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H. N. MISENHEIMER

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ANTENNA CIRCUIT

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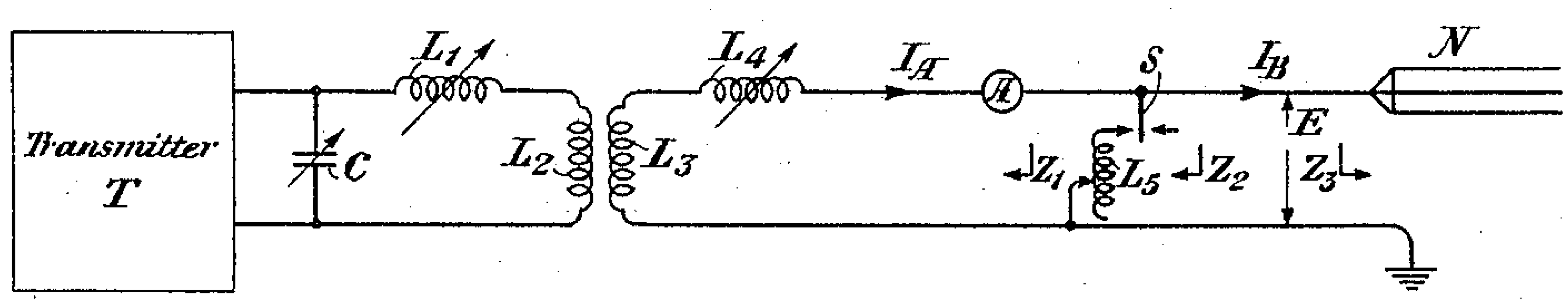

Fig. 1

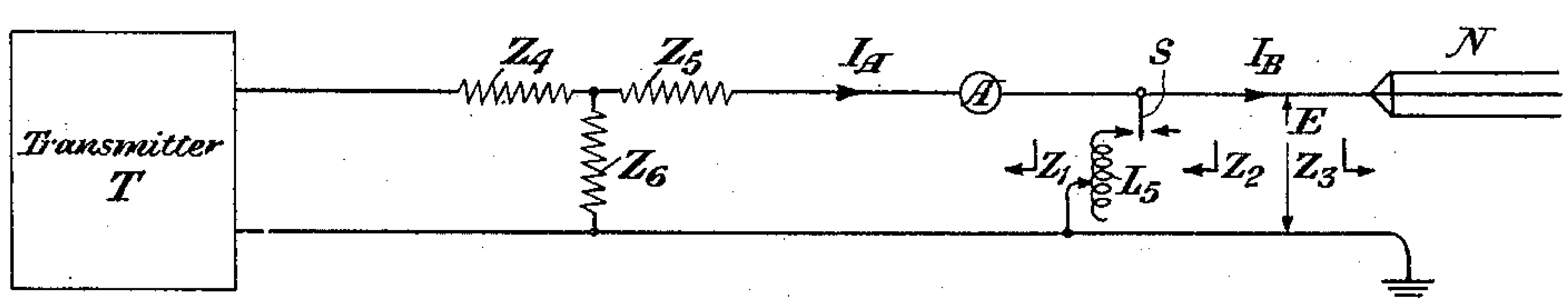

Fig. 2

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UNITED STATES PATENT OFFICE

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ANTENNA CIRCUIT

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This invention relates to transmitters for radio and high frequency currents and to antenna circuits therefor.

In this application there will be described a method for limiting the current in the output circuit of a radio or high frequency transmitter to some definite or predetermined value without limiting or substantially affecting the current delivered to the antenna or antenna circuit, or circuits, coupled or otherwise connected to the transmitter.

It is frequently desirable to increase the power of a radio or high frequency transmitter to such an extent as to necessitate a replacement of the coils, condensers, resistances, if there be any, and/or meters or measuring or indicating devices in the station portion of the antenna feed circuit, such a replacement being deemed essential when any of the above enumerated elements cannot conveniently carry the increased current. The method and arrangements to be described hereinafter permit an increase in the power of the transmitter to be made without changing or replacing any of these elements. The method and arrangements are useful whenever the transmitter is used, at certain times, on a convenient low power, and at certain other times, on a substantially higher power, or powers because it will permit the employment of elements of low current capacity and the meters or other indicating devices may, if desired, give full scale readings or indications of the current magnitude for all powers. The method and arrangements of this invention have been found particularly useful with the well-known multiple tuned antenna, for the adjustment of the antenna feed ratio to the power used may be easily made by operating a single switch or its equivalent, preferably located within the building housing the transmitter and, therefore, this adjustment need not be made by changing the down lead tuning coils at six or so widely distant points along the antenna.

The primary feature of this invention resides in the employment of an inductance so arranged as to shunt some or all of the above mentioned coils, condensers, resistances, meters, etc. connected in the station portion of the antenna feed circuit, this inductance thereby limiting the current flowing therethrough to some definite and predetermined value. The use of this shunt inductance has already been successfully employed in various forms of antenna circuits and has resulted in considerable economy and efficiency.

While this invention will be pointed out with particularity in the appended claims, the invention both as to its further objects and features will be better understood from the detailed description hereinafter following when read in connection with the accompanying drawings in which Figure 1 shows an arrangement interconnecting an antenna with a transmitter, an inductance being arranged to shunt those elements in the antenna feed circuit which are not to carry current of an amplitude greater than some predetermined value, and Fig. 2 shows a generalization of the arrangement shown in Fig. 1.

In Fig. 1 of the drawings there is shown a transmitter T which may be any well-known form of radio or high frequency transmitter. Transmitter T may, for instance, include an oscillator capable of sustaining oscillations of any one of a number of different frequencies, coupled to a source of signals and an amplifier having one or more stages of amplification in order that any desired power level may be obtained. Transmitter T may be terminated by a tuned circuit as shown in Fig. 1, this tuned circuit including a winding L_1, which may be adjustable in the magnitude of its inductance, a winding L_2 and a condenser C of variable capacity in shunt with windings L_1 and L_2. Accordingly, upon adjustment of the inductance of winding L_1 and of the capacity of condenser C, the tuned circuit may be brought into resonance at any desired frequency.

The winding L_2 of the latter tuned circuit is shown coupled to a winding L_3. Winding L_3 is connected in series with another winding L_4 of variable inductance, an ammeter A or other indicating device, and an antenna N, winding L_3 being also connected to ground. It will be apparent that the resonant period of the circuit in series with winding L_3 may be brought to any desired value by changing the magnitude of the inductance of winding L_4.

A single pole, single-throw switch S is in series with a winding L_5 which is also of variable inductance as shown. Switch S may be manipulated to connect winding L_5 in shunt across the series circuit including winding L_3, winding L_4 and ammeter A. Winding L_5 is the inductance of this invention used to shunt windings L_3, L_4 and ammeter A to prevent excessive currents from flowing through the latter elements and this represents one of the novel features of the invention.

When the transmitter T is impressing a particular frequency upon the antenna N, a voltage E may be considered to act in series with the branch including winding L_3. Then if the shunt coil L_5 is not connected to the circuit and if the circuit is brought to resonance at the frequency of transmitter T by the adjustment of the inductance of winding L_4, the inductive reactance in the circuit will be equal to the capacitative reactance, or

$$X_1 = X_2 = -X_3 \quad (1)$$

X_1 being the reactance component of impedance Z_1, X_2 the reactance component of impedance Z_2 and X_3 the reactance component of impedance Z_3. These relations may be more accurately written mathematically as follows:

$$\begin{aligned} Z_1 &= R_1 + jX_1 \quad (2a) \\ Z_2 &= R_2 + jX_2 \quad (2b) \\ Z_3 &= R_3 + jX_3 \quad (2c) \end{aligned}$$

Now let switch S be manipulated so as to connect the coil L_5 in shunt with coil L_3, coil L_4 and ammeter A. Coil L_4 may then be changed in the magnitude of its inductance to cause the circuit to be in resonance at the same frequency as heretofore. Hence,

$$X_2 = -X_3. \quad (3)$$

In this connection, it is to be noted that the resistance components of the impedances Z_1 and Z_2 are very small when compared with the reactance components and may, therefore, be neglected.

Since coils L_3 and L_4 are in series relationship and are in parallel with coil L_5, it will be apparent that

$$\frac{1}{X_2} = \frac{1}{X_1} + \frac{1}{X_S}, \quad (4)$$

where X_S is equal to the reactance of coil L_5. Multiplying both sides of Equation (4) by voltage E it follows that

$$\frac{E}{X_2} = \frac{E}{X_1} + \frac{E}{X_S}. \quad (5)$$

Since

$$\frac{E}{X_2}$$

is equal to the true antenna current, or I_B,

$$\frac{E}{X_1}$$

the current through ammeter A, or I_A, and

$$\frac{E}{X_S}$$

the current in the shunt coil L_5, or I_S, then

$$I_B = I_A + I_S \quad (6)$$

Equation (6) clearly states that the true antenna feed current I_B is equal to the sum of the station feed current I_A and the shunt coil current I_S. It will be apparent that by employing this shunt coil, the true antenna feed current, i. e., the current supplied to antenna N, is divided between two branches, one including coils L_3, L_4 and ammeter A and the other including shunt coil L_5. If the transmitter T is used to supply power in excess of some predetermined value, the shunt coil may be connected as shown to prevent excessive current from flowing through coils L_3 and L_4 and ammeter A. If transmitter T is employed to transmit different power levels in excess of some predetermined value, then coil L_5 may be set at corresponding values of inductance in order that the current flowing through the circuit including coil L_3, coil L_4 and ammeter A may not exceed some predetermined value. Thus, it becomes unnecessary to replace coils L_3 or L_4 or ammeter A as the power output of transmitter T is increased to very great levels.

Equation (5) may be written as follows:

$$I_B = E\left(\frac{1}{X_1} + \frac{1}{X_S}\right) \quad (7)$$

The latter equation clearly shows that the true antenna feed current I_B divides between the station feed circuit, i. e., the circuit including coils L_3 and L_4 and ammeter A, and the shunt coil circuit, i. e., the circuit including coil L_5, inversely in proportion to their reactances. By changing the proportion between the reactance of the shunt coil circuit and the reactance of the station feed circuit, the currents in the respective branches may be brought to any desired ratio.

In Fig. 2, the transmitter T is coupled to the antenna N through a T-type network. Here impedances Z_4, Z_5 and Z_6 are shown generally, impedances Z_4 and Z_5 being connected in series relationship between transmitter T and antenna N, and impedance Z_6 being connected across transmitter T from the point of contact of impedances Z_4 and Z_5. In other respects, elements similar to those in Fig. 1 are designated by similar reference characters.

If the antenna circuit of the arrangement of Fig. 2 need be tuned to the frequency of the current transmitted by transmitter T by means of a series condenser, such a condenser may be located near the antenna and it will be clearly understood that this condenser may be variable so that its capacitative reactance may be changed to any desired value. The capacitative reactance of this condenser, if used, will now be included in impedance Z_3, impedance Z_3 equaling R_3+jX_3. In the arrangement shown, reactance X_1 will always be inductive in effect. Also, when considering the changes produced by the addition of shunt coil L_5, the resistance component of impedance Z_1, i. e., R_1, may be neglected in practice. The ratio of the total antenna current I_B to the station feed current I_A may then be determined by measurement for all frequencies which are to be employed in transmission. For any particular frequency, the true antenna feed current I_B will be equal to the station feed current I_A multiplied by a constant, or

$$I_B=k_1I_A \quad (8)$$

There will be a different constant for each frequency.

It will be understood that the arrangement of Fig. 2 is a generalized circuit showing how shunt coil L_5 may be applied in practice to any transmitting circuit and that variations from that arrangement may be employed in practice without departing from the spirit and scope of the invention.

While this invention has been shown in a particular arrangement merely for the purpose of illustration, it will be clearly understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. The combination of a transmitter, an antenna circuit, a winding having a predetermined inductance connected in series in said antenna circuit, means coupling said transmitter and said antenna circuit, and a circuit connected in shunt with said antenna circuit, said shunt circuit including inductance of variable magnitude, said inductance being set at a value suitable to carry a predetermined proportion of the current to be supplied by said transmitter to said antenna circuit, the inductance of the winding in series with the antenna circuit being of a magnitude such that it will carry the rest of the current to be supplied by said transmitter to said antenna circuit.

2. The combination of a transmitter of radio frequency current, an antenna circuit, a first circuit including inductance of predetermined magnitude, said first circuit being connected in series with said antenna circuit and being coupled to said transmitter, and a second circuit including inductance of predetermined magnitude and switching means for connecting said second circuit in shunt with the first circuit, the inductances of the first and second circuits being of magnitudes inversely proportional to the currents which shall flow thereover.

3. The combination of an antena, a first inductance, an ammeter, said antenna, said first inductance and said ammeter being connected in series relationship, said first inductance and said ammeter conveniently carrying current of an amplitude less than a predetermined value, a second inductance, a switch for connecting said second inductance so as to shunt said first inductance and said ammeter when current is to be supplied to said antenna of an amplitude greater than said predetermined value, said first and second inductances being of magnitudes inversely proportional to the current which shall flow thereover.

In testimony whereof, I have signed my name to this specification this 17th day of July, 1928.

HARVEY N. MISENHEIMER.