Feb. 1, 1938. W. BUSCHBECK ET AL. 2,107,025

ELECTRICAL COULPLING ARRANGEMENT

Filed Aug. 19, 1933

Fig. 1

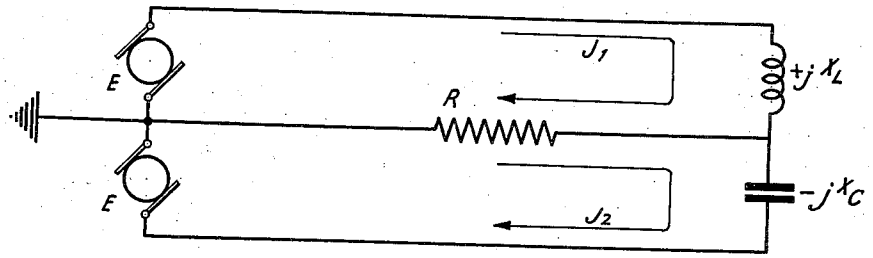


Fig. 2

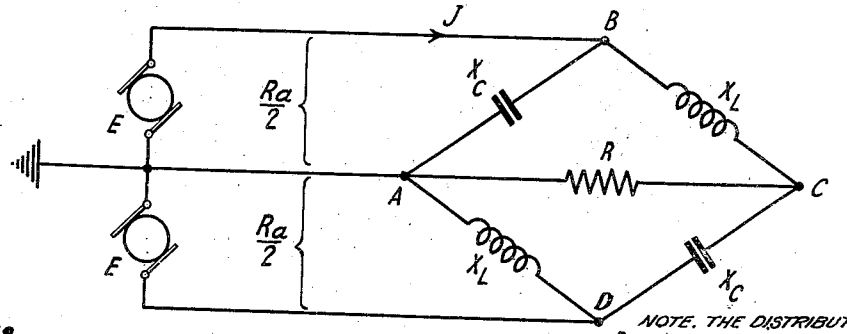
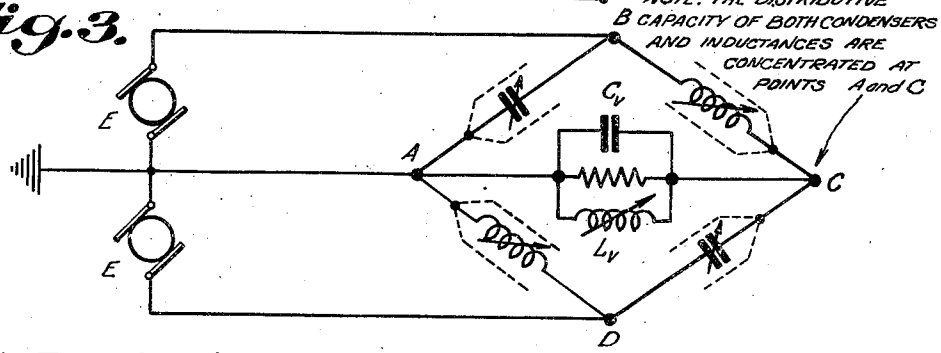


Fig. 3.



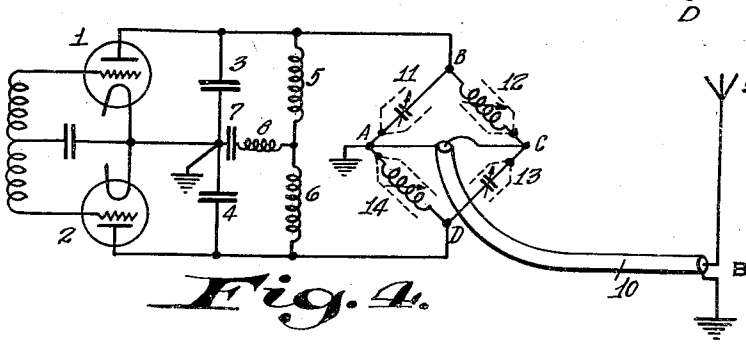


Fig. 4.

INVENTORS
WERNER BUSCHBECK
RICHARD BRUCKNER
BY H. G. Grover
ATTORNEY

Patented Feb. 1, 1938 2,107,025

UNITED STATES PATENT OFFICE

2,107,025

ELECTRICAL COUPLING ARRANGEMENT

Werner Buschbeck and Richard Bruckner, Berlin, Germany, assignors to Telefunken Gesellschaft für Drahtlose Telegraphie m. b. H., Berlin, Germany, a corporation of Germany

Application August 19, 1933, Serial No. 685,915
In Germany August 20, 1932

5 Claims. (Cl. 178—44)

This invention relates to an improved electrical coupling arrangement.

The invention is concerned with a coupling arrangement to match or adapt two series electromotive forces grounded at their junction points to a uni-laterally grounded consumer or load, or vice versa, to match a uni-laterally grounded electromotive force to two series consumers grounded at their junction point. Such a coupling device, especially in radio-frequency work, is frequently used, say, for the connection of a radio-frequency cable with a push-pull transmitter stage. In this case, and in others occasionally arising in practice, the chief desideratum is to make arrangements so that the load will remain perfectly ohmic in nature, for it is then that the loss (energy) in the tubes remains very small. Now, this adaptation has in the past been insured mostly by the aid of transformers, though only loose inductive coupling could be used in order to avoid undesirable stray capacitive couplings. This circumstance presupposes a high ratio between wattless and active power and thus poor transfer efficiency, not to mention large expenditure of materials. The other feasible solution, namely, to insure adaptation by means of a by-pass of a length equal to $\lambda/2$ is practically confined to transmitters working with but one wave or at most very limited range, and it affords an adaptation of characteristic impedances only at a ratio of 1:4, unless, upon wave-change, the length of the lines symmetric with reference to ground is to be altered in addition to a change in length of the bypass line.

Now, the present invention is concerned with a circuit scheme in which adaptation practically of any desired surge impedances, within a wide range of wave-lengths, is accomplishable in a simple manner, while yet preserving satisfactory transmission efficiency.

Now, in order to obviate the difficulties mentioned above, recourse is had here to the use of a series connection of two capacitive and two inductive reactances forming a ring structure of a kind fundamentally known in the art, at the non-consecutive junction points of which the electromotive forces are consumers are united. According to this invention, the impedances are made of like absolute magnitude and they are so interconnected that in sequence a capacitive reactance follows an inductive one.

The invention will best be understood by referring to the accompanying drawing, in which:

Fig. 1 is a circuit diagram of a coupling arrangement known in the prior art;

Fig. 2 is a circuit diagram of the invention;

Fig. 3 is a circuit diagram of another modification of the invention; while

Fig. 4 is a circuit diagram of a push-pull short wave transmitter employing the coupling arrangement of this invention.

The operation of the circuit organization illustrated in Fig. 2 shall in what follows be demonstrated by calculation, the same being predicated upon the circuit scheme Fig. 1 which is known in the prior art.

Referring to the diagram Fig. 1, suppose the upper E. M. F. results in the current J1 and the lower one the current J2. Calculation as can be readily seen results for the two currents respectively, in the values:

$$J_1 = E\frac{2R - jX_C}{X_L X_C + jR(X_L - X_C)} \qquad (1)$$

$$J_2 = E\frac{2R + jX_L}{X_L X_C + jR(X_L - X_C)}$$

Since the resistance R is traversed by the difference between the two currents, the current J_R in the resistance is given by this expression:

$$J_R = J_1 - J_2 = E\frac{-j(X_L + X_C)}{X_L X_C + jR(X_L - X_C)} \qquad (2)$$

In the presence of resonance, in other words, when $X_L = X_C = X_O$, J_R is expressible by this equation

$$J_R = \frac{-j.2E}{X_O}, \qquad (3)$$

whereas the currents J1 and J2 are of the same size and differ only in their phase in relation to e as demonstrated by the following expressions:

$$J_1 = E\frac{2R - jX_O}{X_O^2}$$

$$J_2 = E\frac{2R + jX_O}{X_O^2} \qquad (4)$$

In other words, the E. M. F. does not work upon an ohmic resistance. Now, in order that this condition may be secured, the two E. M. F.'s must in addition be made to work upon pure impedances of such size that the wattless components of the currents will be neutralized. The upper E. M. F., therefore, must be applied in addition to an impedance of a size: $-jX_O$, and the lower one to an impedance of the size: $+jX_O$. In this manner there results finally the scheme shown in Fig. 2 which results in this equation:

$$J_1 = J_2 = J = E\frac{2R}{X_O^2}$$

In order to ascertain the ratio of transformation of the arrangement the ohmic resistance (R_a) upon which the two E. M. F.'s work should be known as a function of the load resistance R. There is found:

$$\frac{R_a}{2}=\frac{E}{J}=\frac{E}{\frac{2R.E}{X_O^2}}=\frac{X_O^2}{2R} \quad (5)$$

or

$$X_O=\sqrt{RR_a} \quad (6)$$

As can be seen from this latter expression, for a given R and R_a, the desired ratio of transformation is adjustable simply by proper selection of X_O. Inasmuch as the latter, quantity, is a function only of the desired resistances R and R_a, only C and L must be altered in proportion to the wave-length and this is a condition easily fulfillable even in the case of great wave-length ranges.

In practical application of the idea, whenever short waves are dealt with, one is likely to meet certain difficulties in so far as the points of the bridge B, C, D not connected with ground will present distributed capacities against ground. The capacities between B and D to ground, to be sure, jointly with the impedances contained in the bridge may be made to result in the requisite normal or rated values; though this, on the other hand, is likely to mean the loss of simplicity of manipulation residing in the positive coupling of corresponding elements of the bridge in case of steady or rectilinear characteristics. Hence, according to another feature and object of this invention, by the shielding of condensers and variometers, the distributed capacities, as shown in Fig. 3, are concentrated or lumped at the bridge points A and C; and the capacitance C_V arising from C in reference to grounded point A (to which under certain circumstances may be added the capacity value due to the "marginal" effect of the concentric line with characteristic impedance R) is compensated by the variometer L_V inserted between points A and C and which may also be coupled with the other variometers.

A push-pull transmitter circuit diagram is shown by Fig. 4 employing the coupling arrangement of this invention comprising an aerial fed from the push-pull stage by way of a high frequency cable, and comprises push-pull connected vacuum tubes 1 and 2, the output of said tubes being formed by condensers 3, 4 and coils 5, 6. The junction point of the condensers 3, 4 is united with the cathodes of the tubes and grounded. The direct current voltage supply is connected across the terminals of condenser 7 which is connected by way of a choke coil 8 with the junction points of the inductances 5 and 6. The opposite points of these last mentioned inductances which are not joined at the junction with choke coil 8 are at an opposite symmetric potential to ground, as will be seen by the diagram, and for optimum transfer of energy these points are connected from the supply source to the antenna 9, by means of a bridge-like arrangement as shown in Fig. 3, the arms of which comprise shielded variable capacities 11 and 13 and shielded variable inductances 12 and 14, which are so arranged that the distributed capacities of both shielded condensers and variometers are concentrated at points "A" and "C" of the bridge. From the points "A" and "C", a high frequency transmission cable is connected, the outer sheath of which is grounded at the antenna end and connected at point "A" of the bridge, the central conductor portion of the transmission cable being connected at "C" of the bridge and to antenna 9.

We claim:

1. A circuit coupling arrangement for coupling a symmetrical circuit with an unsymmetrical circuit comprising two separate means of high frequency alternating current voltage supply of like size and phase, each of said separate means of supply directly connected together in series and grounded at their junction point, the ungrounded portion of said high frequency alternating current voltage supply being connected to a load circuit, said load circuit connected to a bridge-like arrangement having terminal connections at opposite arms for optimum transfer of energy from said supply source, said arms having shielded capacitive and shielded inductive reactances providing a tuned circuit which is tuned to a desired working wave, the distributive capacity of said shielded capacitive and shielded inductive reactances being concentrated at the terminal connections of said opposite arms on said bridge-like arrangement, said tuned circuit being connected to the terminals of the opposite arms of said bridge-like arrangement and in parallel relationship with said load circuit.

2. A circuit coupling arrangement for coupling a symmetrical circuit with an unsymmetrical circuit comprising two separate means of high frequency alternating current voltage supply of like size and phase, each of said separate means of supply directly connected together in series and grounded at their junction points, the ungrounded portion of said high frequency alternating current voltage supply being connected to a load circuit, said load circuit connected to a bridge-like arrangement having terminal connections at opposite arms for optimum transfer of energy from said supply source, said arms having variable shielded capacitive and variable shielded inductive reactances, and a common control means providing a circuit which is tuned to a desired working wave, the distributive capacity of said variable shielded capacitive and variable shielded inductive reactances being concentrated at the terminal connections of said opposite arms on said bridge-like arrangement, said tuned circuit being connected to the terminals of the opposite arms of said bridge-like arrangement and in parallel relationship with said load circuit.

3. A circuit coupling arrangement comprising two separate sources of high frequency alternating current voltage, said separate sources being substantially of like size and phase, a circuit connecting said separate sources directly together in series, a connection between their junction point and the ground, a bridge like arrangement having pairs of opposed arms, each arm comprising capacitive and inductive reactances of absolute magnitude and equal to the geometric mean between the resistance of said load circuit and the total resistance of said separate sources of high frequency alternating current voltage, said capacitive and inductive reactances connected together in sequence in said opposed arms so that the capacitive and inductive reactance gives optimum transfer of energy from said supply source to said load circuit.

4. A circuit coupling arrangement comprising two separate sources of high frequency alternating current voltage, said separate sources being substantially of like size and phase, a circuit connecting said separate sources directly together in series, a connection between their junction point and ground, the ungrounded portion of said high

frequency alternating current voltage source being connected to a load circuit, a bridge like arrangement having pairs of opposed arms, each arm comprising a capacitive and an inductive reactance of absolute magnitude and equal to the geometric mean between the load resistance and the total resistance of said supply source, a load circuit connected between a pair of opposed points on said bridge like arrangement to form one diagonal thereof, means for connecting said series sources between another pair of opposed points in said bridge to form another diagonal thereof and a connection between a point on said bridge and ground so that the capacitive and inductive reactance give optimum transfer of energy from said supply sources to said load circuit.

5. A bridge-like impedance transformation network for coupling a symmetrical circuit with an unsymmetrical circuit comprising two separate supply means of high frequency alternating current, each separate supply means being connected together in series and grounded at the junction point, said bridge type impedance having four arms with shielded capacitive and inductive reactances providing a circuit which is tuned to a desired working wave, an input circuit connected from the outside of said separate supply means to the arms of said bridge, an output load circuit connected to the grounded junction point of said separate supply means and the arms of said bridge network at an opposite point from said input circuit to give optimum transfer of energy from said supply source to said output load circuit.

WERNER BUSCHBECK.
RICHARD BRUCKNER.