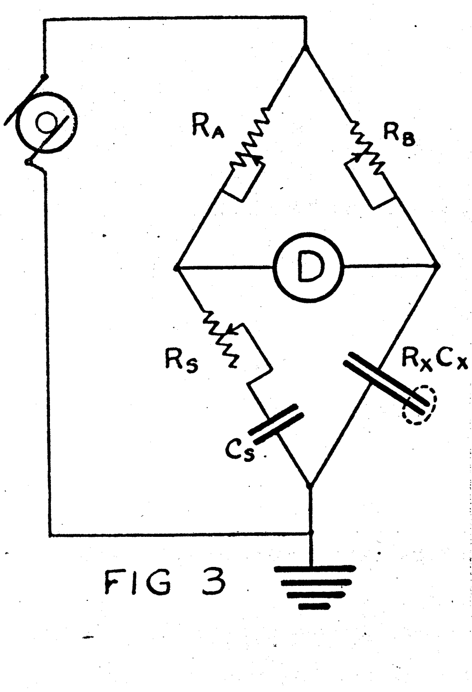


FIG 3

IV. For very small capacities a substitution or differential method is very accurate. (Fig. 5:)

Example: To determine the capacity between grid and filament of a vacuum tube.

Connect as per Fig. 5, balancing the bridge against a ballast condenser $C_o$ which may be known or not. Then close switch (K) and without disturbing anything else, rebalance by means of $C_o$. The difference is the unknown C.

---

The principal sources of error are:

A. Electrostatic and magnetic induction upon the detector from any part of the circuits.

B. Stray capacities and conductances across the various standards, and the unknown.

C. Mutual induction and capacity between these pieces of apparatus.

D. Self-induction of long leads and of some resistances of very small value, say one ohm or less, when using low impedances.

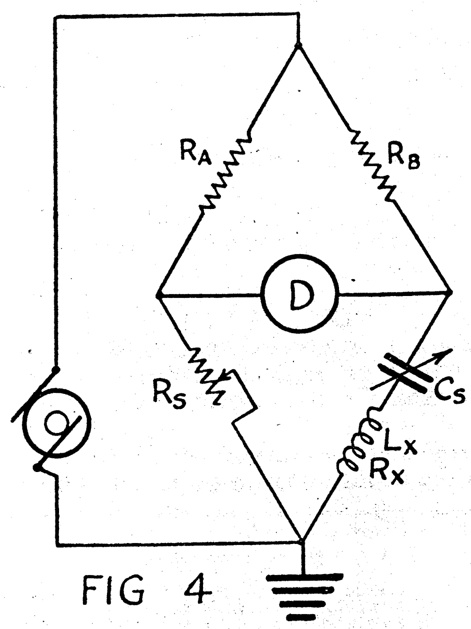


FIG 4

The first and second sources of error are usually the most serious ones. In order to eliminate the first cause, i.e. induction upon the detector, it must be thoroughly screened; but the details will be given when we will show the design of this apparatus.

The stray capacities are unavoidable; they may be made very small and also their effects can be compensated by the following method.

After the best arm ratio $\frac{R_a}{R_b}$ has been selected, the unknown and the standard should be disconnected from corners 3 and 4 (Fig. 1) and a small variable air condenser placed between ground 2, and either corner 3 or 4 as the case may require, and adjusted until the detector is silent. Then the arm ratio should not be disturbed materially, otherwise a new setting of the condenser will be necessary. The other sources of error may be avoided by skillful selection of the apparatus and of their relative positions, as well as by electrostatic screens suitably located.

### II. The Source

The source of A.C. usually is an oscillating audion. It must be such that

(a) the frequency is constant.
(b) the wave shape is sinusoidal.
(c) the voltage is constant.

The oscillating circuit should have a wide range in frequencies and be as free as possible from complicated adjustments. Fig. 6 illustrates a circuit in which these conditions are practically fulfilled.

Two audions are used, and the feed back is obtained by means of a small condenser k, (Fig. 6), made of about 3" of twisted

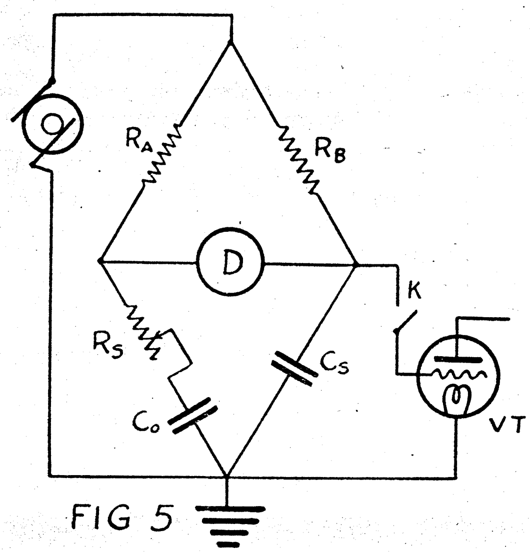

FIG 5

insulated wire. This is fixed for any frequency from about 200 to 200,000 cycles. To vary the frequency all that is necessary is to vary the product LC of the oscillating circuit by adjusting C for various values of L.

A hot wire or a thermo-galvanometer G will measure the A.C. only, as it is in series with a condenser, and may be calibrated in volts. Across its terminals the bridge may be fed directly or thru a potentiometer to reduce the voltage.

In order to secure constant frequency without having to regulate closely the filament current and plate voltage, certain relative values of L and C for a given frequency should be used. By experience we found that it for a given product LC we select C=2L, L being in henries and C in microfarads, the frequency will remain constant within 1% for a 100% change in plate voltage or about 25% in filament current. The assumption involved is that the coil should have a reactance at least 20 times its resistance.

### III. The Detector

The detector consists of a receiving set specially designed so that it is:

(a) Responsive to nothing else but a difference of potential between corners 3 and 4 of the bridge.
(b) Selective.
(c) Sensitive.

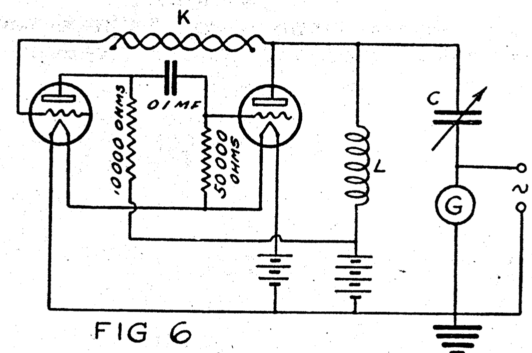

FIG 6

The first condition is of the utmost importance, otherwise misleading balances would result, introducing errors at times of many hundred per cent.

If the detector is selective, it is not necessary to use a pure sine wave for the test, as the detector would be unaffected by the harmonics.

Fig. 7 shows a detector for radio frequencies employing no amplifiers.

Here is a small inductance coil $L_1$ with a corresponding condenser $C_1$ (Fig. 7), joined to Corners 3 and 4 of the bridge, (Fig. 1), and becomes the primary of a regular autodyne receiving set. The only difference from an ordinary set is that it must be all enclosed in a metallic box of rather thick walls so that no electrostatic field may disturb it. A peculiar screen, S, is used between the primary coil $L_1$ and

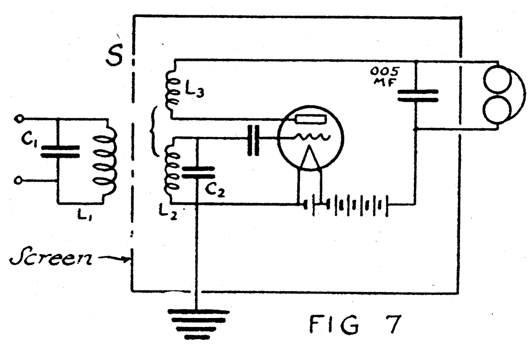

FIG 7

the secondary coil $L_2$ connected to the grid, to prevent electrostatic action and to permit the magnetic field to act upon the detector. This screen may be constructed by pasting tinfoil on a thin board and cutting slits to prevent eddy currents. The tinfoil and the metallic box should be grounded to the negative filament terminal of the audion and to Corner 2 of the bridge.

For audio frequencies the same detector circuit will do but the audion must be non-oscillating, only regenerative, by loosening the plate-to-grid coupling. When the impedances to be measured do not exceed about 1000 ohms, an ordinary pair of wireless phones attached to the high-tension winding of a modulating transformer, with the low tension winding across corners 3 and 4 will make a very sensitive detector, for audible frequencies and free from interference.

For best results, in the detector the primary circuit $L_1$ $C_1$ should have for a given frequency a small L and high C, and the secondary, $L_2C_2$, a high L and low C in order to increase the ratio of transformation from secondary to primary. The low L and high C in the primary will also secure maximum sensitiveness from the bridge itself, which takes place when the impedance of the detector is equal to that of the arms. Usually for a good coil with a resonating condenser across it, the effective impedance is very much larger than the arms of the bridge. The bridge may be used to determine a given frequency with great accuracy. A standard condenser and inductance in a resonating bridge like in Fig. 3 when balanced will give the frequency

$$F = \frac{1}{2\pi\sqrt{LC}}.$$

The detector may thus be calibrated for frequency and become an accurate wave-meter.

## 2ZM'S RADIOPHONE AND C.W. TRANSMITTER

(Continued from page 4)

OPERATION—Drum switch at point O or neutral position opens all circuits. At point 1 to left connects antenna to receiving set, still leaving all circuits open. At point 1 to right connects antenna to transmitter, close filament and high voltage circuits, and connects two tubes as

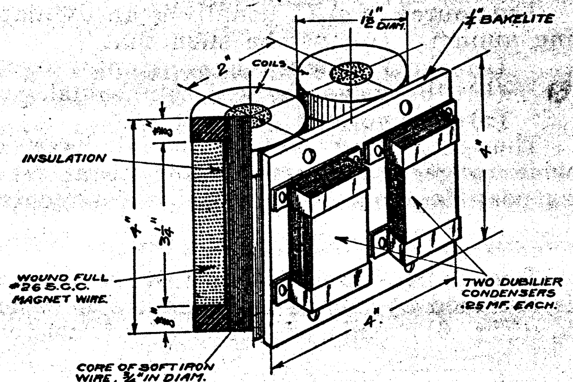


Fig. 7.

oscillators and two tubes as modulators, and is the position for either phone or buzzer transmission, either of which can be used by changing SPDT switch to left for phone and to right for buzzer. At point 2 to right, still closes antenna, filament and high voltage circuits and connects all four tubes in parallel as oscillators for C.W. transmission, which may be sent out by inserting a few turns shunted by a key in the antenna circuit as shown in Fig. 4. The current for both the buzzer and transmitter is supplied from the filament battery through a proper resistance as shown in diagram.