May 9, 1939. G. M. WRIGHT 2,157,312

SWITCHING ARRANGEMENT FOR HIGH FREQUENCY APPARATUS

Filed March 19, 1937 2 Sheets-Sheet 1

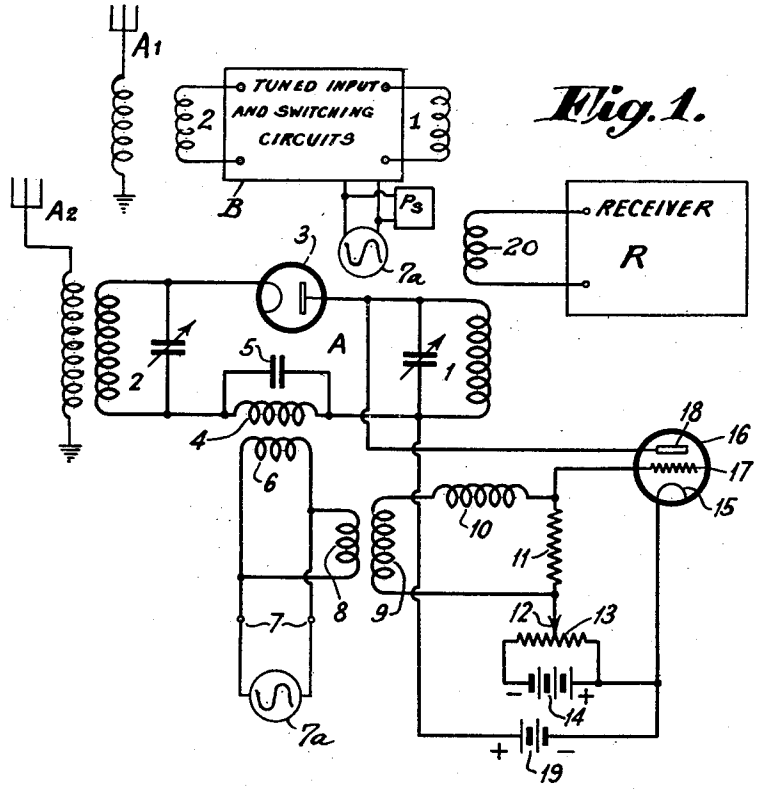


Fig. 1.

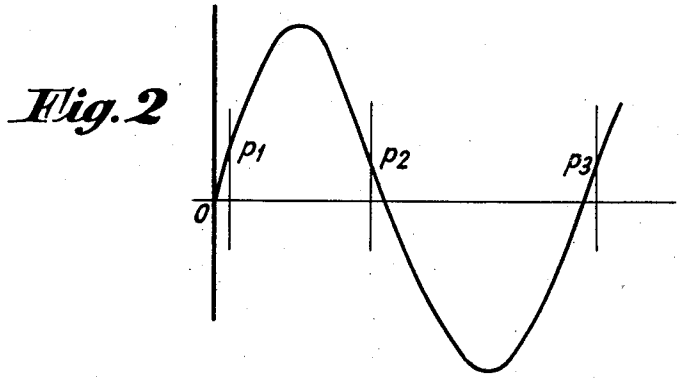


Fig. 2

INVENTOR
GEORGE MAURICE WRIGHT

BY H. S. Brown
ATTORNEY

May 9, 1939. G. M. WRIGHT 2,157,312

SWITCHING ARRANGEMENT FOR HIGH FREQUENCY APPARATUS

Filed March 19, 1937 2 Sheets-Sheet 2

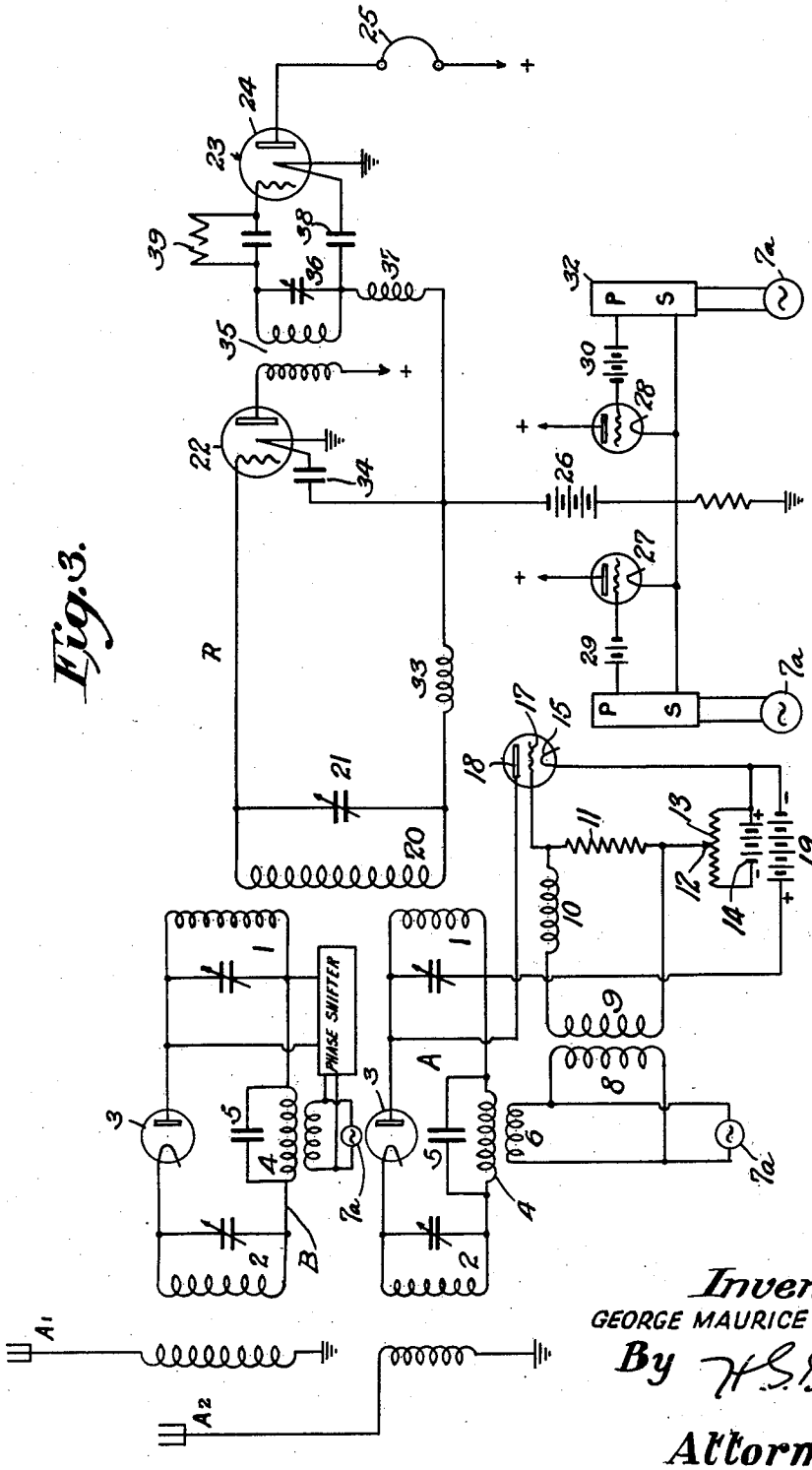


Fig. 3.

Inventor.
GEORGE MAURICE WRIGHT
By H. S. Grover
Attorney

Patented May 9, 1939

2,157,312

UNITED STATES PATENT OFFICE

2,157,312

SWITCHING ARRANGEMENT FOR HIGH FREQUENCY APPARATUS

George Maurice Wright, Woodham Ferrers (Bicknacre), England, assignor to Radio Corporation of America, a corporation of Delaware

Application March 19, 1937, Serial No. 131,790
In Great Britain February 3, 1936

7 Claims. (Cl. 250—20)

This invention relates to switching circuit arrangements for radio and other high frequency apparatus and seeks to solve a problem which arises in cases where it is required to switch a radio or other high frequency circuit of relatively low damping, for example, a parallel tuned circuit, into and out of connection with other apparatus at a relatively high frequency.

Examples of cases in which the problem the present invention seeks to solve arises, are so-called "diversity" radio reception systems, i. e. in radio receiving systems in which a radio receiver proper having the usual tuned input circuit is required to be associated successively with different aerials in a system of geographically spaced and/or differently polarized aerials, and direction finding systems in which a comparison of the reception effected by different aerial combinations is made by rapid switching between alternative aerial arrangements. Diversity receiving systems are, of course, employed mainly for the purpose of minimizing fading and in operation the receiver proper is in effect switched very rapidly from one aerial to the next.

A difficulty which occurs in systems such as those above mentioned is that when the connection of the receiver input circuit with one aerial system is broken prior to the connection of said receiver input circuit with another aerial system, the high frequency energy already in said input circuit does not cease immediately but, of course, decays in accordance with well known decrement laws. If the speed and frequency of switching is high, and in such receiving systems it usually is, there will still be flowing in the receiver input circuit at the instant when it is connected to one aerial in the system, a substantial amount of energy due to its previous connection with the preceding aerial. This fact obviously leads to difficulties and one of its disadvantageous results is that, in practice, it has usually been necessary hitherto to design the receiver input circuit (and incidentally also the other frequency selective tuned circuits of the receiver proper) to have a wider pass range than would be necessary for selectivity requirements only. To put this matter in another way, the difficulty above referred to has hitherto usually involved that in practice the receiver proper must be made less selective than it might be. This, in turn, involves that the amount of interference and undesired signal reception which takes place is in excess of that which would obtain were there higher receiver selectivity.

The principal object of the present invention is to solve the problem and remove or reduce the difficulties above referred to.

According to this invention, a system wherein relatively high frequency switching means or the equivalent thereof is provided for switching a high frequency circuit of relatively low damping into and out of connection with other apparatus is characterized by the provision of means for momentarily applying damping to said high frequency circuit so that the oscillations therein are quenched substantially immediately upon disconnection of said circuit by said switching means from said other apparatus.

One way of carrying out this invention as applied to a diversity radio receiving system as known per se, will now be described with reference to the accompanying diagrammatic Figure 1, the accompanying Figure 2 being an explanatory graphical figure. Fig. 3 shows the application of a circuit of this invention which is further carried out to include damping of other carrier resonance or selective circuits.

Referring to Figure 1, the input circuit of a receiver proper R consists of a parallel tuned circuit (tuned to the working frequency) which is connected successively to different aerials A_1 and A_2 of a system of geographically spaced aerials. Each aerial feeds into a parallel tuned input circuit A and B which, when said aerial is to supply energy to the receiver R, is connected to the input tuned circuit first mentioned. For the sake of convenience in description and simplicity in Figure 1, the means for connecting and disconnecting one only of the aerial tuned circuits to the received input circuit A will be described, it being understood, however, that similar means are provided with regard to the other aerial tuned circuits as indicated by block B which is a duplicate circuit of A, the whole arrangement being as stated, such that the different aerials are connected successively with the receiver.

The two tuned circuits in question, namely, the input tuned circuit and the aerial tuned circuit considered, are represented at 1 and 2, respectively. These two tuned circuits are connected together on one side through the anode-cathode space of a diode 3 and are also connected together at their other end through a transformer secondary 4 which is shunted by a high frequency bypass condenser 5. The primary 6 of the transformer is connected at 7 to a suitable source of substantially sine wave alternating current voltage of desired, predetermined frequency. The whole arrangement is such that for a substantial portion of alternate half waves of the applied

alternating current voltage, the diode 3 is conductive, while for the rest of the applied voltage wave the diode 3 is non-conductive, thus acting as an electronic switch. When the diode 3 is conductive, the two tuned circuits 1, 2 are effectively connected together and when the diode 3 is non-conductive the said two tuned circuits are effectively insulated from one another. Accordingly, the diode 3, in conjunction with the transformer and the source 7a of applied alternating current E. M. F., connected at 7 constitute a switching arrangement operating at a frequency determined by the frequency of the said applied E. M. F. This switching arrangement as so far described does not, per se, constitute part of this invention.

Fig. 2 shows in conventional graphical manner one wave of the switching frequency voltage applied at 7, voltage being plotted as ordinate values, against time, and represents, therefore, the rise and fall of E. M. F. across the secondary 4. Starting from the origin (0), when the E. M. F. is zero, the potential difference across secondary 4 rises in a direction to make the anode of diode 3 positive and at some predetermined point, such as P_1, the diode becomes conductive and remains so until a second predetermined point P_2, of approximately the same voltage value as P_1, is reached. The diode then becomes non-conductive and remains so until a third predetermined point, such as P_3, is reached.

Now, with an arrangement as so far described, there will be an appreciable period following each instant at which the diode 3 becomes non-conductive during which the oscillations in the receiver input circuit 1 will be dying away, and in accordance with this invention, this period is reduced substantially to zero by momentarily applying damping to the receiver input circuit 1 at the instants when the diode 3 becomes non-conductive. This damping is applied in the embodiment illustrated in Fig. 1 by means of the following additional apparatus:

In parallel with the primary 6 is the primary 8 of a second transformer whose secondary 9 is shunted by an inductance 10 in series with a resistance 11. The end of resistance 11 remote from inductance 10 is connected to a tapping point 12 (which may be adjustable) upon a potentiometer resistance 13 which is shunted by a battery or other suitable potential source 14, the positive terminal of which is connected to the cathode 15 of a valve or tube 16, which may be termed the damping valve. The junction point of the inductance 10 with the resistance 11 is connected to the grid 17 of the damping valve 16 and the anode 18 of the said damping valve is connected to one end of the receiver input circuit 1, i. e., to the anode of the diode 3. The cathode 15 of the damping valve 16 is connected through a suitable potential source 19 to the other end of said receiver input circuit 1, the negative terminal of the source 19 being connected to the said cathode 15. If the value of the inductance 10 is such that at the switching frequency the impedance offered thereby is large relative to the resistance 11 in series therewith, then the phase of the E. M. F. set up across the said resistance 11 will be approximately 90° different from the phase of the E. M. F. across the transformer secondary 9. By properly choosing the sense of the connections and suitably selecting the values of the circuit elements employed, it is obviously possible to cause the grid 17 to become positive with respect to its associated cathode 15 for a brief interval, i. e. momentarily, immediately upon the diode becoming non-conductive, i. e. when the "switch" is opened. When the grid 17 becomes positive, the anode-cathode space of the valve 16 becomes conductive and accordingly heavy damping is momentarily applied to the receiver input circuit 1. By adjusting the tapping 12 on the potentiometer resistance 13 it is possible to control the length of the momentary period during which damping is applied across the receiver input circuit 1, that is, the damping is made to last as long a period as desired. In this way, the oscillations in the receiver input circuit 1 are rapidly quenched when the "switch" is opened so that when the said circuit is connected to another receiving aerial, there will be substantially no oscillatory energy therein. Accordingly, the said input circuit 1 may be made more selective than would be possible were the present invention not employed.

For the sake of simplicity in description in the above embodiment, the application of damping has been described only with reference to the receiver input tuned circuit 1. In practice, however, damping is also applied in similar manner to such other carrier frequency resonant or selective circuits, as may be provided in the receiver, as shown by Fig. 3, wherein 20 is a coil coupled to the input circuit 1 and leads to the receiver R, which may comprise a tuning condenser 21, input tube 22, detector tube 23, whose plate 24 connects to phones 25. One side of the input circuit is connected to a voltage supply source 26 which is connected in series with the cathodes of tubes 27 and 28. The grids of tubes 27 and 28 are connected to a source of potential 29 and 30 which connects with phase shifting devices 31 and 32, which applies damping to the circuits in a manner mentioned above by means of the alternating current generator 7a. Other parts of this circuit comprise a radio frequency choke 33, a bypass condenser 34, coupling transformer 35, tuning condenser 36, choke 37, bypass condenser 38 and condenser and grid leak 39. The antenna switching and radio frequency input circuit, together with the damping means, is similar to that of Fig. 1, the operation of which is completely described as above.

It is not necessary in carrying out this invention to provide a valve or valves specially for the purpose of applying damping. For example, in the case of a receiver with thermionic valves coupling the various resonant circuits together, the necessity of providing valves specially for damping may be avoided by so arranging the circuit that the controlling E. M. F. (i. e. the E. M. F. set up across the resistance 11) causes the grid or grids of one or more of the said valves to become momentarily positive at the required instants and for the required short periods. In this way, one or more of the normally provided valves of the receiver itself may be caused momentarily to offer low grid-cathode resistance values and therefore to apply the necessary damping to quench oscillations in the tuned circuits connected to the said valves.

What is claimed is:

1. A system of relatively high frequency switching comprising electronic switching means for switching a high frequency circuit of relatively low damping into and out of circuit connection with other apparatus, a circuit including a resistance and an inductive element connected to the control grid of an electron discharge device coupled by a transformer to said electronic

switching means for momentarily applying damping to said high frequency circuit so that the oscillations therein are quenched substantially immediately upon disconnection of said circuit by said switching means from said other apparatus.

2. A system of relatively high frequency switching, comprising electronic switching means for switching a high frequency circuit of relatively low damping into and out of circuit connection with other apparatus, a high frequency circuit including an electron discharge device having means for being alternately rendered conductive and non-conductive to provide switching action, a frequency switching voltage source coupled by a transformer to said electron discharge device, a second electron discharge device coupled by a second transformer whose primary is in shunt with the primary of said first mentioned transformer, the secondary of said second transformer being connected to the input circuit of said second electronic discharge device, the output of said first mentioned electron discharge device being connected to the output of said second mentioned electron discharge device, and an inductance and a resistance connected in series with the secondary of said second mentioned transformer so that the frequency switching voltage will apply damping to said high frequency circuit when said second electron discharge device is rendered conductive by having said frequency switching voltage control the internal resistance of said second electron discharge device.

3. A system according to claim 1 wherein said second electron discharge device has its control grid connected to an inductance and a resistance element which is coupled by a transformer to said frequency switching voltage source so as to apply a voltage substantially in quadrature with the voltage applied from said frequency switching voltage to said first mentioned electron discharge device.

4. A system of relatively high frequency switching comprising electronic switching means for switching a high frequency circuit of relatively low damping into and out of circuit connection with other apparatus, a high frequency circuit including a radio receiver and an electron discharge device having means for being alternately rendered conductive and non-conductive to provide switching action, a frequency switching voltage source coupled by a transformer to said electron discharge device, a second electron discharge device coupled by a second transformer which is connected in shunt with said first mentioned transformer, a grid of said second electron discharge device connected to a phase shifting device including a resistance and an inductance which is coupled to said frequency switching voltage source so as to apply a voltage substantially in quadrature with the voltage applied from said frequency switching voltage source to said first mentioned electron discharge device and to apply damping to said high frequency circuit when said second electron discharge device is rendered conductive by having said frequency switching voltage control the internal resistance of said second electron discharge device.

5. A diversity radio receiving system, comprising a plurality of aerial circuits, electronic switching means for switching said aerial circuits into and out of connection with a receiver circuit, said electronic switching means comprising an electron discharge device having means for being alternately rendered conductive and non-conductive to provide switching action, a frequency switching voltage source coupled to said electron discharge device, a second electron discharge device coupled to the output of said first mentioned electron discharge device and said frequency switching voltage to momentarily apply damping to said high frequency circuit when said second electron discharge device is rendered conductive by having said frequency switching voltage control the internal resistance of said second electron discharge device.

6. A high frequency switching system for switching a high frequency circuit in and out of connection with other apparatus comprising in combination a plurality of high frequency input circuits coupled to said other apparatus, a transformer having its secondary coupled in series with one side of said input circuits, a diode coupled in series with the other side of said input circuits, a second transformer, a phase splitting circuit including an inductance and a resistance connected in series with the secondary of said second transformer, said phase splitting circuit also including an electron discharge device having at least anode, grid and cathode electrodes, a direct current source of bias potential having one side connected to the cathode circuit of said electron discharge device and its other side connected to one side of the high frequency circuits, said resistance having a variable tap connected in shunt with said biasing potential, the variable tap being connected to said resistance and one side of said second transformer secondary, the grid of said electron discharge device being connected to the junction point of said inductance and said resistance, the anode of said electron discharge device connected to one side of said high frequency circuits, the other side of said high frequency circuits connected to a second direct current source which is connected in series with the cathode circuit of said electron discharge device, the whole arrangement being such that said diode alternately becomes conductive and non-conductive and said electron discharge device becomes conductive to quench oscillations in said high frequency circuits substantially immediately upon its disconnection by the diode from the other apparatus.

7. A high frequency switching system for switching a high frequency circuit in and out of connection with other apparatus, comprising in combination a plurality of high frequency input circuits, synchronous means including a diode to alternately switch one of said high frequency circuits with said other apparatus and to periodically apply damping to said high frequency circuits so that oscillations will quench substantially immediately upon disconnection of the circuit, said means comprising an electronic switching member, a coupling device coupled to said high frequency circuit and said electronic switching member, a phase shifting device connected in shunt with said coupling device, and an alternating current generator connected to said coupling device so as to quench oscillations in said high frequency circuits when said diode alternately becomes conductive and non-conductive to quench oscillations in said high frequency circuits substantially immediately upon its disconnection with the diode from other apparatus.

GEORGE MAURICE WRIGHT.