Oct. 26, 1937. F. H. DRAKE 2,097,272

PROTECTIVE DEVICE FOR RADIO RECEIVERS

Filed June 24, 1933

Fig. 1.

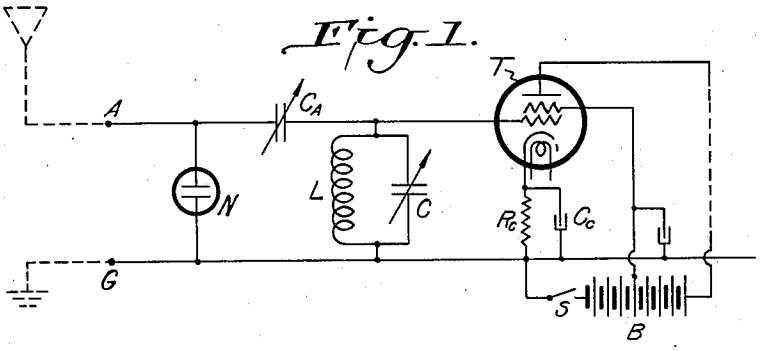


Fig. 2.

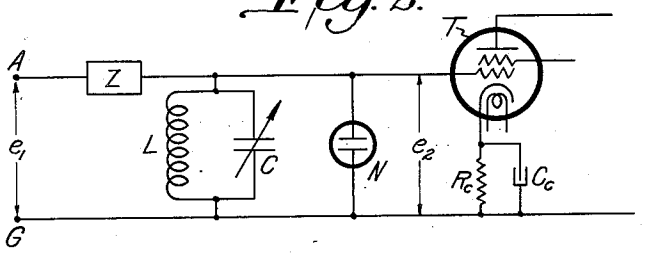


Fig. 3.

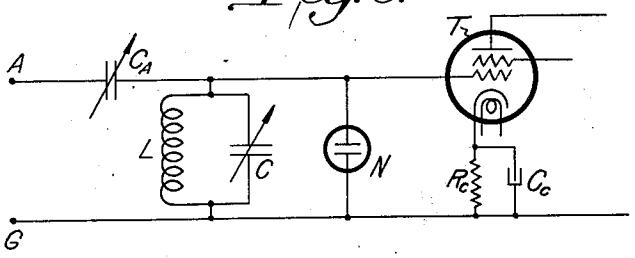
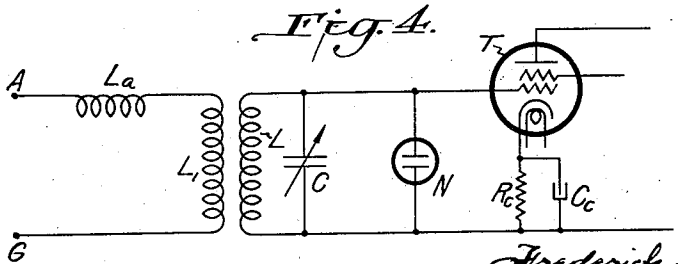


Fig. 4.



Inventor:
Frederick H. Drake,
By Byrnes, Townsend & Potter,
Attorneys.

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PROTECTIVE DEVICE FOR RADIO RECEIVERS

Frederick H. Drake, Boonton Township, Morris County, N. J., assignor, by mesne assignments, to Radio Corporation of America, New York, N. Y., a corporation of Delaware

Application June 24, 1933, Serial No. 677,513

2 Claims. (Cl. 179—171)

This invention relates to protective devices for radio receivers and particularly to a protective device for use with receivers having a tuned input circuit.

It has long been common practice when operating radio receivers in connection with, or adjacent to, radio transmitters, to disconnect the receiving antenna before transmitting. This is usually done through complicated relay systems. It is frequently undesirable, particularly at high frequencies, to use the same antenna for transmitting and receiving, and the present invention makes it possible, by using separate receiving and transmitting antennas, to eliminate the complication of antenna throw-over relays, without the danger of damaging the receiver by induction of voltage from the local transmitter into the receiving antenna.

When a radio receiver with a tuned input has a large voltage impressed upon its input, damage may result in a number of places. First, the voltage may produce sparks across various circuit elements, especially the tuned circuit elements connected between grid and filament of the first tube. If elements in the tuned circuit do not spark over first, the voltage may rise sufficiently to produce a spark between the grid and some other element in the vacuum tube fed by the input circuit. Such discharges are particularly dangerous if the receiver is used where explosive fumes may collect, as in airplanes; and in general will progressively reduce the insulating values of the various dielectrics in the circuit.

For example, when a receiver is exposed to a strong local transmitter, the voltage at the input terminals of the receiver may easily be several hundred volts and, if the input circuit is near resonance with the frequency of this impressed voltage, the actual voltage across the input of the first tube may be many times this voltage, e. g., if the step-up in the input circuit is ten, there will be several thousand volts impressed across the grid-cathode of the first tube. Usually successive tubes and stages in the amplifier will suffer less than the first because the first tube will block. This radio frequency voltage in itself is dangerously high and if, furthermore, as is the usual practice, a resistance and condenser are used in the cathode circuit to provide bias voltage, there may be generated across this resistance and condenser a high direct current voltage. In actual practice, a direct current voltage of 1500 volts has been observed when a receiver has been exposed to a 50 watt local transmitter emitting the resonant receiver frequency. Usually this voltage will break down the condenser and render the receiver inoperative.

In the past, adjustable or fixed spark gaps have been used to safeguard receivers against excessive voltage. These are unsatisfactory because of the hazard of explosive fumes and deterioration of electrodes. It has also been proposed to protect the input circuit and first tube by shunting a negatively-biased diode across the input terminals of the tube. Such an arrangement is bulky, requires a source of current for biasing the diode to preserve the high impedance of the input circuit for input voltages of a safe magnitude and, what is of more importance, the capacity of the diode is shunted across the input circuit and so reduces seriously the antenna coupling and hence the signal-noise ratio of the receiver.

In fact, while such a protective device may appear to afford some advantages, a more satisfactory receiver design is obtained by omitting the diode protective device and employing circuit elements of a physical construction which will not be affected by abnormally high voltages.

An object of the invention is to provide a protective device, or a radio receiver including a protective device, that operates reliably and automatically to prevent damage to the receiver when it is exposed to strong radio fields. An object is to provide a radio receiver including a reliable and automatic protective device which protects the various elements of the receiver from damage when the receiver is connected to a collector structure in proximity to an operating radio transmitter. More particularly, an object is to provide a radio receiver including a tuned input circuit of high parallel impedance across which enormous radio voltages tend to build up when the receiver is located in a strong radio field, and a low-pressure gaseous discharge tube shunted across the tuned circuit to reduce the impedance of the circuit when the radio voltage exceeds a predetermined value.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawing, in which:

Figs. 1 to 4, inclusive, are fragmentary circuit diagrams of radio receivers embodying the invention.

In the drawing, the reference characters A, G identify the receiver terminals for receiving connections from an antenna structure and ground,

respectively, to impress received radio signal voltages upon the tuned input circuit L, C of the first tube T through a coupling condenser C_A. In accordance with the present usual practice, the cathode circuit of the tube T includes a bias resistor R_c shunted by a radio frequency by-pass condenser C_c. When the receiver is a part of a two-way communication system which includes a radio transmitter, a switch S may be so inserted in the circuit of the direct current source, here indicated schematically as a battery B, as to remove the energizing potentials from the screen grid and plate. This permits the cathodes of all receiver tubes to be continuously heated during operation of the transmitter, thus rendering the receiver operable as soon as switch S is closed.

In accordance with the invention, a gaseous discharge tube or current-limiting tube N is shunted across the receiver terminals A, G (Fig. 1) or across the tube input terminals (Figs. 2, 3 and 4) to prevent the radio voltage from rising to abnormal and dangerous values when the receiver is located in a strong radio field of the frequency to which the LC circuit is tuned. The tube N, hereinafter referred to as a "neon tube" as it is customary to employ neon though other gases may be used, consists of a small glass envelope containing two wires in an atmosphere of neon, argon or the like, under such pressure that ionization occurs at an alternating current voltage of approximately 100 volts or less.

The arrangement of the receiver elements of the Fig. 2 and Fig. 3 circuits is similar to that of Fig. 1, except that a generalized coupling impedance Z is shown in Fig. 2, but the protective neon tube is shunted directly across the tube input terminals. As shown in Fig. 4, the coupling impedance may be an inductance L_a in series with the coil L_1 which is coupled to coil L of the tuned input circuit.

The necessity for and the method of operation of the protective device are the same in all of the illustrated circuits, and will be explained with reference to the more general diagram, Fig. 2.

In normal reception, the circuit LC is tuned for the frequency of the desired signal in order that an antenna voltage e_1 across the receiver terminals A, G will establish a maximum radio voltage e_2 at the tube input terminals. In this condition, the impedance between the input terminals of the tube is very high and the actual voltage e_2 assumes a value, as is well known, which may be many times the voltage e_1 impressed upon the circuit from the antenna. This effect, sometimes known as "antenna-circuit step-up" is employed in all well designed receivers of the type having a tuned input circuit, and may result, in a practical receiver, in a value of e_2 which is from 5 to 30 times the value of e_1 depending upon the form and constants of impedance Z, the desired signal-to-noise ratio, and other considerations of radio receiver design which form no part of this invention.

The point to be emphasized is that at resonance for any given value of coupling impedance Z, a voltage e_2 across the tuned circuit and the first amplifier tube is developed which is usually many times e_1 and that this voltage step-up requires, for its existence, a tuned circuit at LC of relatively high parallel impedance at the frequency of maximum voltage step-up. Now suppose that a stray voltage of relatively large value and approximately the same frequency is impressed on the input terminals, it will be stepped up in the same way and may damage the receiver as described above. In a practical case, with a receiver not equipped with a gaseous tube and designed for an input voltage step-up of about 10, radio voltages of the order of 2000 volts have been measured across the tuned input circuit when the receiver was near a local transmitter of relatively low power. One practical consequence of this, aside from possible damage to the tube and the elements of the tuned circuit, is the generation by grid rectification, of a high direct current voltage across resistor R_c and condenser C_c; this rectification will occur if the tube cathode is left heated, as is frequently done in receive-transmit operations, even though the plate voltage is turned off by opening switch S. In the example mentioned above, a direct current voltage of over 1500 volts was produced across the bias elements R_c, C_c, with an ordinary receiving tube when a high value of R_c was used. But the limiting action of the gaseous tube, even though it is an extremely small device as described, is positive and complete, provided the tube is designed with proper power-dissipating capacity. What actually happens is that when voltage e_2 reaches the non-damaging ionizing potential of tube N, current flow is established in this tube, and in the case of a tube containing neon at suitable pressure the resistance of the tube instantly drops from a substantially infinite value to a value much lower than the parallel impedance of the circuit LC. The voltage e_2 is thus held at a value only slightly greater than the ionizing potential of tube N, even though the original powerful transmission is maintained, or even though impressed voltage e_1 is increased. The reason for this is that after ionization the impedance of tube N decreases as the voltage across it increases. The tube N is self-restoring, and the protective effect occurs without appreciable lag for an indefinite period depending upon the life of tube N.

In actual tests, it has been demonstrated that the voltage established across the by-pass condenser C_c dropped from values of several hundred volts to a value of about 25 or 30 volts when the protective tube was inserted in the position shown in Fig. 2. The advantage of this location of the protective tube, over the arrangement shown in Fig. 1, is that the antenna step-up establishes a much higher voltage across condenser C of the tuned circuit than exists across the input terminals A, G, and, obviously, the protective tube is best located at the region where the high voltages tend to arise.

The introduction of the neon or gaseous discharge tube into the input circuit does not have any substantial effect upon the design or performance of the input circuit since the inherent capacity between the elements of the tube and their leads may be made of the order of one micromicrofarad. The addition of this minute capacity in shunt with the inductance L does not destroy the possibility of obtaining a desired high antenna step-up by the customary design of the circuit elements Z, L and C.

I claim:

1. The combination with an amplifier tube having a cathode cooperating with a control grid and a plate, of a plate-cathode output circuit including a grid biasing resistor shunted by a by-pass condenser, a parallel tuned circuit comprising a coil shunted by a tuning condenser connected across said control grid and the low potential end of said resistor whereby said coil and biasing resistor provide a path for direct current

between said control grid and cathode, connections including a coupling impedance for connecting said tuned circuit to a source of signal voltage, means for heating the cathode of said tube, and a gaseous discharge tube having two electrodes only shunted across said tuned circuit, said tube ionizing to reduce the impedance thereof when the voltage across the same is less than the breakdown voltage of said by-pass condenser.

2. A radio frequency amplifier stage comprising a vacuum tube having a cathode, a control grid and a plate, an input circuit connecting said control grid and cathode and including a parallel resonant portion consisting of a coil shunted by a tuning condenser, said turning condenser being adjustable to tune said coil through a range of radio signal frequencies, an output circuit connecting said cathode and plate, a resistor common to said input and output circuits, a by-pass condenser shunted across said resistor, an antenna coupled to said input circuit, and a gaseous discharge tube having two electrodes only and said electrodes being directly connected respectively to the opposite sides of said tuning condenser and the capacity between said electrodes being negligible as compared to the capacity value of said tuning condenser and the gas of said discharge tube ionizing when the voltage between its electrodes is substantially less than the breakdown voltage of either said tuning condenser or said by-pass condenser whereby both said condensers are protected from excessive voltage variations.

FREDERICK H. DRAKE.