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ENERGY CONSERVATION IN RADIO SYSTEMS

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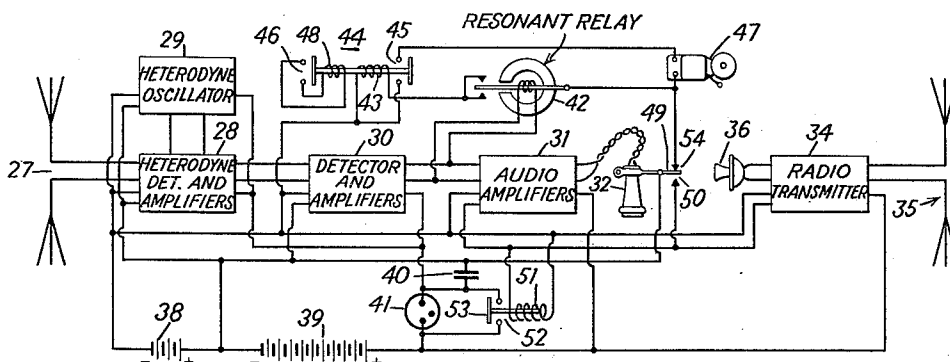


Fig. 1

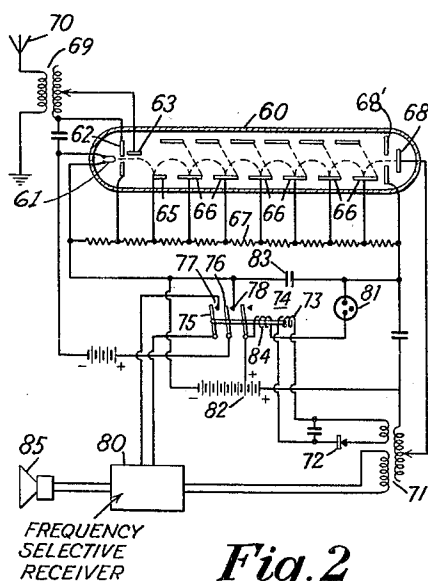


Fig. 2

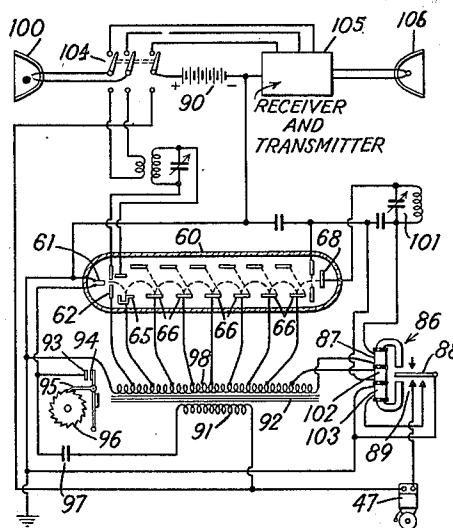


Fig. 3

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ENERGY CONSERVATION IN RADIO
SYSTEMSClarence W. Hansell, Rocky Point, N. Y., assignor
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372,636. Divided and this application March
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8 Claims. (Cl. 250-6)

The present application is a division of my application #372,636, filed December 31, 1940, and relates to radio communication systems and, more particularly, to a method of and a means for conserving the amount of energy utilized by such systems while, at the same time, continuously maintaining said system in an operative condition.

In many radio communication systems, particularly those which are to be operated at carrier frequencies above 30 megacycles, a problem often arises in respect to the cost and inconvenience of maintaining the equipment always in a condition to operate. In radio relaying systems by means of radio frequency amplifiers connected between receiving and transmitting antennas, for example, it must always be possible to transmit signals through the system at will and yet, in many cases, the percentage of total time in which communication is desired may be small. As a consequence, in previously known types of equipment, of which I am aware, it is necessary to keep the amplifier equipments of the relay system energized continuously even though they may be used only a part of the time. In other applications, such as radio telephone systems to replace wire line telephone exchanges, particularly those systems which may serve rural districts around small towns, through central exchanges in the towns, one of the greatest obstacles to be overcome has been that of maintaining equipment at the farm home always in condition to respond to calls even though the percentage of time during which the equipment may be used is very small. When calls are to be made from the farm home to the central exchange the farmer may be expected to energize his equipment before using it and to de-energize it when the conversation is finished. However, a much more difficult problem arises in keeping the subscriber's equipment energized sufficiently for calling or ringing from the central exchange. This requires continuous power input of some amount and, over a long period of time, presents a problem in supplying the power. Ordinarily, it is desired that the subscriber's equipment be capable of taking its power from a battery of moderate size. The power demand for a period of several months to a year for operating radio telephone equipment might be supplied from dry cell batteries or from a single charging of a 6 volt, 100 ampere hour storage battery if it is possible to substantially eliminate the need for any appreciable amount of stand-by power to keep the equipment in condition for calling or ringing when not actually in use.

It is, therefore, an object of the present invention to provide means for use in systems as above described by which the stand-by power requirements may be reduced while, at the same time, the

equipment is continuously maintained in a condition to receive calls from other stations.

This may be accomplished, in accordance with my invention, by employing means for energizing a minimum amount of the equipment required for calling purposes for only very short time periods repeated at sufficiently frequent intervals. During the energized periods if radio frequency input is received from the central office this input may serve to hold the equipment continuously energized and to cause the operation of a bell or other signal device. If the subscriber does not answer the call the central office may return the subscriber's equipment to the stand-by condition by merely removing the radio frequency energy which is being transmitted from the central transmitter to the subscriber's equipment.

In accordance with one aspect of the present invention, the subscriber's equipment may be energized for calling purposes momentarily at spaced time periods by utilizing a low pressure gaseous discharge gap inserted between the power source and the radio equipment and placing a condenser across the circuit on the load side of the gap. The gaseous discharge gap provides a device which changes almost instantly from an insulator to a low resistance conductor if the potential across it exceeds a critical value and which returns to an insulating condition as soon as the current through it and the potential across it fall to some other critical value. By this means the condenser is charged periodically through the gap and discharged first through the radio frequency equipment and then through a high leakage resistance down to a point where the gap again breaks down. By this means it is possible to energize the minimum amount of radio equipment required for ringing for periods of, for example, 0.01 second at intervals of 10 to 15 seconds. By this means the average stand-by power required may be reduced by a factor of 1000 to 1 compared with the power required for continuously energizing the equipment for calling.

The present invention will be more fully understood by reference to the following detailed description which is accompanied by a drawing in which Figure 1 illustrates one form of my invention particularly useful for ultra-short wave radio telephone systems, while Figures 2 and 3 illustrate modifications of the form of the invention shown in Figure 1.

A form of the present invention is shown in Figure 1, which is a schematic diagram of a radio telephone station, such as might be employed at a farm home to communicate through a central telephone exchange. Naturally similar arrangements may be used at any radio telephone station at which it is desired to be able to receive calls at any time without requiring more than

a minimum of standby power consumption. In this diagram I have shown an antenna system 27 supplying radio frequency energy to a superheterodyne type radio receiver employing a heterodyne detector 28, a heterodyne oscillator 29, intermediate frequency amplifiers, a second detector 30, an audio amplifier 31 and a receiver 32. This figure also shows in block form a radio transmitter 34 connected to an associated antenna 35. I have indicated the transmitter input by a conventional microphone 36.

All of the receiving and transmitting equipment shown in this figure is energized by a cathode supply battery 38 and an anode supply battery 39. Battery 38 may be of the 6 volt storage battery type while battery 39 may be a 180 volt dry battery. Control electrode bias batteries may be employed, if desired, though they have not been illustrated in this figure. When the equipment is in the standby condition only the cathodes of the first portions of the receiver are energized and these portions employ vacuum tubes of the lowest obtainable cathode and anode power demand. The tubes in this portion of the receiver are not continuously energized with full anode potential but have substantially full anode potential supplied in pulses of perhaps 1 or 2 seconds duration repeated at intervals of from 10 to 20 seconds. This is accomplished by supplying anode currents to these portions of the equipment over a relatively large condenser 40 which is charged at intervals.

Condenser 40 is charged through a gaseous discharge tube 41 which may be a low pressure neon tube or a neon lamp having no resistance in series therewith. After the condenser is charged from source 39 through the gas discharge tube 41 the current through tube 41 drops to such a low value that the discharge is extinguished. The condenser then discharges through the vacuum tube anode circuits within portions 28, 29 and 31 of the receiver, first, at normal anode current values and then with diminishing current values until, finally, the discharge is at a relatively slow rate. Eventually, the potential across the condenser 40 reaches such a low value and the potential across the neon tube 41 therefore reaches such a high value that another discharge through tube 41 takes place recharging the condenser. This repeated charging and discharging of the condenser takes place continuously during all time periods when the equipment is not in use. If it should be desired to call the station of Figure 2, the central exchange station radiates a carrier wave of the frequency to which the receiver is tuned and which is modulated at a characteristic frequency of, say, 40 cycles. During periods when the condenser is charged the fully energized portions of the receiver, that is, portions 28, 29 and 30, deliver 40 cycle current to a resonant relay 42 which is resonant to 40 cycles. Vibrations of the responsive element of the resonant relay energize winding 43 of a slow acting relay 44 to close contacts 45 and 46. The closure of contacts 45 energizes a call bell 47.

Since it is desirable that the slow acting relay 43 should close relatively quickly and open relatively slowly, the contacts 46 short-circuit a coil 48 when the relay is energized. Short-circuited coil 48 tends to prevent the collapse of the magnetic flux in the core of relay 44 and thus the contacts are held closed for some time after the winding 43 is actually deenergized. Other elec-

trical or mechanical arrangements may be utilized to accomplish the same purpose, if desired.

The subscriber, hearing the ringing of bell 47, removes earphone 32 from the hook 49, thus closing contacts 40, and automatically energizing the cathodes of the tubes in amplifier 31 and the tubes in transmitter 34 and in so doing allows anode current to flow in them. The same operation energizes winding 51 of relay 52 closing contacts 53 across the neon tube 41 and thereby continuously energizes the anodes of the entire receiver. The operation of removing receiver 32 from its hook also opens contact 54 and de-energizes bell 47. The subscriber may then reply to the calling office by means of microphone 36 and transmitter 34. The conversation may then be carried on in the conventional manner. Replacing of the earphone 32 automatically de-energizes the transmitter and most of the receiving equipment and returns the remainder of the receiver to the condition for again receiving calls.

It will be noted that as long as the batteries 38 and 39 are in good condition the neon tube 41 flashes at regular intervals. Tube 41 may, therefore, be mounted in such a position that it may be easily visible and the condition of the batteries may be checked at any time. It is to be assumed that in giving the equivalent of rural party line service a number of receivers may be adjusted to operate on a common radio carrier frequency and the corresponding transmitters all operate on another common radio carrier frequency. Selective calling may then be accomplished by means of different calling modulation frequencies, such as 35, 40, 45 and 50 and 55 cycles per second, each receiver being equipped with a resonant relay 42 tuned to its particular frequency.

The system may equally well be employed for telephone by amplitude, phase or frequency modulation of the radio carrier and by systems employing various sub-carrier combinations.

While I have shown a superheterodyne type of receiver it may not be necessary in all cases to use this type but the receiver may be a tuned radio frequency receiver, a super-regenerative receiver or any other suitable type.

Another form of application of the invention is shown in Figure 2. In this arrangement I have shown a multistage secondary emission type of amplifier 60 including a cathode 61 which is preferably of very minute dimensions, a first anode 62 having a hole or slit therein for forming a stream of electrons and a control electrode 63 for deflecting the beam of electrons to vary the number thereof which impinge on surface 65. Secondary electrons are emitted as a result of the electrons impinging on surface 65 and on successively later secondary emitting surfaces 66 at successively higher potentials. Each surface emits more electrons than impinge thereon and thus give an increasing current in successively later stages. The successively higher potentials on the different emitting surfaces 66 are supplied through taps on a voltage divider 67. Finally, after being greatly increased in strength the current is terminated on an anode 68. A screen electrode 68' may be provided before anode 68 to prevent the escape of secondary electrons from anode 68. Amplifiers of this general type are often known in the art as electron multipliers. The anode current is varied or modulated in accordance with high frequency input to the control electrode 63. The high frequency

input to control electrode 63 is supplied thereto through a coupling circuit 69 from an antenna 70. A portion of the high frequency output from the secondary emission amplifier 60 is applied through coupling circuit 71 to a suitable rectifier 72 which is preferably a fixed type of crystal detector or a copper oxide type of rectifier where it is rectified into direct current. Output from the rectifier or detector 72 is applied to winding 73 of a relay 74 to operate contact arms 75, 76 into engagement with contacts 77 and 78. The operation of contact arms 75, 76 into contact with 77, 78 controls power input to the secondary emission amplifier 60 and an associated radio receiver 80. Since the secondary emission amplifier 60 is shown as normally not energized with input power potentials, means are provided for momentarily applying impulses of power. This consists of a gaseous discharge tube 81 which breaks down and carries electrical current freely if a potential is applied thereacross which is above a certain value less than the power source potential. Assuming a direct potential is applied from sources 82, the gaseous discharge tube breaks down and passes current to charge a condenser 83 and then open circuits itself as the condenser becomes fully charged. From the condenser 83 potentials are applied to the electrodes of the secondary emission amplifier 60 by way of the voltage divider network 67.

In series with the gaseous discharge tube is a winding 84 of relay 74. The discharge current closes the contacts of the relay 74 momentarily energizing the cathode 61 of the secondary emission amplifier and allowing the amplifier to function. If there is no incoming radio frequency carrier from 70 the relay falls open again when the discharge current has ceased. The condenser then slowly discharges through the voltage divider network 67 which is preferably made of a material called "Thyrite" so that the rate of condenser discharge will decrease to a low value as the potential falls. After the potential across the condenser 83 drops to a low level the potential across the gaseous discharge tube 81 is again low enough to cause another breakdown and current discharge. Thus, at intervals of from 15 seconds, or so, the amplifier is energized for .01 to .1 second.

If now, a carrier wave current is delivered to the secondary emission amplifier from antenna 70, then this current will be amplified and rectified when the amplifier is energized. The rectified high frequency current will then hold the relay 74 closed through winding 73 and keep the amplifier energized continuously. The relay also starts up a receiver 80 by the closure of contacts 75, 77 by means of which modulations of the received carrier wave may be made audible in loudspeaker 85. The contacts 75, 77 are preferably equipped with time delay closing by means of devices known in the art.

In Figure 3 I have shown another means for energizing an amplifier and detector momentarily at spaced time intervals in combination with means for calling by means of a bell. In this system, a secondary emission amplifier 60 is used as before but the amplifier also serves as a detector to operate a relay 86 through winding 87 to close contacts 88, 89 and ring bell 47. In the arrangement shown in this figure all of the power for the calling and ringing system is obtained from a single low voltage battery 90. Current from the battery is passed through the primary winding 91 of an induction coil transformer 92 in

series with an instantaneous opening but slow closing contact arrangement 93, 94 actuated by the magnetic field of the induction coil 92. The contact is made slow closing by means of a pawl 95 carried by contact arm 94 engaging ratchet wheel 96. The ratchet wheel may be supplied with a suitable time delay mechanism such as a fluid friction device, a mechanical governor or a clock escapement to allow it to turn freely but only slowly. In some cases sufficient time delay may be obtained merely by making ratchet wheel 96 heavy.

Each time the induction coil contacts 93, 94 close they momentarily energize the cathode 61 of the amplifier 60, raising its temperature high enough to cause electron emission and then the contacts are pulled open by the magnetic field of the induction coil 92. A condenser 97 across the contacts permits them to open with little, if any, arcing and slows up the decrease of current in the primary winding 91 of the induction coil. The decreasing current in the primary winding and collapse of the magnetic field through coil 91 energizes the secondary emission amplifier electrodes 62, 65, 66 and 68 momentarily by induction into the secondary winding 96 of the induction coil 92. If there is no radio frequency input to the secondary emission amplifier 60 from antenna 100, the application of the electrode potentials causes a momentary flow of current in the anode circuit and a weaker pulse in the circuit of screen electrode 68'. If there is a radio frequency input caused by application of carrier current from the district central transmitter, then a radio frequency potential will be built up across the circuit 101 which is tuned to the central transmitter frequency and which is in series with anode 68. This high frequency potential reduces the magnitude of the pulse of direct anode current and increases the pulse of screen electrode current. The anode and screen currents are utilized to energize windings 87 and 102 of polarized relay 86 which is thrown to and remains in one position, or another, depending on whether the central station transmitter is energized and operated at the frequency corresponding to calling the particular subscriber's station. A third winding 103 is provided on the core of relay 86 in order to make the armature 88 slow to operate in one position, as described with reference to relay 44 in Figure 1. If the induction coil is designed to provide impulses about once every 15 seconds, then the bell 47 will ring at 15 second intervals while the subscriber's station is being called until the subscriber answers the call by operating switch 104, thus energizing his radio receiving and transmitting equipment 105. Thus, the calling unit at the subscriber's station, in this modification, is made a separate accessory which may be provided, or not, according to need.

After the subscriber has thrown switch 104 so that his receiver and transmitter are energized he may communicate with the central station in the usual manner and through the central station to other individual stations. Antennas 100 and 106 are preferably directional antennas in order to reduce the power requirements as much as possible. The single battery 90 will operate the system for a long time on one charge. The battery may be kept charged by any of the conventional means such as a wind operated battery charger. Wave, tide or temperature operated generators may also be used for charging. While I have particularly shown and described

several modifications of my invention, it is to be distinctly understood that my invention is not limited thereto but that improvements within the scope of the invention may be made.

I claim:

1. A communication station comprising standby signal responsive means substantially continuously in an operative condition, said means requiring little power for its operation, further signal receiving and transmitting means requiring substantially greater amounts of power for operation, said means being normally de-energized and means responsive to receipt of signals by said standby means for energizing said receiving and transmitting means, said signal responsive means being intermittently energized solely by energy stored in a condenser, the said energy being supplied to said condenser in short pulses, the time of initiation of said pulses being determined by the energy level in said condenser.

2. A communication station comprising standby signal responsive means substantially continuously in an operative condition, said means requiring little power for its operation, further signal receiving and transmitting means requiring substantially greater amounts of power for operation, said means being normally de-energized and means responsive to receipt of signals by said standby means for energizing said receiving and transmitting means, said signal responsive means being energized by energy stored in a condenser, and means for applying short pulses of energy to said condenser from a primary source of energy at spaced time intervals, the time duration of said pulses being substantially less than the time of energization of said signal responsive means and the said energy being supplied to said condenser in short pulses, the time of initiation of said pulses being determined by the energy level in said condenser.

3. A communication station comprising standby signal responsive means substantially continuously in an operative condition, said means requiring little power for its operation, further signal receiving and transmitting means requiring substantially greater amounts of power for operation, said means being normally de-energized and means responsive to receipt of signals by said standby means for energizing said receiving and transmitting means, said signal responsive means being energized by energy stored in a condenser, a primary source of energy, a gas discharge tube connected between said source and said condenser and so arranged that discharge of said condenser below a predetermined charge causes said tube to become conductive and charge said condenser.

4. A communication station comprising standby signal responsive means substantially continuously in an operative condition, said means requiring little power for its operation, further signal receiving and transmitting means requiring substantially greater amounts of power for operation, said means being normally de-energized and means responsive to receipt of signals by said standby means for energizing said receiving and transmitting means, said signal responsive means being energized by energy stored in a condenser, a primary source of energy, a gas discharge tube connected between said source

and said condenser and so arranged that discharge of said condenser below a predetermined charge causes said tube to become conductive and charge said condenser, and means for disabling said call signal and short-circuiting said gas discharge tube.

5. A communication station comprising signal responsive means, means for intermittently supplying energy to said signal responsive means, said energy supplying means including energy storage means and being intermittently supplied with pulses of energy through a cyclically completed path from a source of energy, and means responsive to the receipt of signals by said signal responsive means for locking said cyclically completed path in a continuously conducting condition so that energy is continuously supplied to said signal responsive means, the time of cyclic closure of said path being of substantially shorter duration than the repetition time of said cyclic closure.

6. A communication station comprising signal responsive means, means for intermittently supplying energy to said signal responsive means, said energy supplying means being intermittently provided with pulses of energy from a source and means responsive to the receipt of signals by said signal responsive means for so altering the operation of said energy supplying means that energy is continuously supplied to said signal responsive means, said energy supplying means including a condenser and a gas discharge tube connected between said condenser and said source and so arranged that discharge of said condenser below a predetermined charge causes said gas tube to become conductive and charge said condenser.

7. A communication station comprising signal responsive means including an electron multiplier tube, means for intermittently supplying energy to said multiplier tube, said energy supplying means being intermittently provided with pulses of energy from a source and means responsive to the receipt of signals by said signal responsive means for so altering the operation of said energy supplying means that energy is continuously supplied to said electron multiplier tube, the said energy being supplied to energy storage means, the time of initiation of said pulses being determined by the level of the energy in said storage means.

8. A communication station comprising signal responsive means including an electron multiplier tube, means for intermittently supplying energy to said multiplier tube, said energy supplying means being intermittently provided with pulses of energy from a source and means responsive to the receipt of signals by said signal responsive means for so altering the operation of said energy supplying means that energy is continuously supplied to said electron multiplier tube, said energy supplying means including a condenser and a gas discharge tube connected between said condenser and said source and so arranged that discharge of said condenser below a predetermined level causes said gas discharge tube to become conductive and charge said condenser.

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