The present invention relates to a remotely-controlled receiver for the reception of audio frequency control impulses transmitted from a central control station by way of the conductors of an energy distribution network having a tuned series resonance circuit connected therewith, which circuit co-operates with a sensitive relay. The characteristic feature of the invention is that the sensitive relay is a multi-electrode cold cathode glow-discharge relay and that for the purpose of an increased amplitude limitation at relatively high impulse voltages and increased operating safety as well as for obtaining a definite and reliable ignition of the glow discharge relay, the impulse voltage across the coil of the series resonance circuit is applied by way of a capacitively loaded rectifier circuit having a short time constant to a control electrode path which is independent of the other electrode paths.

The receiver according to the invention is suitable for the reception of audio frequency control impulses which are superimposed on the main voltage or the main current of a distribution network (main frequency normally 40, 50 or 60 cycles/sec.), by means of parallel or series feed. The audio frequency control impulses are injected into the network at a point which is central in respect of the distribution of energy, and which may be at a high-voltage, medium-voltage or low-voltage stage. The injection, which in general is 3-phase, may be effected either with the use of a coupling quadrupole, which may be a band filter or a simple resonant circuit, or by simple capacity or transformer coupling. The power injected is so chosen that at the electrically most remote point of the network the available control voltage is at least as large as the maximum value of the voltage disturbances naturally occurring in the network. In general, a voltage of 800 mv. to 1 volt will be the lowest limit of the received voltage for reliable operation of remotely-controlled receivers.

In the receiver according to the invention, the control impulses are augmented by a series resonance circuit, the augmented control impulses are rectified and are applied to the control electrode of a multi-electrode glow-discharge relay. In addition to its great sensitivity and its high adaptability to the supply voltages, the advantage of the multi-electrode relay resides in the possibility of making the control circuit of the relay independent of the anode circuit. The glow-discharge relay does not require any heating current, does not consume any current when inoperative, and is capable of instantaneous operation. As the anode current is considerable, the anode circuit can include a standard robust direct-current relay. The direct-current relay may for example operate a known synchronous selector which runs synchronously with an impulse sender rotating at the control station and which energizes for example relays which are connected with the apparatus to be operated.

To start the synchronous selector it is necessary to have an impulse from the control station, the so-called starting impulse. A further so-called control impulse is necessary for actuation of any apparatus which is to be controlled, e.g. the switch of a boiler, etc. During one rotation it is possible to transmit as many commands in succession as there are contacts or control positions on the synchronous selector.

The invention will now be described more fully with reference to the accompanying drawings.

Fig. 1 shows a circuit diagram of a remotely-controlled receiver with a four electrode glow-discharge relay and direct coupling to the resonant circuit.

Fig. 2 shows diagrammatically the arrangement of the electrodes of a four electrode glow-discharge relay.

Fig. 3 shows a transformer coupling for the series resonant circuit.

In Fig. 1, the cold cathode glow-discharge relay 1 has an anode A, control grid G1, screen grid G2 and a cathode K which also is of grid-like construction. The small main transformer 2 (0.5 watt) has its primary winding 2′ connected to the mains 11, 12. One end 40 of the secondary winding 2″ of the transformer 2 is connected by way of an anode circuit with the anode A of the relay 1. The anode circuit consists of the parallel connection of a normal direct current relay 21 (taking 1–5 watts on make) with a smoothing condenser 25, a protective resistance 19 being provided in series with the condenser. Voltage is applied to the grid G1 from the tapping 41 by way of a protective resistance 18. The cathode K is connected to the other end 43 of the secondary winding 2″. In the rest condition of the remote control system, a voltage of normal main frequency is applied to the grid G1 from the tapping 42 on the secondary winding 2″ by way of the coil 14, the rectifier 15 and the protective resistance 18. The coil 14 and the condenser 13 constitute a series resonance circuit tuned to the frequency of the control impulse voltage. This frequency lies in the frequency range of 300 cycles/sec. to above 50,000 cycles/sec.
cycles/sec., the so-called medium frequency band. So long as the relay 1 does not strike and with a suitable choice of the value of the condenser 17, the voltage on the grid $G_1$ is practically the same as the voltage at the tapping $T$. A synchronous motor $S$ operated by the main voltage drives the cam disc 4 and the wiper arm 5' of the selector 6. The motor 3 is connected on one side to the terminal 11, and on the other side to the terminal 5' of the contact 5 as well as to the starting contact 23. In the example shown, the selector 6 has a starting contact 23 and sixteen control contacts. The direct current relay 21 controls a switch 22, one contact of which is connected to the main terminal 12 whereas the other contact is connected to the wiper arm 6' of the selector 6. In the rest position, as shown, the cam 4' of the cam disc 4 opens the contact 5, the terminal 5' of which is connected to the main terminal 12. In the present example, the windings of the four alternating current relays 5, 8, 9, 10 are connected on the one hand to the terminals 24 . . . 31 of the selector 6, and on the other hand to the main terminal 11. Voltage can be supplied to the apparatus to be operated, by way of the contacts 32, 33, 34 and 35.

The mode of operation of the receiver is as follows:

So long as there are no control impulses in the mains 11, 12, the electrodes of the relay 1 are subjected solely to the medium-frequency voltages from the transformer 2. These voltages are so chosen that the relay 1 does not ignite either on main distortions of the usual amplitude or on the occurrence of voltage fluctuations which may amount to 15%. When however medium frequency control impulses are superimposed on the main voltage at the control contact, then these control voltages reach the resonant circuit consisting of condenser 13 and coil 14, and augmented by resonance are fed to the capacitively loaded rectifier circuit consisting of rectifier 15, protective resistance 16 and condenser 17. In consequence, rectified impulses appear across the condenser 17 at the terminals 43, 44 which are also the terminals for the electrode path from cathode to control grid, so that if the impulses are of sufficient voltage they cause immediate striking between the control grid $G_1$ and the cathode $K$. In view of the grid-like character of the cathode $K$, the discharge extends to the path between cathode and screen-grid and thus to the cathode-anode path.

As soon as the relay 1 strikes as a result of the first impulse, the so-called starting impulse, a rectified current flows in the direct current relay 21 as the relay 1 acts as a rectifier for its anode circuit. This current energizes the relay 21 so that the switch 22 is closed and the contact 5 is bridged for the duration of the starting impulse and so long as the wiper arm 6' of the selector 6 is in contact with the starting contact 23. In this way the motor 3 is energized and drives the selector 6 synchronously with a selector at the control station. This starting impulse is followed by control impulses which control the apparatus to be actuated as required. If, for example, a boiler (not shown) connected to the terminal 32 is to be operated in accordance with a predetermined programme, then the wiper 6 is set in operation by means of a starting impulse as described above. As soon as the selector at the control station and synchronously therewith the wiper 6' reach the control contact 24, a control impulse is sent over the mains 11, 12 to cause the relay 1 to strike as explained above; the switch 22 closes and the upper winding of the relay 1 is energized by way of the wiper 6' and the contact 24 so that the terminal 32 is connected to the main terminal 12, and in consequence the boiler is switched on. When the wiper 6' has made a complete rotation, the cam 4' opens the contact 5 and switches off the motor 3. After the motor is stopped, the wiper 6' is again in its initial position, i.e., on the contact 23 and is ready for a new switching operation. Each command requires a corresponding control impulse, i.e., the rotation of the wiper does not in itself cause a switching operation. The possibility of mistakes due to disturbance impulses is thereby greatly reduced, as an individual disturbance impulse which might cause the wiper to move does not suffice to initiate a false switching operation. It is only if further disturbance impulses of sufficient magnitude arise at the precise instant at which the wiper 6' engages one of the contacts 24 . . . 31, that a false switching can be initiated. In general, the probability of this is very small, provided that the supply voltages are suitably chosen.

In practice, it is important that such a remotely-controlled receiver should be capable, without special provision, of receiving impulses of different amplitude. If, for example, the lower limit of reception is 1 volt, then it must be possible to receive voltages of 10 to 15 volts without using a change-over mechanism. In the present invention, this requirement is met in a simple manner by the use of a capacitively loaded rectifier circuit, which due to the curve characteristic of the rectifier affords a natural amplitude limitation. If, for example, the voltage received increases in the proportion of 1:10, then the rectified control voltage applied between control grid and cathode increases only in the proportion of 1:4 to 1:5.

Amplitude limitation can also be obtained by suitable choice of the dimensions of the coil 14, because the rectified medium volts reach the resonant amplification is smaller. If the two effects are combined in a suitable manner, then with a received voltage ratio of 1:10, the ratio in the rectified voltage is from 1:2 to 1:3.

As seen from Fig. 2, the surface of the electrodes decreases from the control grid to the anode, the anode being a rod which is surrounded electrically by the other electrodes. As the surface of the anode is relatively small, a discharge with the anode as the effective cathode is avoided, in spite of the alternating current supply. By the use of a rectifier in the control grid circuit, a reverse ignition is avoided to a large extent even with abnormally large control voltages, provided the rectifier is so connected that the ignition in the discharge path between control grid and cathode always occurs in the positive sense. The rectifier also has a beneficial effect in respect of sensitivity, as the sensitivity of the glow-discharge relay decreases depending on the gas content, with increasing frequency.

If the capacitive loading of the rectifier circuit is appropriately chosen, it affords the advantage that the charge on the condenser 17 at the moment of ignition causes a practically instantaneous instantaneous ignition of the glow-discharge relay, whereas with the same time at the remaining medium frequency voltage is conducted away. In contradistinction to known methods, the condenser 17 is not a storage con-
denser for a relatively long period, but the receiver according to the invention operates practically without delay, the time interval between the dispatch of a signal and the striking of the relay being smaller than 1/50 second. In this way, it is possible to allow the individual control impulses to follow one another at intervals of 1 second for instance, so that for example for transmitting 50 double commands with a two stage decade selector, a time of only 100 seconds is required.

As seen from Fig. 1, the control path G—K in the relay 1 lies outside the main discharge path A—K. This arrangement has the advantage that the action of the main discharge path A—K on the control path G—K is negligibly small.

In Fig. 3, the coil 14 of Fig. 1 is replaced by a coupling transformer 14', the main inductance of which in conjunction with the condenser 13' constitutes the series resonance circuit. The transformer ratio m_1/m_2 is greater than unity. Instead of a main transformer 2 (Fig. 1), use may be made in the circuit of Fig. 3 of a high resistance voltage divider, consisting of the resistances 49, 50 and 51. The remaining parts of the receiver are identical with those shown in Fig. 1. The mode of operation is similar to that of the receiver of Fig. 1, with the difference that the increased voltage is stepped up by the coupling transformer 14' so that a somewhat better resonance quality is obtained than in the receiver of Fig. 1. This circuit arrangement may be advantageous at lower control frequencies (e.g., 1 kilocycle/sec.) as in this range the quality of resonance is less than at higher frequencies. Naturally, in the arrangement of Fig. 3, it is possible to employ a mains transformer connected to the tapping 41' and 42'.

The embodiments described with reference to the drawing are given solely by way of example. It is for instance possible to replace the four electrode glow discharge relay by a five-electrode relay, in that to afford better adaptation to the supply voltage, a further electrode is introduced between cathode and anode and is supplied by way of protective resistance similarly to the screen grid G_2 in Fig. 1. The coupling transformer 14' in Fig. 3 may be constructed as an auto-transformer, provided that the supply voltages are derived from a mains transformer as in Fig. 1. Also the anode circuit of the receiver may be different. Moreover, it is possible to construct receivers without synchronous selectors, either by operating with only one control frequency and causing some known relay system such as stepping switches to operate in the anode circuit, or else by operating with a different control frequency for each group of apparatus to be actuated. In place of a supply transformer, use may be made of a voltage divider provided that the mains voltage is higher than the required anode-cathode voltage. If however the main voltage is equal to the required anode-cathode voltage, the voltages for the screen grid and the control grid may be derived from a high resistance voltage divider. Capacitive voltage dividing arrangements may be employed if desired. The protective resistance in the anode circuit may be included in the direct anode lead. In Fig. 1, the condenser 17 could be connected to the tapping 42 instead of to the cathode K. In Fig. 1, the rectifier 15 may be connected the other way round, if the one end of the coil 14 is connected to the end 43 of the mains transformer instead of to the tapping 42, and the cathode K and the cathode side of the condenser 17 are connected to the tapping 42.

I claim:

1. A remotely controlled electric receiver for the reception of audio frequency control impulses from a control station over the main lines of an electric power distributing network, said receiver comprising a multi-electrode glow discharge relay having an anode and a cold cathode, a grid between said anode and said cathode, and a control grid disposed at the side of said cathode which is distal with respect to said anode, a capacitively loaded rectifier of small time constant wired to said control grid, and a series resonance circuit wired to said rectifier and to said main lines and tuned to the frequency of the control impulse voltage impressed on said main lines.

2. A remotely controlled electric receiver as defined in claim 1, said series resonance circuit consisting of a coil and a condenser connected in series, and said rectifier being wired to the electric conduit between said coil and said condenser.

3. A remotely controlled electric receiver as defined in claim 1, said series resonance circuit consisting of a coil and a condenser connected in series, and said rectifier being wired to the electric conduit between said coil and said condenser and in parallel with said coil.

4. A remotely controlled electric receiver as defined in claim 1, said series resonance circuit consisting of a condenser and a step-up transformer having a primary coil connected in series with said condenser, both being connected with said main lines, and having a secondary coil wired in series with said rectifier.

5. A remotely controlled electric receiver as defined in claim 1, comprising a transformer having a primary coil wired between two of said main lines and a secondary coil wired to the electrodes of said relay.

6. A remotely controlled electric receiver as defined in claim 1, comprising a high resistance voltage divider wired between two of said main lines and to the electrodes of said relay.

GUNTER H. ISAY.

No references cited.