

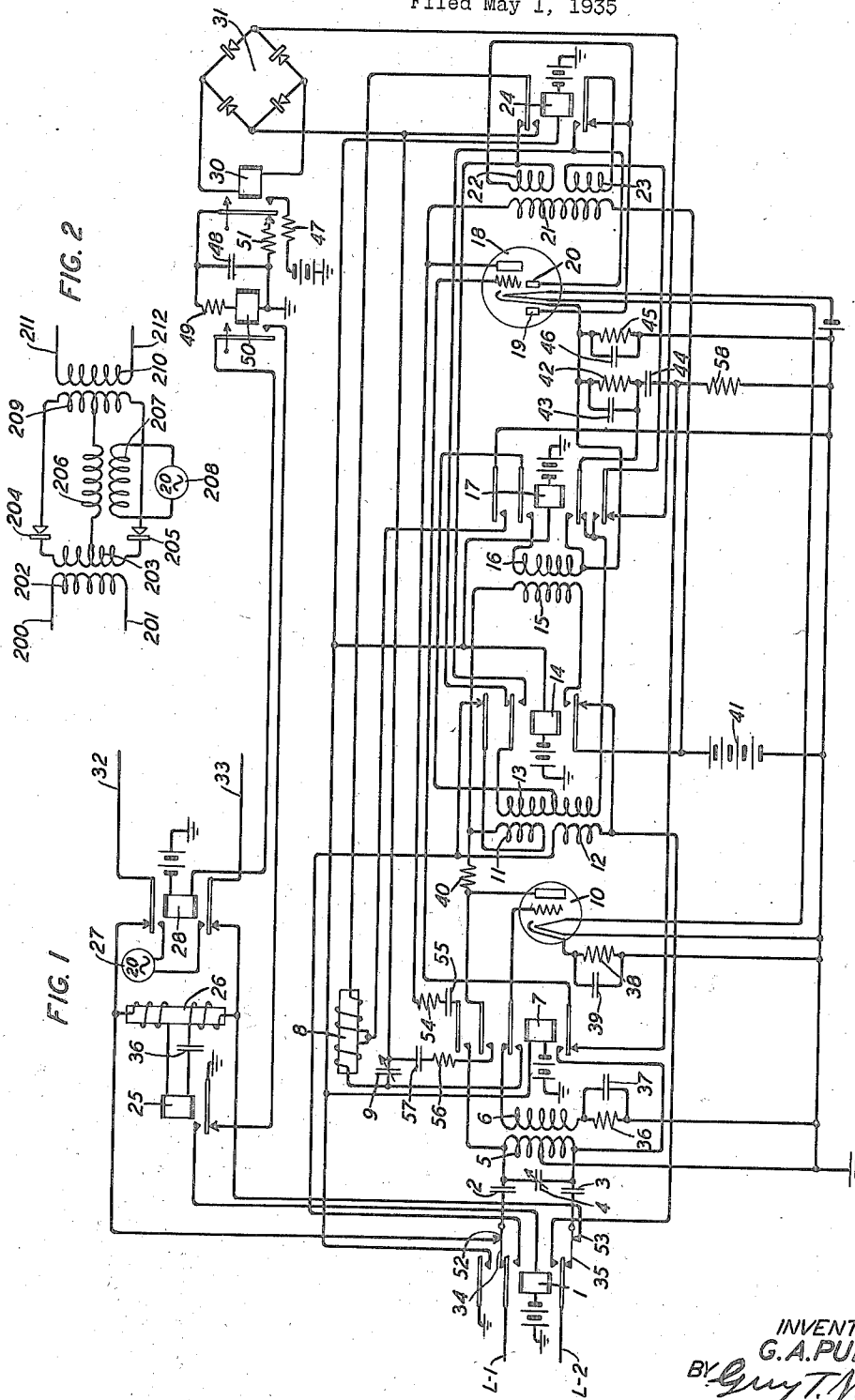
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CIRCUIT FOR VOICE FREQUENCY RINGING AND FOR VOICE FREQUENCY CURRENT

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This invention relates to a combination incoming circuit for voice frequency ringing and outgoing circuit for voice frequency ringing current and particularly to relays and relay circuits adapted to organize certain electrical elements, including tuned circuits and electric discharge tubes, to achieve a circuit adapted to perform either one of the above indicated functions at the will of an operator.

In a more specific aspect the invention has to do not only with a voice frequency ringing current, whether used as incoming or outgoing energy, but such a current modulated by a relatively low frequency, the voice frequency wave playing the role of a carrier and the modulation component, which may have a frequency of the order of 20 cycles per second, adapted to condition the local ringing apparatus, or the like, at the receiver switchboard.

Although fully applicable to carrier wave or voice frequency systems generally, the invention has perhaps a special application to a class of communication circuits which may be treated, in some aspects, as intermediate between a carrier telephone circuit and a conventional telephone circuit, that is, a telephone circuit employing unmodulated waves. Such a circuit would perhaps not be sufficiently long to justify the use of the carrier principle to transmit the voice although long enough to simulate the usual conditions of toll circuits and therefore to introduce certain transmission problems not found in conventional localized telephone systems. An example would be a circuit which includes a short radio link. Because the radio link would ordinarily have to be positioned as determined by special considerations of expediency, not having to do with the length of telephone circuits connecting the link with urban switchboards, it frequently happens that these connected telephone circuits are of this class. The difficulty relates to the transmission of the ringing impulses. A 20-cycle current, to which telephone terminal switchboards are adapted by design, although they are usually adapted also for direct current, cannot efficiently be transmitted over such telephone circuit; neither could a voice frequency ringing current, as such, be used as a practical matter to actuate the ringing circuits at the terminals because of the liability of false operation due to frequency components of speech. The solution involves the employment of the 20-cycle current used for the immediate ringing operation as a modulation, for example, an interruption, of a

voice frequency carrier current, such as a 1000-cycle current.

The invention makes possible a conversion of an incoming voice frequency ringing circuit, as above, and therefore involving perhaps a tuned circuit for selection of the incoming modulated wave, an amplifier of said wave, a detector of said modulated wave and an amplifier and selector for the eventual 20-cycle wave, into a corresponding outgoing circuit for generating the 1000-cycle carrier wave modulated by a 20-cycle wave for transmission to the ringing circuit at the opposite terminal. The outgoing circuit, as reorganized from the incoming circuit utilizes a certain tuned circuit and amplifier tube as components of the 20-cycle current source, and a certain other tuned circuit and the detector as components of the 1000-cycle carrier wave generator and modulator.

It is the object of the invention to promote the development of circuits capable of such reorganization, with its attendant economy of plant, and to achieve such reorganization with a maximum of simplicity and use of conventional and most generally available means, such as relays and relay circuits.

A specific feature of the invention relates to one of the component circuits, namely the outgoing circuit, and comprises a means for modulating the output of the vacuum tube of the voice frequency carrier oscillator by periodic interruption without reaction, or effect generally, on the tube in its primary function as a generator of carrier waves. The means therefore in part comprises circuit elements in the path of the output oscillator current which, with respect to the interrupting wave impressed thereon have a certain balanced relation with respect to the output electrodes of the oscillator tube so as to prevent plate modulation therewith, and a simple series, that is unbalanced, relation with respect to the flow of the oscillator current therethrough.

The above objects and features, as well as others more fully hereinafter appearing, are exemplified by the circuits and structure set forth in the following description, and illustrated in the accompanying drawing in which:

Fig. 1 discloses a combination system of the invention; and

Fig. 2 discloses an alternate modulator which might be used in place of the modulator shown in Fig. 1.

Referring now particularly to Fig. 1, an embodiment of the invention is shown with the necessary circuit elements, switching relays, etc.,

so that the apparatus may be made to perform two distinct functions. In its normal condition the circuit elements are so connected that a carrier wave modulated at a lower frequency, say a ringing frequency, incoming over line wires L—1 and L—2 is demodulated, relay 28 operated and ringing current from a local ringing supply 27 is applied to conductors 32 and 33 as the signal of an incoming call. On the other hand, if ringing current from the local supply (not shown) is applied to conductors 32 and 33 the switching relays are operated and the circuit elements function to generate a carrier wave modulated at the lower frequency and the modulated wave is transmitted over line wires L—1 and L—2 to the distant point as a ringing signal.

The operation of the circuit when operating as a demodulator will now be described in detail. When an incoming carrier wave, modulated at a lower frequency, say 20 cycles per second, is impressed on line wires L—1 and L—2 it first encounters a line filter composed of transformer winding 5 and variable condenser 4, condensers 2 and 3 being used to exclude any direct current which may be present on line wires L—1 and L—2. This circuit is traced from line wire L—1 through contact 34 of relay 1, condenser 2, through transformer winding 5 shunted by tuning condenser 4, through condenser 3 and contact 35 of relay 1 to line wire L—2. Condenser 4 is adjusted so that the filter elements resonate at the carrier frequency for which the system is designed and allows only this frequency to be impressed on transformer winding 6 which is inductively coupled to winding 5. Retard coil 26, relay 25 and condenser 36 are also connected across line wires L—1 and L—2 but are designed to resonate at the lower frequency and to have a high impedance at the carrier frequency and do not therefore have any appreciable effect on the operation of the circuit while operating as a demodulator.

The carrier frequency generated in transformer winding 6 is amplified in vacuum tube 10 prior to being demodulated. Vacuum tube 10 functions in the conventional manner, the upper terminal of transformer winding 6 being connected through the upper, inner, back contact of relay 7 to the grid and the lower terminal being connected through resistance 36 shunted by condenser 37 in series with resistance 38 shunted by condenser 39 to the cathode. The plate circuit is traced from the plate of vacuum tube 10 through resistance 40, winding 11, upper outer back contact of relay 14, transformer winding 12, lower back contact of relay 14, plate battery 41 to the cathode of vacuum tube 10 through resistance 38, shunted by condenser 39, the voltage drop across the latter resistance being used as a grid bias for vacuum tube 10.

The amplified carrier signal appears on the secondary transformer winding 13 and is demodulated by rectification in vacuum tube 18. Vacuum tube 18 is a so-called duplex-diode-triode and is arranged to perform the operations of rectification and amplification of the rectified signal in the same envelope. To accomplish this two anode elements are provided in addition to the usual grid, plate and cathode elements. The rectifying circuit is traced from the upper terminal of transformer winding 13 through the upper inner back contacts of relay 14, anode 20 and cathode of vacuum tube 18 to the lower terminal of transformer winding 13, through resistance 42 shunted by condenser 43. A demodulated

ringing frequency wave is accordingly built up in the usual manner across resistance 42 which is impressed upon the grid and cathode elements of tube 18. This will be apparent from the fact that the upper terminal of resistance 42 is connected directly to the cathode of vacuum tube 18 while the lower terminal of resistance 42 is connected through condenser 44 and the lower back contact of relay 7 to the grid of vacuum tube 18. The plate circuit of the triode element of vacuum tube 18 is traced from the plate of the tube through transformer winding 21, plate battery 41 to the cathode of vacuum tube 18 through resistance 45 shunted by condenser 46, the voltage drop across resistance 45 being applied through resistance 58 and the circuit already traced to the grid of the triode element of vacuum tube 18 as a grid bias.

Transformer windings 22 and 23 which are inductively coupled to winding 21 and receive the amplified ringing current wave are connected through a ringing current filter to a load circuit consisting of a full-wave rectifier and a ringing relay combination. The purpose of the ringing current filter is to exclude extraneous frequencies from the load circuit. This circuit is traced from the inner terminal of transformer winding 22, upper back contacts of relay 24, the winding of retardation coil 8, variable tuning condenser 9 to one input terminal of full-wave rectifier 31. From the other input terminal of rectifier 31 the circuit is traced through the lower, outer back contact of relay 17, transformer winding 23, lower back contacts of relay 24 to the upper terminal of transformer winding 22. The output terminals of full wave rectifier 31 are connected to ringing relay 30 in the usual manner.

Ringing relay 30 operates in the circuit just described provided the modulated carrier wave is applied for a sufficient length of time. Relay 30 is of the slow operate type and its contacts are connected in a circuit which builds up slowly so that surges on the line will not bring in the ringing signal falsely. Thus, when relay 30 operates it closes a circuit from battery through resistance 47 and its front contacts to a network comprising condenser 48 shunted by relay 50 and resistance 49 in series to ground. When relay 30 first closes its front contacts the effective resistance of condenser 48 (by reason of an initial zero or low counter-electromotive force) is low and for this reason very little current flows through the higher resistance path comprising resistance 49 and relay 50. As condenser 48 becomes charged, however, its effective resistance rises and current begins to flow in the winding of relay 50, increasing until relay 50 operates. The operation of relay 50 closes a circuit traced from ground through the back contacts of relay 25, the contacts of relay 50 to battery through the winding of relay 28. Relay 28 operates in this circuit and connects ringing current from the local source 27 to conductors 32 and 33 where it operates an audible or visible device (not shown) in the usual manner. When relay 30 releases, condenser 48 is discharged through resistance 51 so that several short operations of relay 30 will not build up the charge on condenser 48 sufficiently to operate relay 50 falsely.

As stated previously the circuit is arranged to function as a modulator using the same circuit elements as are used for the function of demodulation. To illustrate this feature it will be assumed that ringing current from a local source (not shown) is connected to conductors 32 and 75

33. This current operates relay 25 in a circuit traced from conductor 32 through the upper back contacts of relay 28, the upper winding of retard coil 26, the winding of relay 25, condenser 36, the lower winding of retard coil 26 and the lower back contacts of relay 28 to conductor 33. As previously mentioned retard coil 26, relay 25 and condenser 36 are designed to resonate at ringing frequency. Relay 25, operated, opens the operating circuit of relay 28, preventing the false operation of the latter and operates relay 1 by connecting ground to its winding terminal. Relay 1, operated, performs the following steps: opens the transmission circuit between conductors 32 and 33 and line conductors L—1 and L—2 at contacts 52 and 53; connects line conductors L—1 and L—2 to the output circuit of the modulator (to be described later); and operates switching relays 7, 14, 17 and 24 by connecting ground to their winding terminals. The connection between conductors 32 and 33 on the one hand and the line conductors L—1 and L—2, above referred to, is necessary in the normal operation of the system to permit the transmission of the voice-frequency currents in both directions therebetween.

The operation of relays 1, 7, 14, 17 and 24 rearranges the circuit elements so that the circuit functions as a carrier frequency oscillator whose output is modulated at a lower frequency, say at ringing frequency. Thus, the triode elements of vacuum tube 18 with the tuned feed-back circuit comprising transformed winding 5 and variable capacity 4 function as a carrier frequency oscillator and vacuum tube 10 and the tuned feed-back circuit consisting of retardation coil 8 and variable capacity 9 function as a ringing frequency oscillator. The carrier wave is modulated at the lower frequency by utilizing the two additional anodes in vacuum tube 18 as in accordance with the copending application of H. M. Pruden Ser. No. 16,118, filed April 13, 1935.

In more detail, it will be observed that the plate circuit of vacuum tube 18 in addition to traversing transformer winding 21 is also connected through resistance 54, condenser 55, uppermost front contacts of relay 7, transformer winding 5 shunted by variable condenser 4, lower front contacts of relay 7 to the grid of vacuum tube 18. The cathode of this tube is connected to the mid-point of winding 5 through resistance and condenser elements 58, 44, 43 and 42. The grid, plate and cathode of this tube, therefore, function as a conventional oscillator generating a carrier wave of the same frequency as elements 4 and 5 were adjusted for when they were functioning as a line filter. In a similar manner the plate circuit of vacuum tube 10 not only traverses resistance 40, transformer winding 15 and the lower front contacts of relay 14 to plate battery 41 but is also connected through the upper middle front contacts of relay 7, resistance 56, condenser 57, retard coil 8 shunted through the upper front contacts of relay 24 by variable condenser 9 to the grid of vacuum tube 10 through the upper inner front contacts of relay 7. The cathode of this tube is connected to the mid-point of coil 8 through the upper front contact of relay 17 and the network comprising resistance 38 and condenser 39. Vacuum tube 10, therefore, oscillates, generating a wave of the frequency determined by the constants of retard coil 8 and variable condenser 9 which were adjusted as a ringing frequency filter when the circuit was being used as a demodulator.

The output of the carrier frequency oscillator appears on secondary transformer windings 22 and 23 and that of the ringing frequency oscillator appears on secondary transformer winding 16. The circuit is arranged to modulate the carrier frequency output at the ringing frequency by the use of a vacuum tube containing two anode elements in addition to the usual three elements, the specific circuit arrangement being in accordance with the copending application of H. M. Pruden, filed April 13, 1935, Ser. No. 16,118. In this arrangement the transformer on which the carrier frequency appears is effectively included in circuit with the ringing frequency oscillator and the two additional anode elements, the latter operating as an interrupter to connect the carrier frequency to the load at the frequency of the ringing frequency oscillator. During alternate half cycles of the ringing frequency oscillator the upper terminal of transformer winding 16 is positive with respect to the lower terminal and this causes the two anodes 19 and 20 of vacuum tube 18 to become positive with respect to the cathode of vacuum tube 18. This circuit is traced from the upper terminal of transformer winding 16, upper, inner front contact of relay 17 to the mid-point of transformer winding 13. From this point the circuit divides into two paths, one being traced through the upper part of transformer winding 13, the upper, inner front contacts of relay 14 and transformer winding 22 to anode 19 and the other being traced through the lower part of transformer winding 13, lower outer front contacts of relay 17, transformer winding 23 and the lower front contacts of relay 24 to anode 20. The lower terminal of winding 16 is connected directly to the cathode of vacuum tube 18. Anodes 19 and 20 being positive with respect to the cathode provide a low resistance path through vacuum tube 18 and the carrier wave appearing at transformer winding 21 is transmitted to transformer winding 13 through windings 22 and 23 and the two anodes and cathode of vacuum tube 18 over the paths just traced. It should be particularly noted that the transformer windings 22 and 23 have a different relative relation when heated as part of the output for the carrier oscillator than as part of the circuit for impressing the ringing frequency wave. In particular, the arrangement permits of the modulation of the carrier wave by interruption to the exclusion of any other modulation effect by avoidance of impression of the ringing frequency wave on the anode of the tube through the output transformer. The modulated carrier wave from transformer winding 12, which is inductively coupled to winding 13, is transmitted to line wires L—1 and L—2 in a circuit traced from line conductor L—1 through the upper inner front contacts of relay 1, transformer winding 12, lower inner front contacts of relay 1 to line conductor L—2.

Fig. 2 discloses an alternate method of modulation which, being similar to the one used in Fig. 1, could be used in the same manner in a combined modulator and demodulator. In Fig. 2 a carrier wave input generated as in Fig. 1 or by any other method is introduced over conductors 200 and 201 to transformer winding 202. At the same time an alternating current of lower frequency than the carrier wave, say of ringing frequency, generated in device 208 is introduced through transformer winding 207. It will be observed that during the half cycle of the ringing frequency wave when the right-hand terminal of trans-

former winding 206, which is inductively coupled to winding 207, is more positive than the left-hand terminal, the resistance of unidirectional devices 204 and 205 will be low and current will flow in the two balanced circuits. One of these circuits is traced from the right-hand terminal of transformer winding 206 through the upper section of transformer winding 209, unidirectional device 204 in the conducting direction, the upper section of transformer winding 203 to the left-hand terminal of winding 206. The other path is traced from the right-hand terminal of transformer winding 206 through the lower section of transformer winding 209 unidirectional device 205 in the conducting direction, the lower section of transformer winding 203 to the left-hand terminal of transformer winding 206. In a similar fashion it will be seen that these circuits are effectively open at devices 204 and 205 when on the next half cycle of the ringing current the potential at the right-hand terminal of transformer winding 206 is negative with respect to the left-hand terminal.

From the above analysis it will be clear that the carrier current appearing at transformer winding 202 is connected to load transformer winding 210 and to load conductors 211 and 212 whenever the right-hand terminal of transformer winding 206 is positive with respect to the left-hand terminal and is effectively prevented from connection to load transformer winding 210 whenever the right-hand terminal of transformer winding 206 is negative with respect to the left-hand terminal. Therefore, the carrier wave is modulated at the lower frequency and appears on load conductors 211 and 212 as a modulated carrier wave.

What is claimed is:

1. In a signaling system, a source of modulated carrier waves, a demodulator therefor, an amplifier for the reproduced modulating component of the demodulated wave, and relay operated means having elements respectively in circuit with said demodulator and amplifier to reorganize said amplifier into an oscillation generating circuit and said demodulator into a modulator for the waves from said generator.

2. In a signaling system, a source of modulated carrier waves, a frequency selective circuit and an amplifier therefor, a demodulator therefor, a selective circuit and an amplifier for the reproduced modulating component of the demodulated wave, and an integral relay circuit having a component in operative relation with each of the said above elements for simultaneously reorganizing said selective circuits and amplifiers into generators for a carrier and a modulating wave, and said demodulator into a modulator for said generated waves.

3. The system recited in claim 2 in which the frequencies of said generated carrier and modulating waves are the same as the corresponding frequencies of the given modulated carrier wave.

4. A combination incoming and outgoing ringing circuit comprising, a line for receiving a carrier current modulated by a ringing current and for transmitting a like modulated current, a tuned circuit and an electric discharge device for selecting and amplifying the received waves, a demodulator for the received waves, an electric discharge device and a tuned circuit for amplifying the demodulated current and selecting the reproduced modulating component therefrom, and an integral relay circuit having a component in operative relation with each of said above ele-

ments for simultaneously reorganizing said tuned circuits and amplifiers into generators for a carrier and a modulating wave identical in frequency with the waves used in the production of the received modulated wave, and said demodulator into a modulator for said generated waves.

5. The circuit specified in claim 4 in which said integral relay circuit is adapted to reorganize said first tuned circuit and last electric discharge device into the carrier generator and said last tuned circuit and first electric discharge device into the modulating wave generator.

6. The circuit of claim 4 including additionally means for rectifying the received reproduced modulating component and applying the same to a relay means for applying a local ringing source to the incoming ringing circuit, said integral relay circuit including a component adapted during the simultaneous reorganization of the circuit generally to interrupt the normal connection between said ringing circuit and said line, said integral relay circuit being adapted to be energized by ringing current from the ringing circuit to which said local source is connected.

7. A combination incoming and outgoing ringing circuit comprising, a line for receiving a carrier current modulated by a ringing current and for transmitting a line modulated current, a tuned circuit and an electric discharge device for selecting and amplifying the received waves, a duplex-diode-triode electric discharge device for demodulating the received waves by at least one of its diode paths and for amplifying the demodulated wave by the triode elements thereof, a tuned circuit for selecting the reproduced modulating component from the output of the demodulator, and an integral relay circuit having a component in operative relation with each of said above elements for simultaneously reorganizing said first tuned circuit and said triode element into a generator of the outgoing carrier wave, said last tuned circuit and first electric discharge device into a generator of the modulating wave for said carrier wave, the frequency of the carrier and modulating waves being identical with those used in the production of the received modulated wave, and the diode path of said second electric discharge device into a modulator for said generated waves.

8. The circuit specified in claim 7 including additionally means for rectifying the received reproduced modulating component and applying the same to a relay means for applying a local ringing source to the incoming ringing circuit, said integral relay circuit including a component adapted during the simultaneous reorganization of the circuit generally, to interrupt the normal connection between said ringing circuit and said line, said integral relay circuit being adapted to be energized by ringing current from the ringing circuit to which said local source is connected as recited.

9. A modulator comprising in combination, an electric discharge device having input and output electrodes, external circuits associated with said device to constitute the whole generator of a carrier current, a transformer for said generator connected to the output electrodes of said discharge device and having a divided secondary winding, an output circuit for said generator comprising in series one portion of said secondary winding, two interrupter elements in series, the other portion of said secondary winding and the primary winding of an output transformer, said interrupter elements having such a characteristic

as to be made conducting to the carrier current upon the imposition of a super-threshold potential thereacross, and means for impressing an alternating potential of said super-threshold value between the junction points of said interrupter elements and the mid-point of the primary winding of said output transformer so as to permit a corresponding alternating current to flow symmetrically and in parallel through like portions of the output circuit including said interrupter elements whereby the carrier current may be

interrupted at the frequency of said alternating potential without reaction on the output electrodes of said discharge device.

10. A modulator circuit like that specified in the preceding claim in which the interrupter elements comprise dry contact rectifier devices. 5

11. A modulator circuit like that specified in claim 9 in which the interrupter elements comprise copper-oxide rectifiers.

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