COMMUNICATION RECEIVER INCORPORATING TONE OPERATED PULSER CIRCUIT AND ELECTRONIC SWITCH

Original Filed Sept. 29, 1969

9 Sheets-Sheet 1

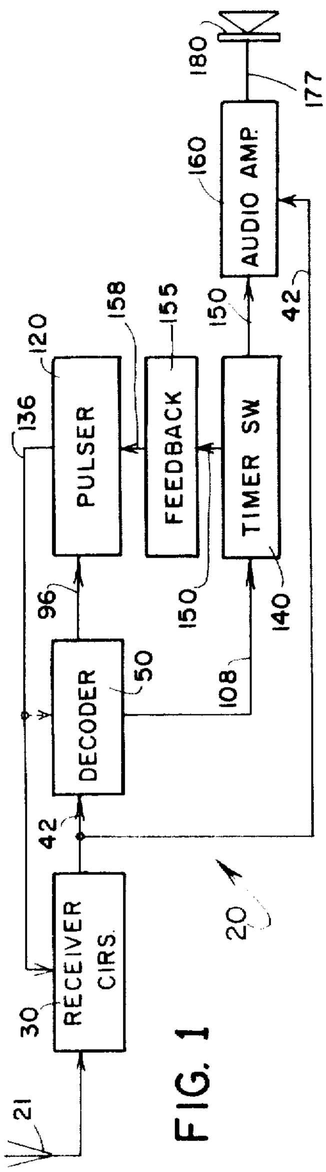

FIG. 1

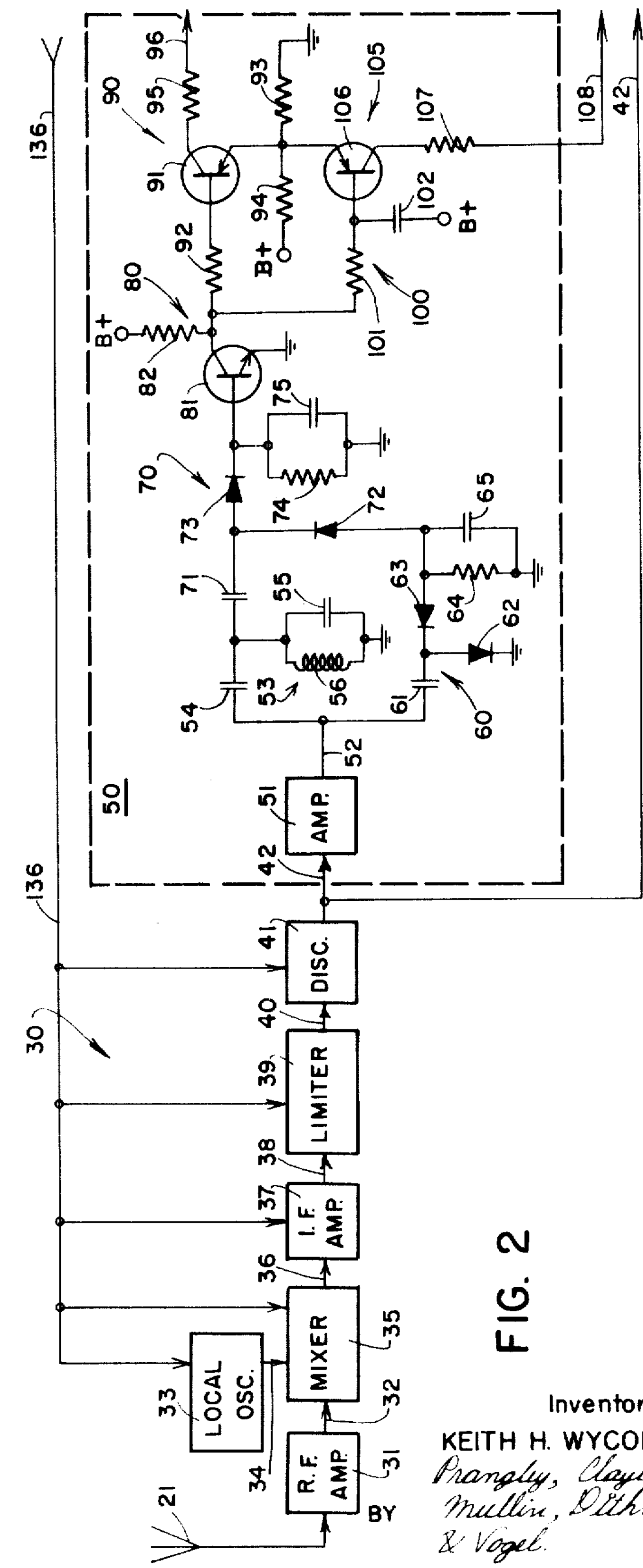

FIG. 2

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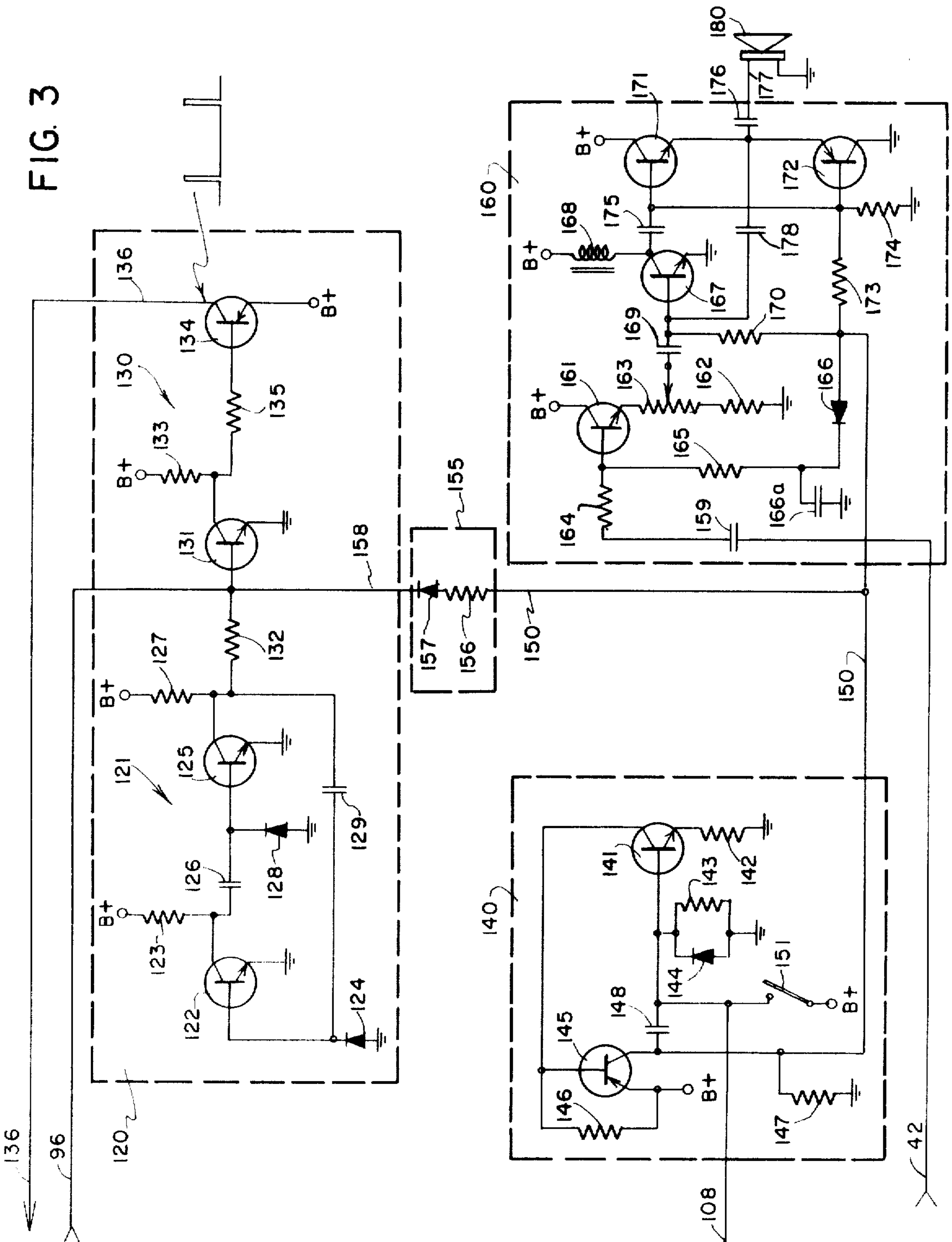

FIG. 3

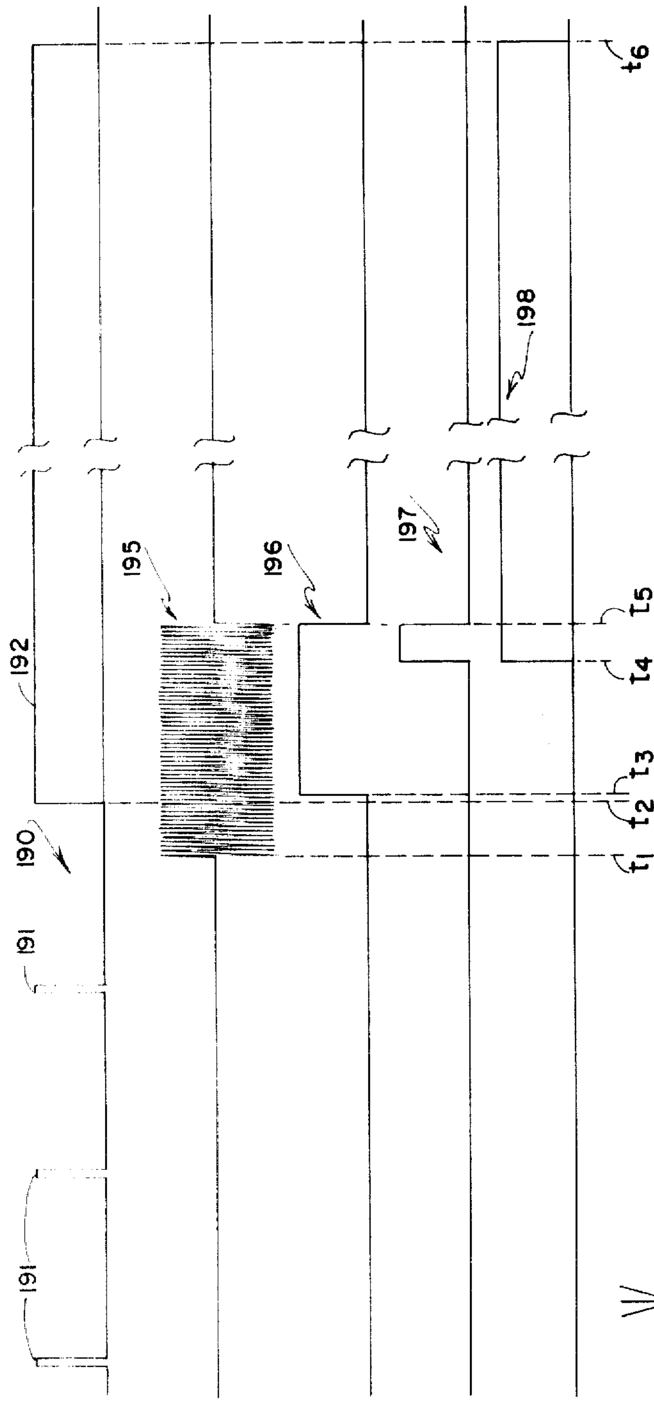
192
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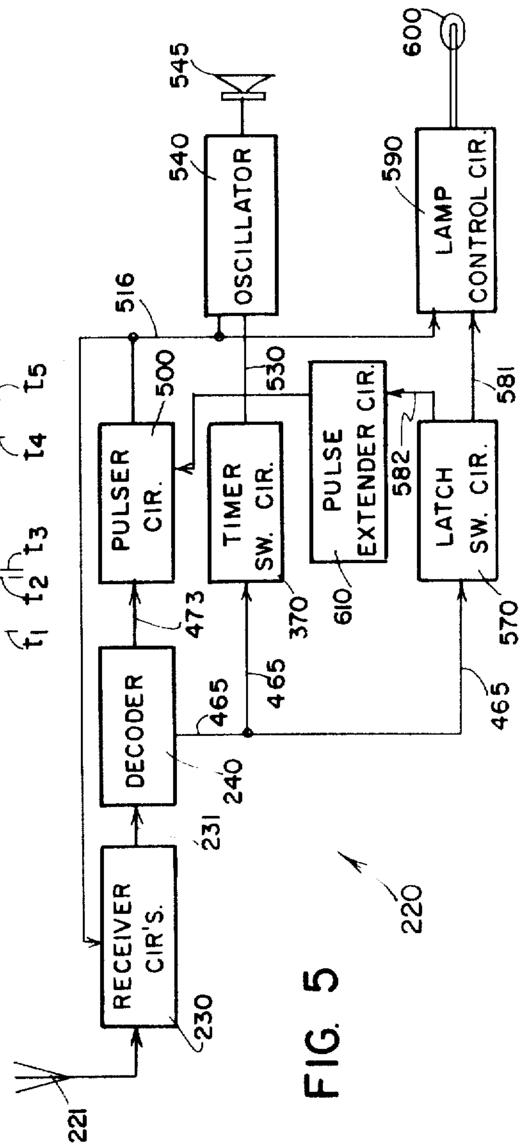
FIG. 4


RECEIVER CIR'S.
DECODER
PULSER CIR.
TIMER SW. CIR.
PULSE EXTENDER CIR.
LATCH SW. CIR.
OSCILLATOR
LAMP CONTROL CIR.
221
230
231
240
465
473
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516
530
370
610
582
570
581
590
540
545
600
220

FIG. 5

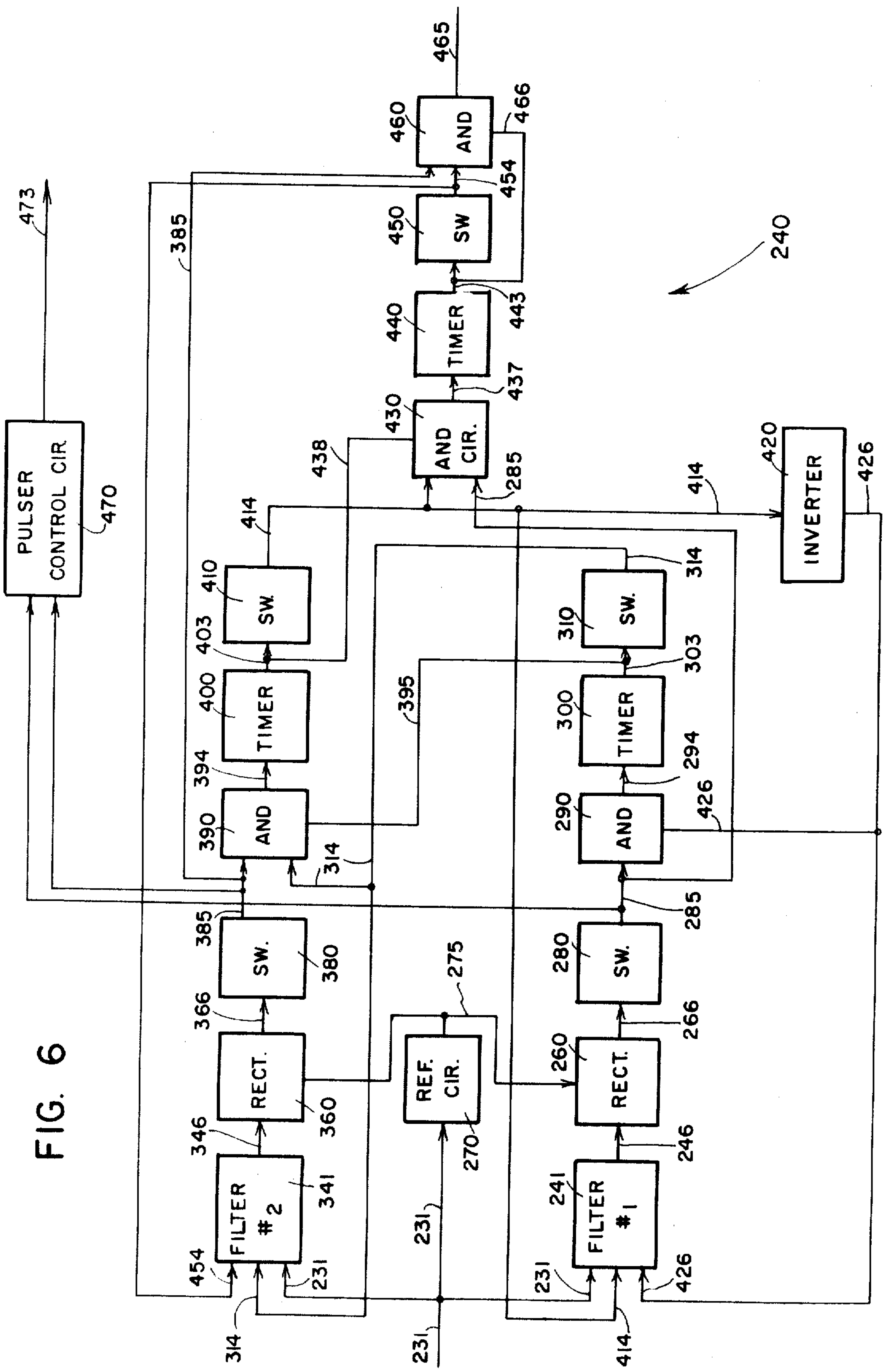
PULSER CONTROL CIR
FILTER #2
RECT.
SW.
AND
TIMER
SW.
REF. CIR.
FILTER #1
RECT.
SW.
AND
TIMER
SW.
AND CIR.
TIMER
SW
AND
INVERTER

FIG. 6

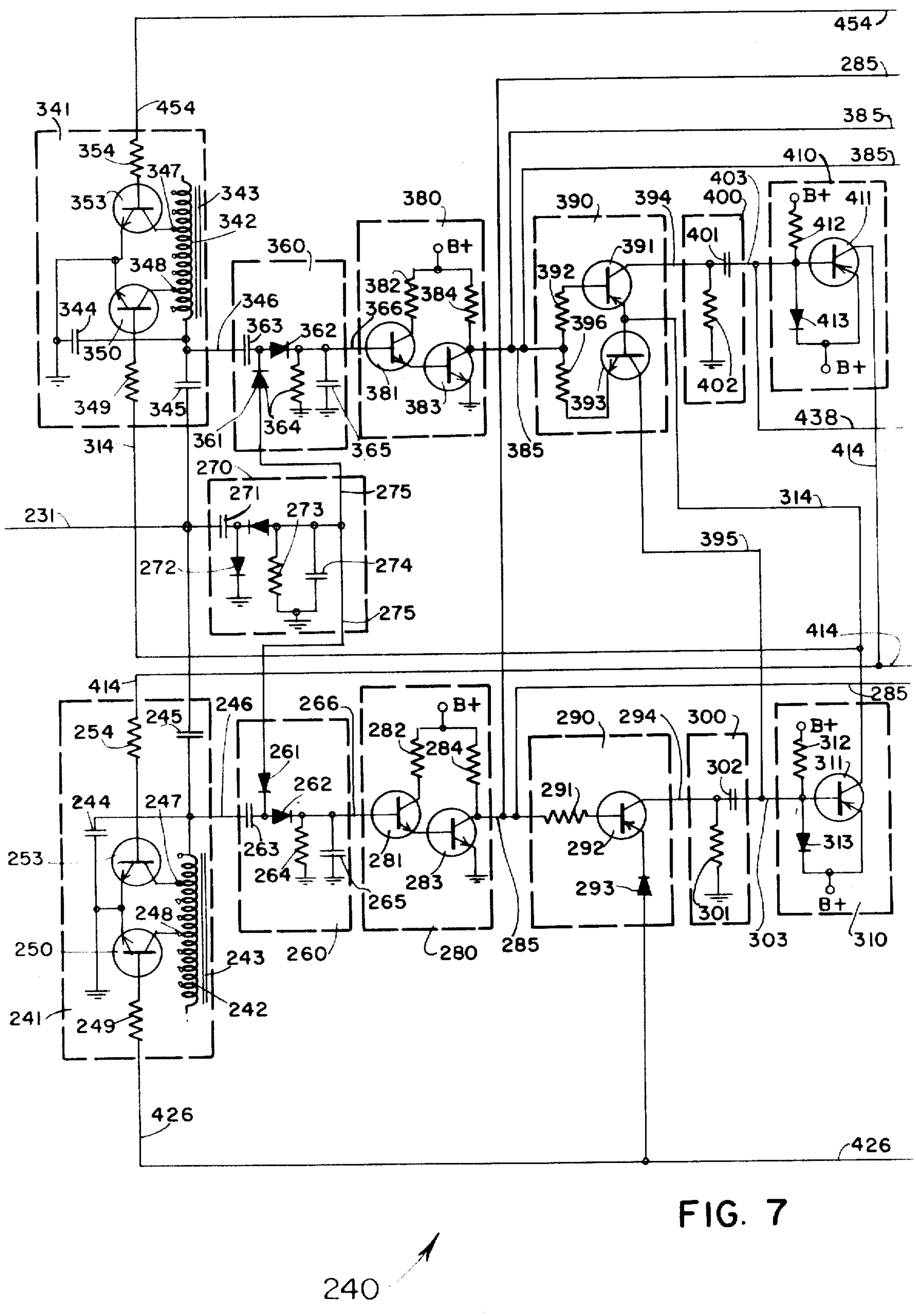
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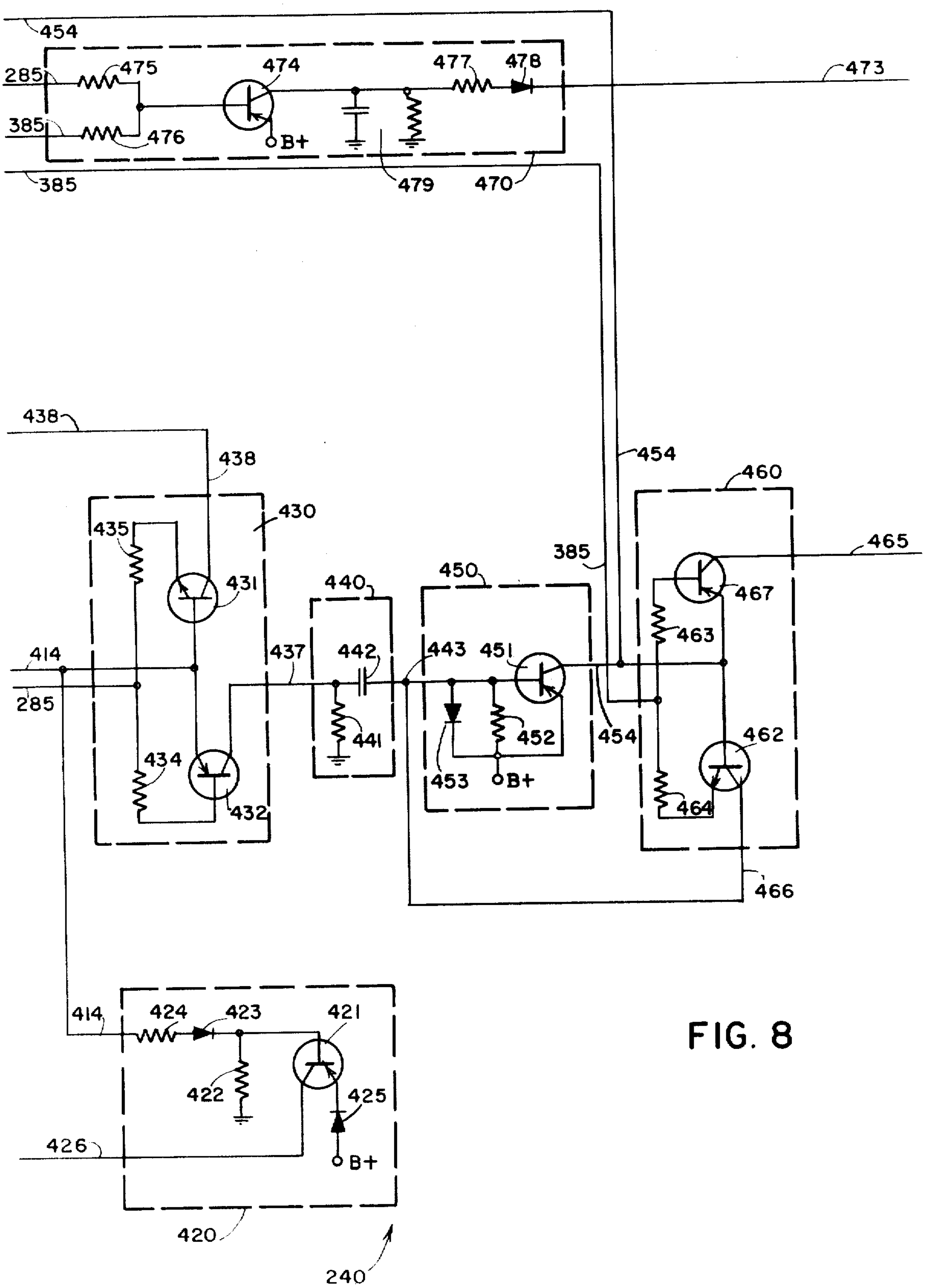
FIG. 7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465
450
467
440
463
414
437
442
443
451
285
441
452
454
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434
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466
414
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426
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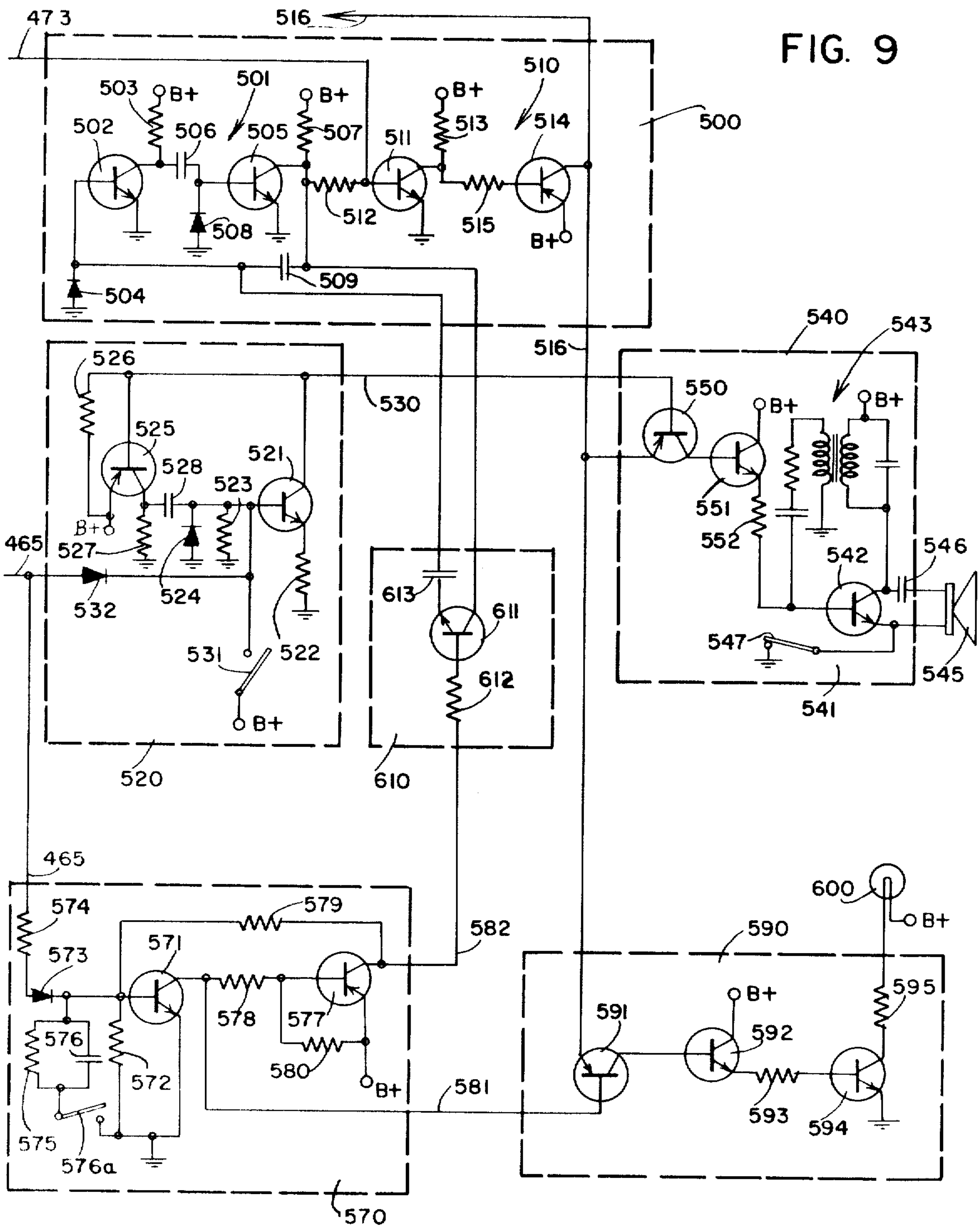
240

FIG. 8

FIG. 9


473
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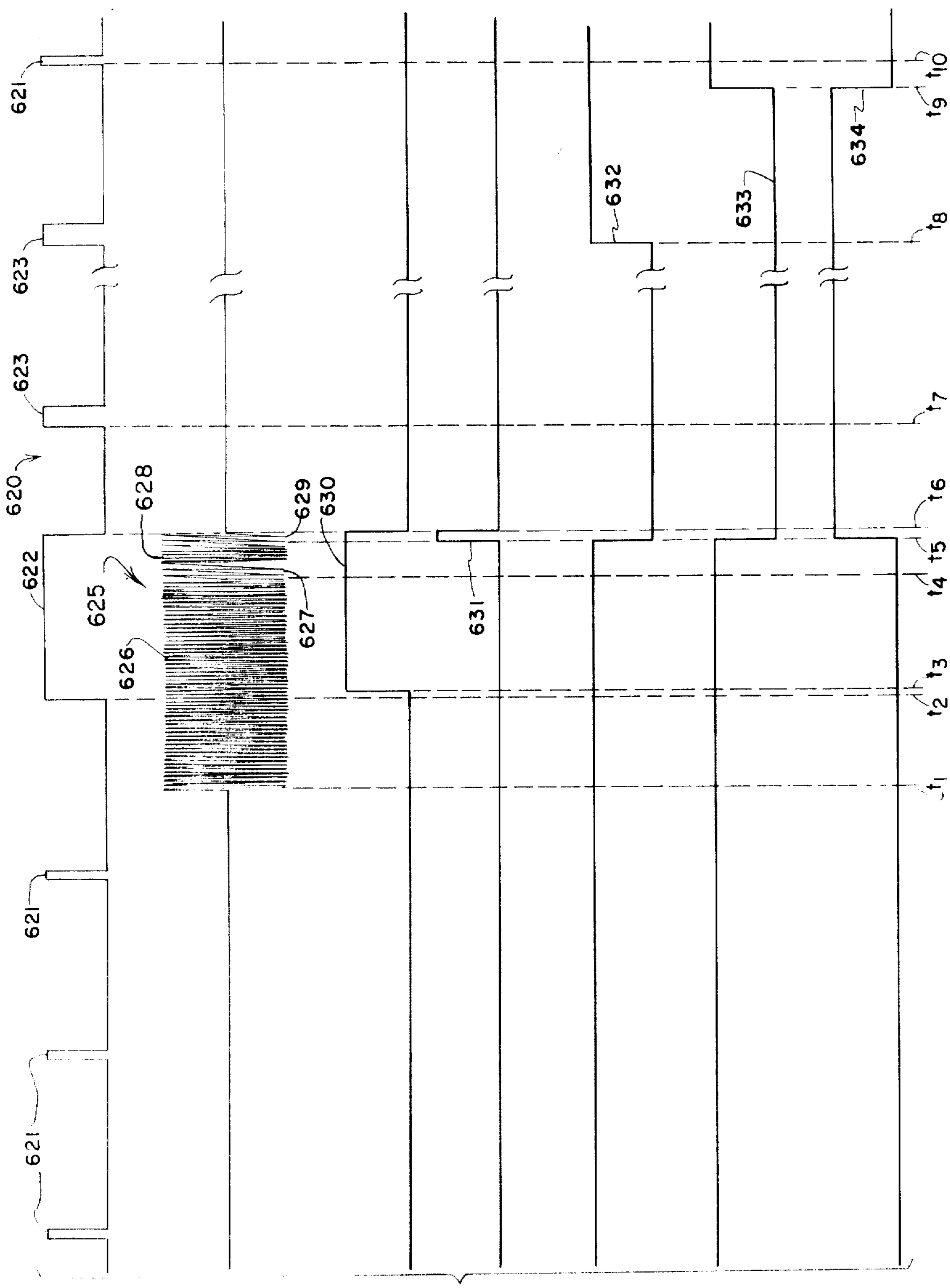
621
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t_5
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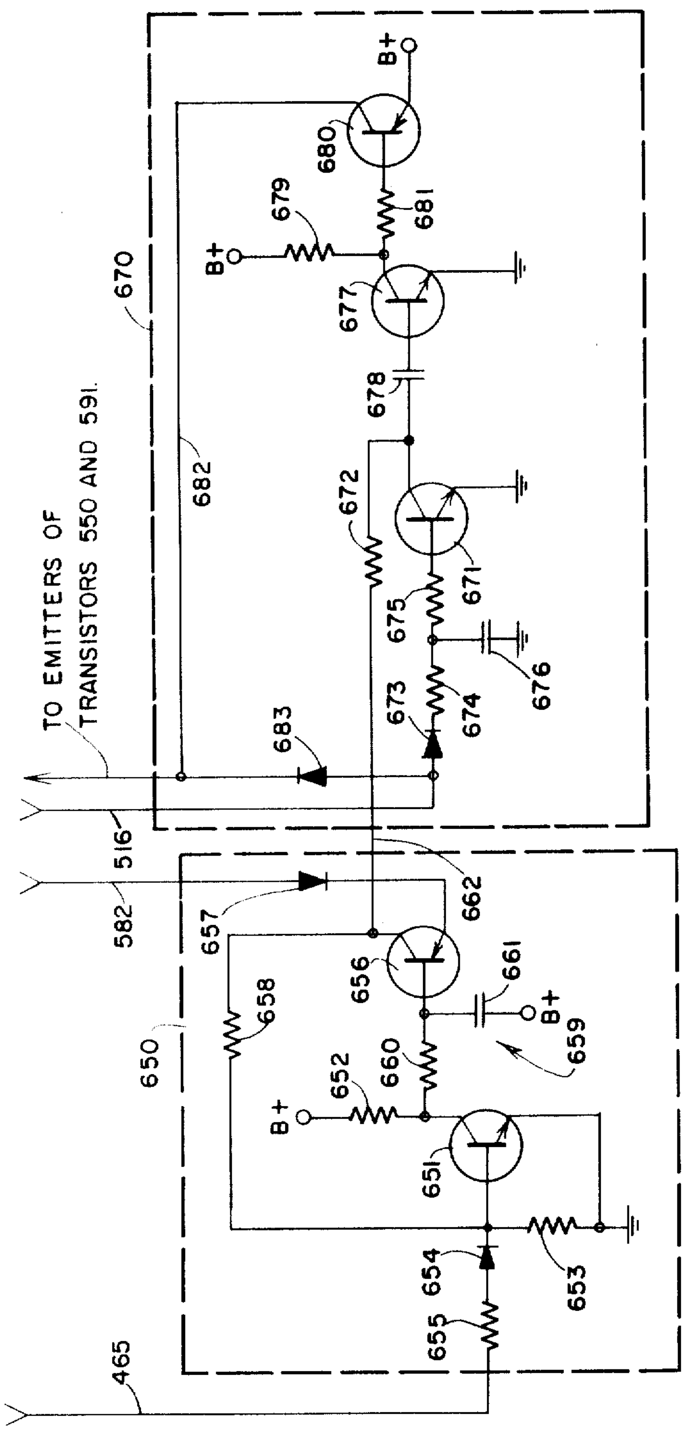
t_9
t_{10}

FIG. 10


TO EMITTERS OF TRANSISTORS 550 AND 591.
B+
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680
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582
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654
653
655
465

FIG. 11

United States Patent Office Re. 28,222
Reissued Nov. 5, 1974

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28,222

COMMUNICATION RECEIVER INCORPORATING TONE OPERATED PULSER CIRCUIT AND ELECTRONIC SWITCH

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Int. Cl. H04b *1/06*
U.S. Cl. 325—492 26 Claims

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

ABSTRACT OF THE DISCLOSURE

A communication receiver comprising a processing circuit for receiving modulated carrier signals and detecting one or more control tones therein, a pulser circuit coupled to the processing circuit and operative to produce a series of pulses for intermittently rendering the processing circuit operative, and a decoder circuit coupled to the processing circuit and responsive to the control tone or tones for generating at the output thereof a control signal, the pulser circuit being coupled to the output of the decoder circuit and responsive to the application thereto of the control signal to furnish a continuous supply voltage for the processing circuit for an interval substantially longer than the duration of each pulse in the series of pulses.

The present invention is directed to communication receivers, and particularly to a communication receiver incorporating therein a pulser circuit to maximize battery life and to provide other useful functions in the receiver.

It is an important object of the present invention to provide a communication receiver for receiving signals modulated by at least one control tone, the receiver comprising a processing circuit for receiving modulated carrier signals and detecting one or more control tones therein, a pulser circuit coupled to the processing circuit and operative to produce a series of pulses for intermittently rendering the processing circuit operative, and a decoder circuit coupled to the processing circuit and responsive to the control signal, the pulser circuit being coupled to the output of the decoder circuit and responsive to the application thereto of the control signal to furnish a continuous supply voltage for the processing circuit for an interval substantially longer than the duration of each pulse in the series of pulses.

In connection with the foregoing object, it is another object of the invention to provide a receiver comprising a switch circuit coupled to the tone decoder circuit and responsive to the control signal developed by the decoder circuit to provide an enabling signal, a utilization circuit coupled to the switch circuit and responsive to the presence of the enabling signal to provide an output signal, and an annunciator coupled to the utilization circuit for converting the output signal into usable form.

In connection with the foregoing object, it is another object of the invention to provide a communication receiver in which the utilization circuit consists of an oscillator circuit and/or an audio amplifier and the annunciator consists of a lamp and/or a loudspeaker.

Still another object of the present invention is to provide a pulsating supply voltage for intermittently operating an RF signal processing circuit, and a pulse extender to increase the length of the pulses for operation of an annunciator system.

Yet another object of the present invention is to provide a communication receiver including a pulser circuit that generates a series of pulses of one frequency in response

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to a set of control tones and a different frequency in response to a set of control tones having a different makeup.

A further object of the present invention is to provide a communication receiver having a pulser circuit that generates a pulsating signal for intermittently operating an alerting device such as a lamp or a loudspeaker.

A still further object of the present invention is to provide a communication receiver having a pulser circuit for producing a pulsating signal during standby and a continuous signal when audio information is being received, the audio amplifier being inoperative during standby and being rendered operative by the continuous supply voltage for amplification of the audio information.

Another object of the present invention is to maximize the useful life of a battery used in a communication receiver, while maintaining small size and light weight.

Still another object of the present invention is to provide a battery-saving circuit that is highly sensitive, highly efficient in respect to minimizing current drain, and permits high speed signaling to accommodate maximum use of the available spectrum.

Yet another object of the present invention is to provide a battery-saving circuit which will intermittently energize the receiver during standby but will continuously energize the receiver when a proper control tone or series of control tones is received, and will be affected only negligibly by control tones other than those to which the receiver is to respond.

A further object of the invention is to provide a paging system which will not only provide an audible alerting tone for the user of the pager, but will also provide a visual alerting signal to enable use of the system in noisy locations.

In connection with the foregoing object, it is a still further object to minimize drain on the battery when the visual and audible alerting signals are generated.

Further features of the invention pertain to the particular arrangement of the elements of the communication receiver, and the components and elements thereof, whereby the above-outlined and additional operating features thereof are obtained.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which:

FIG. 1 is a block diagram of a communication receiver made in accordance with and embodying the principles of the present invention;

FIG. 2 is a more detailed block diagram with respect to the receiver circuits and depicts schematically the decoder for responding to a single control tone;

FIG. 3 is a schematic diagram of the pulser circuit, the feedback network, the timer switch and the audio amplifier in the drawing of FIG. 1;

FIG. 4 is a graph showing the signals at various points in the circuitry of FIG. 3;

FIG. 5 is a block diagram of a second embodiment of the present invention;

FIG. 6 is a detailed block diagram of the decoder circuit of FIG. 5;

FIGS. 7, 8 and 9 are detailed schematics of the certain portions of the communication receiver of FIG. 5;

FIG. 10 is a graph depicting the signals at various points in the circuitry shown in FIG. 9; and

FIG. 11 shows an additional system that may be used in conjunction with the receiver of FIG. 9.

The principles of the present invention are equally applicable to communication systems utilizing lines, modulated supersonic signals, AM radio signals, and FM radio signals. For illustrative purposes, there is shown in the drawings, a communication system employing FM radio signals. Those skilled in the art will readily understand that the various principles to be described hereinafter in conjunction with the system employing FM radio signals can be readily adjusted to the other types of communications systems using other forms of transmissions such as those set forth above.

Referring now to FIG. 1 of the drawings, there is shown a communication receiver **20** made in accordance with and embodying the principles of the present invention, the receiver being generally designated by the numeral **20**. The receiver **20** is adapted to receive an RF carrier modulated by audio signals and one or more control tones. The transmissions are received by the receiver **20** at the antenna **21** thereof and are coupled to receiver circuits **30** which process the modulated RF carrier and converted it into a demodulated composite signal comprised of the audio signals and the control tone. The output from the receiver circuits **30** appears on a conductor **42** which applies the audio signals to the audio amplifier **160**, which in turn has its output coupled via conductor **177** to a speaker **180**.

In accordance with the present invention, a decoder **50** is coupled to the conductor **42** and generates a control signal on the conductor **96** when the modulated RF carrier received by the receiver **20** includes the control tone to which the decoder **50** responds. Connected to the decoder **50** via a conductor **96** is a pulser circuit **120**, the pulser circuit **120** producing on the conductor **136** a series of pulses for intermittently rendering the receiver circuits **30** (and the decoder **50**, if desired) operative. In an operative embodiment, the pulses had a duration 15 milliseconds and the interval between pulses was 300 milliseconds, the receiver circuits **30** being rendered operative during the 15 millisecond duration of a pulse. If a modulated RF carrier is impressed on the antenna **21** while the receiver circuits **30** are operative, that is, during the presence of a pulse on the conductor **136**, the receiver circuits **30** will become operative for a given time interval to process and detect the tones and the information and translate it to the decoder **50**. If the signal contains the control tone to which the decoder **50** is tuned, a control signal will appear on the conductor **96**, which energizes the pulser circuit **120** to cause it to provide a continuous supply voltage for a predetermined time. The supply voltage on the conductor **136** renders the receiver circuits **30** operative for that predetermined time. As indicated by the dashed line, the series of pulses (or continuous supply voltage, depending on which is present) may be applied to the decoder **50** to supply its power also. In the specific embodiment shown, the pulser circuit **120** is rendered operative to produce a continuous supply voltage to the receiver circuits **30** until the termination of the control tone. After that predetermined time has lapsed, the pulser circuit **120** again reverts to its quiescent operation to produce the series of pulses on the conductor **136**, intermittently to render the receiver circuits **30** operative.

Also, the decoder **50** produces, on the conductor **108**, a delayed control signal when the RF signal contains the control tone to which the decoder **50** is tuned. A timer switch **140**, to which the conductor **108** is connected, produces an enabling signal on the conductor **150** which renders the audio amplifier **160** operative to amplify the audio signals present on the conductor **42**. The audio signals are then coupled to the speaker **180** which converts them into sound waves. Since the decoder, in the embodiment shown, renders the pulser operative to provide a continuous supply voltage only for the duration of the control tone, there is provided a feedback circuit **155** connected via a conductor **150** from the timer switch **140** through a conductor **158** to the pulser circuit **120**. The timer switch **140** may be set to maintain the pulser circuit **120** operative to provide a continuous supply voltage for any desired time interval even after termination of the control tone, so that the receiver circuits are operative to relay all the audio information contained in the RF signals to a utilization circuit such as the audio amplifier **160**.

There is illustrated in FIG. 2 of the drawings, a more complete diagram of the communication receiver **20**. The carrier signal is picked up by the antenna **21** and is conveyed to the input of a radio frequency amplifier **31**. The output of the radio frequency amplifier **31** is applied by a conductor **32** as one of the inputs to the mixer **35**, the usual local oscillator **33** being provided and having the output thereof connected by a conductor **34** as a second input to the mixer **35**. The intermediate frequency (IF) signal which is the output of the mixer **35** is applied by a conductor **36** as the input to the IF amplifier **37**, the output of which is transmitted by the conductor **38** to the input of a limiter **39**. The output of the limiter **39** appears on a conductor **40** and is the input to the discriminator **41**, the output of the discriminator being a composite demodulated signal appearing on the conductor **42**. The composite demodulated signal includes audio signals for coupling via conductor **42** to the audio amplifier **160** (FIG. 1).

The composite demodulated signal present on the conductor **42** also includes a control tone which is applied to a decoder **50**, the decoder **50** including an amplifier **51** connected to the conductor **42** and having its output coupled via a conductor **52** to a tone filter **53** by a capacitor **54**, the tone filter **53** including a capacitor **55** coupled in parallel with an inductor **56**. The filter **53** is coupled between ground and the junction of a capacitor **71** and the capacitor **54**. The decoder **50** further comprises a reference circuit **60** including an input capacitor **61** connected to the conductor **52** and a diode **62** connected to ground. There is also provided a diode **63** connected between the junction of the capacitor **61** and the diode **62** to a filtering network comprising a resistor **64** and a capacitor **65** coupled in parallel to ground. The decoder **50** further includes a rectifying circuit having a pair of diodes **72** and **73** coupled in series from the anode of the diode **63**, the capacitor **71** being coupled to the junction of the diodes **72** and **73**. The rectifying circuit also includes a resistor **74** and a capacitor **75** connected in parallel from the cathode of the diode **73** to ground to provide filtering for the rectified voltage.

The amplified signal, containing the control tone and voice, on the conductor **52** will be rectified in the reference circuit **60** and will be filtered thereby to provide a reference voltage applied to the anode of the diode **72**. If the signal on the conductor **52** includes the control tone to which the filter **53** is series resonant with the capacitor **54**, the control tone at an increased amplitude, will appear at the cathode of the diode **72**. In order to provide an output from the diode **73**, the control tone appearing at the cathode of the diode **72** must have a peak-to-peak value in excess of the reference voltage on the anode of the diode **72**, before the diode **72** will conduct to provide an output. In effect there is provided a filter **53** followed by a voltage doubler circuit (the tone rectifier circuit **70**) which is biased in such a way that there is no DC output voltage from the diode **73** until the reference voltage on the anode of the diode **72** is exceeded. Thus, the bandwidth over which the tone produces a DC output voltage can be readily controlled by controlling the relationship between the filter output voltage and the reference voltage. With the particular filter shown, for example, the capacitor **54** may be increased in value to produce a greater tone output and consequently a wider bandwidth or lessened in value to similarly produce a narrower bandwidth.

The decoder **50** further includes an electronic switch **80** comprised of an NPN transistor **81** having its emitter grounded and its collector coupled through a resistor **82** to a supply voltage, the base being coupled to the cathode of the diode **73**. There is provided a first output stage **90** consisting of a PNP transistor having its base coupled through a resistor **92** to the collector of the transistor **91**.

The emitter of the transistor **91** is coupled to ground via a resistor **93** and is coupled to the source of supply voltage by a resistor **94**, whereby the resistors **93** and **94** function as a voltage divider to provide a reference voltage on the emitter of the transistor **91**. The collector of the transistor **91** is coupled by a resistor **95** to the first output conductor **96**. There is also provided a second output stage **105** which includes a PNP transistor **106** having its base coupled by way of a resistor **101** to the collector of the transistor **81** and having its emitter coupled to the junction of the resistors **93** and **94**. A capacitor **102** is coupled between the source of supply voltage and the base of the transistor **106**, the resistor **101** and the capacitor **102** defining a time delay network **100** as will be explained presently. The collector of the transistor **106** is coupled by way of a resistor **107** to a second output conductor **108**.

The rectified and filtered DC voltage appearing at the base of the transistor **81** in the presence of the proper control tone causes conduction of the transistor **81**, thus to "switch" the collector voltage from B+ to ground reference potential. This, in turn, causes the transistor **91** to conduct heavily to provide a positive DC voltage on the conductor **96**, which acts as a control signal. The conduction of the transistor **81** also provides a path for current flow from B+ through the capacitor **102**, the resistor **101** and the collector-emitter junction of the transistor **81**, thereby to charge the capacitor **102**. As soon as the capacitor **102** has been sufficiently charged, the transistor **106** will begin to conduct heavily to place a positive voltage on the conductor **108**, which acts as a second control signal. The charging of the capacitor **102** effectively delays the time at which the second control signal appears on the conductor **108**, by an amount depending on the RC time constant of the capacitor **102** and the resistor **101**. Thus, the first control signal appears on the conductor **96** as soon as the control tone is received, whereas the second control signal does not appear on the conductor **108** for some predetermined time thereafter. The purpose for the delay network **100** will be explained as the description proceeds.

Referring now to FIG. 3, the first control signal on the conductor **96** is applied to a pulser circuit **120** which includes an astable multivibrator **121** in which there is an NPN transistor **122** having its emitter on ground, its collector coupled through a resistor **123** to the supply voltage, and its base coupled to the cathode of a diode **124**, the anode of which is on ground. The multivibrator **121** also has a second NPN transistor **125** with its emitter grounded and its base coupled through a capacitor **126** to the collector of the transistor **122**. The collector of the transistor **125** is coupled to the source of supply voltage by way of a resistor **127**. There is also provided a diode **128** coupled from ground to the base of the transistor **125**. Last, the multivibrator **121** includes a feedback capacitor **129** coupled from the collector of the transistor **125** back to the base of the transistor **122**. The diode **124** provides a fast discharge path for the capacitor **129**, and the diode **128** provides a fast discharge path of the capacitor **126**.

The pulser circuit **120** also includes an electronic switch **130** having an NPN transistor **131** with its emitter grounded, its base coupled to the resistor **132** and its collector coupled by way of a resistor **133** to the source of supply voltage. The switch **130** also includes a PNP transistor **134** having its emitter coupled to the source of supply voltage, its base coupled to the collector of the transistor **131** by way of a resistor **135** and its collector coupled to the output conductor **136**. Also coupled to the base of the transistor **131** is the conductor **96**.

In operation, the multivibrator **121** serves, by well-known operation, to produce a series of pulses having a peak-to-peak value equal to the value of the supply voltage. The duration of the pulses is determined primarily by the values of the resistor **123** and the capacitor **126**; and the interval between successive pulses is determined

primarily by the values of the resistor **127** and the capacitor **129**. In an operating circuit incorporating the present invention, each pulse had a duration on the order of 15 milliseconds and about 300 milliseconds elapsed between successive pulses. The series of pulses is applied to the electronic switch **130**, which causes successive conduction of the transistors **131** and **134** to provide a series of pulses on the conductor **136** having a peak-to-peak value equal to the value of the supply voltage. The series of pulses are translated along the conductor **136** to the various elements of the receiver circuits **30**, as is most clearly shown in FIG. 2 wherein offshoots of the conductor **136** are provided for the RF amplifier **31**, the local oscillator **33**, the mixer **35**, the IF amplifier **37**, the limiter **39** and the discriminator **41**. It should be clear that these pulses of supply voltage render operative each element in the receiver circuits **30** so that it is able to process RF signals appearing at the antenna **21**. Of course, if an RF signal appears at the antenna **21** between pulses, the receiver circuits **30** will not be operative and that signal will not be processed.

As explained previously, if an RF signal is received at an instant when a pulse is present, the signal will be processed in the receiver circuits **30**, with the audio signals being applied along the conductor **42** to the audio amplifier **160**. If the composite signal on the conductor **42** contains the control tone to which the filter **53** is tuned, a first control signal will appear on the conductor **96** as previously described. The control signal on the conductor **96** is applied (FIG. 3) to the base of the first transistor **131** in the switch **130** to render the transistor **131** conductive, which in turn renders conductive the transistor **134** to place on the conductor **136** a constant DC voltage equal to the B+ supply voltage, which is applied back to each element in the receiver circuits **30**. Now the receiver circuits **30** are in condition to receive and process any RF signals impressed on the antenna **21** for the duration of the control signal on the conductor **96**. It should be apparent that once the control signal is removed, the pulser circuit **120** reverts back to its original state and produces the series of pulses for intermittently energizing the receiver circuits **30**. In the embodiment shown, the control signal on the conductor **96** terminates at the same time that the control tone ends.

However, it may be desired to maintain the receiver circuits **30** operative for a period of time after termination of the control tone. For that purpose there is provided an electronic switch circuit **140** which may either be timed to maintain the pulser circuit **120** operative to generate a continuous supply voltage for a longer duration, or may be of the latching variety in which case the pulser circuit **120** will produce a continuous supply voltage until some positive act is effected by the user to interrupt its operation. In the embodiment shown, the switch **140** is a monostable multivibrator and functions as a timer.

The electronic switch **140** includes an NPN transistor **141** having its emitter coupled to ground via a resistor **142** and having its base coupled to ground by way of a resistor **143** and a diode **144** coupled in parallel. There is also provided a PNP transistor **145** having its base connected directly to the collector of the transistor **141**, its collector connected through a resistor **147** to ground and its emitter connected to a source of supply voltage, a resistor **146** being connected between the base and the emitter of the transistor **145**. The collector of the transistor **145** is coupled by way of a capacitor **148** to the base of the transistor **141**. A conductor **150** is coupled from the resistor **147** to a feedback network **155** consisting of a resistor **156** and a diode **157** coupled in series. The cathode of the diode **157** is coupled through a conductor **158** back to the base of the transistor **131** in the pulser circuit **120**. The conductor **150** is also coupled to the audio amplifier **160**. There is also provided a manually operable switch **151** coupled between the source of supply voltage and the base of the transistor **141**. Finally, the conductor

108 which carries the delayed control signal from the decoder 50 is coupled to the base of the transistor 141.

In operation, the appearance of the delayed control signal on the conductor 108 causes conduction of the transistor 141 which provides a path for current flow from the source of supply voltage through the base-emitter junction of the transistor 145 and the collector-emitter junction of the transistor 141. This renders the transistor 145 highly conductive so as to provide current flow through its collector-emitter junction and the resistor 147 and thereby place the supply voltage on the conductor 150. The supply voltage becomes an enabling signal for rendering the audio amplifier 160 operative, as will be explained presently.

During the conduction periods of the transistors 141 and 145, current flows from B^+ through the collector-emitter junction of the transistor 145, through the capacitor 148 and through the base-emitter junction of the transistor 141 to charge the capacitor 148. Accordingly, when the control signal on the conductor 108 is removed by virtue of the control tone terminating, the transistor 141 remains conductor as the capacitor 148 continues to charge through the base-emitter junction of the transistor 141 and the resistors 142 and 143. Of course, the conduction of the transistor 141 maintains the transistor 145 conductive to maintain the enabling voltage on the conductor 150 for a time interval determined by the RC time constant of the switch circuit 140, that is, the resistors 142 and 143 and the capacitor 148. By selecting the value of those parts, the time period that the enabling signal remains on the conductor 150 may be controlled.

The audio amplifier 160 includes a first stage of amplification consisting of an NPN transistor 161 having its emitter coupled through a volume-control potentiometer 163 and a resistor 162 to ground. The collector of the transistor 161 is coupled to the source of supply voltage and its base is coupled by a resistor 164 and a capacitor 159 to the conductor 42. A bias voltage is derived by a resistor 165 and a diode 166 coupled in series from the conductor 150 to the base of the transistor 161. A capacitor 166*a* filters the DC voltage on the conductor 150. There is also provided a second stage of amplification consisting of an NPN transistor 167 having its emitter on ground, its collector coupled through a choke 168 to the source of supply voltage and its base coupled through a capacitor 169 to the movable arm of the potentiometer 163. Bias voltage for this transistor is supplied by a resistor 170 coupled between its base and the conductor 150. There is also provided a third stage of amplification consisting of a pair of complementary symmetry transistors 171 and 172, the base voltage for these transistors being supplied by a voltage divider consisting of resistors 173 and 174 connected between the conductor 150 and ground. The collector of the transistor 167 is coupled through a capacitor 175 to the connected-together bases of the transistors 171 and 172. The collectors of the transistors 171 and 172 are respectively coupled to B^+ and ground. The emitters of the transistors 171 and 172 are connected together and through a capacitor 176 to an annunciator such as the speaker 180. A feedback capacitor 178 reduces crossover distortion by providing negative feedback.

In operation, the enabling signal appearing on the conductor 150 in response to a control tone, is applied through the diode 166 and the resistor 165 to establish a positive voltage on the base of the transistor 161 and thereby render it conductive. The diode 166 prevents the audio signals on the conductor 42 from being applied to the electronic switch 140 by way of the conductor 150. Similarly, the enabling signal on the conductor 150 is applied through the resistor 170 to the transistor 167 to render it conductive also. Also, the enabling signal provides a bias voltage across the resistor 174 for the transistors 171 and 172. In this condition, audio signals on the conductor 42 will be amplified by the transistor 161, then by the transistor 167 and power amplified by the transistors 171 and 172. The potentionmeter 163 functions as a volume control and is accessible to the user of the receiver. Of course, without the enabling signal on the conductor 150, none of the transistors 161, 167, 171, or 172 are operative to amplify the audio signals on the conductor 42. It is thus desirable that the RC time constant in the electronic switch circuit 140 be selected to be long enough to maintain the audio amplifier 160 operative for the duration of the audio information. However, if the audio information extends beyond the time that the electronic switch 140 opens, the user can close the manual switch 151 which provides the enabling signal on the conductor 150. In the circuit shown in FIG. 3, the audio amplifier 160 may be viewed as a utilization circuit which utilizes the enabling signal appearing on the conductor 150. The speaker 180 may be viewed as an annuciator for the audio signal developed in the audio amplifier 160.

Recapitulating, the pulser circuit 120 produces a series of pulses on the conductor 136 which are used intermittently to provide supply voltage for the various elements in the receiver circuits 30. In a particular embodiment, the pulse width was 15 milliseconds and the time between pulses was 360 milliseconds, or a 4 percent duty cycle. This means that during 96 percent of the time, the communication receiver 20 was drawing essentially no current, and during the other 4 percent of the time the receiver was drawing "standby" current. In standard communication receivers, the receiver circuits are maintained continuously operative so that they provide a constant drain on the battery. Since the receiver 20 receives audio signals intended for it a fraction of 1 percent during the course of a day, the greatest drain on the battery is the amount of "standby" current drawn. It can be appreciated that in the case of the "standard" receiver, where the receiver circuits continually draw current, there is a maximum drain on the battery and a minimum useful life thereof. On the other hand, using the 4 percent duty cycle as an example, the receiver circuits 30 are drawing "standby" current only 4 percent of the time, whereby the useful life of the battery may be increased theoretically by a factor of 25. Of course the pulser circuit 120 does draw some current, so that the actual increase in battery life may be slightly less than 25 times. The circuit disclosed above means that a battery having lesser capabilities, and thus smaller size, can be used. This is most important in the particular type of receiver to which the invention is particularly adapted, namely, a portable one. To be portable, the size of the receiver must be minimized, and, since batteries always consume a substantial portion of the usable space, it is an important advantage to be able to reduce the size of the battery without sacrificing performance of the receiver. As a matter of fact, the size of the battery may be reduced and its useful life may be substantially increased at the same time by virtue of the above invention. Also, manufacturers of this type of portable equipment strive always to reduce the weight of the receiver, another objective which is accomplished by the above invention due to the smaller size of the batteries.

Reference is made to the graph of FIG. 4, wherein the waveform 190 represents the signal appearing on the conductor 136 (see FIG. 3) which is the output of the pulser circuit 120 and consists of a series of pulses 191. For purpose of illustration, the duration of each pulse is 15 milliseconds and 360 milliseconds elapses between pulses. Accordingly, the receiver circuits 30 are rendered operative for the duration of each pulse 191 and are inoperative between the pulses 191. If an RF signal carrying a control tone represented by the waveform 195 is impressed on the antenna 21 during the presence of a pulse 191, it will be detected in the discriminator 41 and will appear on the conductor 52. If the control tone has the frequency to which the filter circuit 53 is tuned, it will pass into the rectifier circuit 70. The signal on the conductor **52**, including the noise thereon, is rectified by the reference circuit **60** to provide a reference voltage on the anode of the diode **72**. If the signal **195** exceeds the reference voltage, it will be rectified in the rectifier circuit **70** and amplified by the transistors **81** and **91** to provide a control signal on the conductor **96**. This causes the electronic switch **130** to close and provide a continuous supply voltage, which is indicated by the numeral **192** of the waveform **190**. The continuous supply voltage is applied to the receiver circuits **30** to cause the control signal **196** to appear on the conductor **96**. It should be noted that, although the control tone commenced at t_1, it would not be processed by the receiver circuits **30** since at t_1 the supply voltage was not being applied thereo. At t_2, however, a pulse **191** has commenced to render the receiver circuits **30** operative to translate the RF signal and detect the control tone **195** therein. There is a short delay of perhaps 8 milliseconds for the decoder **50** to respond so that at t_3 the control signal **196** commences, and terminates at t_5 with the termination of the control tone. Without more, the continuous supply voltage **192** would also terminate at this time. The output of the decoder **50** on the conductor **108** is shown as a waveform **197** and, as can be seen, it has the same appearance as the waveform **196**, but delayed in time so that it commences at t_4. This is, of course, due to the delay provided by the network **100** in the decoder **50**. The control signal on the conductor **108** causes the switching circuit **140** to provide on the conductor **150** an enabling signal represented by the waveform **198**, commencing at t_4. One leg of the conductor **150** is coupled through the feed back network **155** to the electronic switch **130** in the pulser circuit **120** to maintain the switch closed and continue to provide the continuous voltage supply **192** in spite of the termination of the control tone at t_5. The continuous supply voltage on the conductor **136** will be present until t_6 which is determined by the time constant in the electronic switch circuit **140**. It is, therefore, apparent that the receiver circuits **30** are operative to translate audio information via the conductor **42** to the audio amplifier **160** for the duration of t_2 to t_6. If the user finds that additional audio information is still being received, he can close the manual override switch **151** to maintain the continuous supply voltage **192** beyond t_6.

The conductor **150** also couples the enabling signal to the audio amplifier **160** to render the same operative to amplify the audio signals on the conductor **42**. The period of conduction of the audio amplifier **160** is during the period t_4 to t_6. However if the audio information is still being received at t_6, the manual override switch **151** can be closed to maintain the audio amplifier **160** operative beyond t_6. In one embodiment of the invention, the duration of t_4 to t_6 was ten seconds, although any time shorter or longer than that is easily attained.

The delay provided by the network **100** in the decoder **50** is to minimize the possibility of the receiver responding to a false signal, particularly noise. Of course noise contains a wide spectrum of signals including the signal to which the filter circuit **53** in the decoder **50** responds. Accordingly, such a noise signal can provide a control signal on the conductor **96** to render the pulser **120** operative to produce a continuous supply voltage for the receiver circuits **30**. The control tone in the noise is necessarily very short in duration so that it is unlikely that the receiver circuits will be on for more than a couple of milliseconds or so, whereby no increase in current drain occurs. Such a signal would not yield a control signal on the conductor **108** because of the delay in the network **100**. Accordingly, in the presence of noise or other extraneous signals, no enabling signal is provided on the conductor **150**, whereby no voltage is fed back to the pulser circuit **120** to lengthen the duration of the continuous supply voltage and whereby the audio amplifier **160** is not rendered conductive.

To insure that the control tone will operate the receiver in the manner described, the duration thereof should be longer than the lapsed time interval between successive pulses **191** by an amount at least equal to the turn on delay period t_2–t_4. So, in the example given, if the time between pulses is 360 milliseconds, then a control tone that lasts for 400 milliseconds plus the turn on delay period t_2–t_4 will necessarily be present during the occurrence of a pulse **191** and also provide for variations in the elements of the receiver.

An important feature of the invention is the fact that it responds to a control tone and will not respond to carrier signals alone. If the RF signal received by the receiver **20** does not contain a control tone at the frequency to which the filter circuit **53** is tuned, the pulser circuit **120** will not provide a continuous supply voltage, nor will the audio amplifier **160** be turned on. This is particularly important when it is considered how necessary it is today to make optimum use of the frequency spectrum. If the receiver were to be rendered operative solely by an RF signal of the proper frequency, it would be turned on many, many times during the day, even though it contained information for the user of that receiver perhaps two or three times. On the other hand, the communication receiver **20** described will draw current only during the presence of the proper carrier containing the proper control tone, thus to energize the receiver **20** only during the two or three times a day that the receiver is called.

In a typical operating example of the circuits shown in FIGS. 2 and 3, the various components thereof had the following values: capacitors **54** and **55** and the inductor **56** had values determined by the frequency to which the decoder **50** was to respond; the capacitor **61**, 0.02 microfarads; the resistor **64**, 1 megohm; the capacitor **65**, 0.02 microfarads; the resistor **74**, 5 megohms; the capacitor **75**, 0.01 microfarad; the resistor **82**, 1 megohm; the resistors **92** and **101**, 1 megohm; the resistors **93** and **94**, 100 kilohms; the resistor **95**, 220 kilohms; the resistor **107**, 100 kilohms; the resistor **123**, 220 kilohms; the capacitor **126**, 0.1 farad; the resistor **127**, 220 kilohms; the capacitor **129**, 0.02 farads; the resistors **132** and **133**, 470 kilohms; the resistor **135**, 4.7 kilohms; the resistor **146**, 2.2 megohms; the resistor **147**, 100 kilohms; the capacitor **148**, 1.5 microfarads; the resistor **143**, 2.2 megohms; the resistor **[143]** *142*, 22 kilohms; the resistor **156**, 220 kilohms; the capacitor **159**, 820 picofarads; the resistor **164**, 1 megohm; the resistor **165**, 220 kilohms; the capacitor **[166]** *166a*, 1.5 microfarads; the potentiometer **163**, 0 to 10 kilohms.

Referring now to FIG. 5 of the drawings, there is illustrated a second embodiment of the present invention wherein a sequence of four tones is required to actuate the communication receiver which is designated by the numeral **220**. The receiver **220** includes an antenna **221** for receiving RF signals, and receiver circuits **230** comprising the same elements as the receiver circuits **30** shown in FIG. 2. In the interest of brevity, further detailed description of the various elements of the receiver circuits **230** will be omitted. Appearing on the conductor **231**, the output of the receiver circuits **230**, is a composite demodulated signal including the control tones and intelligence if any. In the particular embodiment shown in FIG. 5, the communication receiver **220** has no provision for audio circuitry but rather is a paging device. Accordingly, the conductor **231** will not have any intelligence (i.e., voice) thereon. There is provided a pulser circuit **500** which is constructed and operates similarly to the pulser circuit **120** in the first embodiment. The pulser circuit **500** produces a series of pulses on the conductor **516**, which is coupled back to the receiver circuits **230** to provide the supply voltage therefor. During the presence of the pulses, the receiver circuits **230** are operative to process and detect RF signals impressed on the antenna **221**; whereas between successive pulses, the receiver circuits **230** are inoperative and any signals on the antenna **221** will not pass through to the decoder.

A decoder **240** is coupled to the conductor **231** and if the control tones are at the frequencies to which the decoder **240** is tuned, a control signal will be developed on the conductor **473** for application to the pulser circuit **500**. The control signal on the conductor **473** commences essentially at the same time as the inception of the first control tone in the series of control tones, the control signal causing the pulser circuit **500** to furnish a continuous supply voltage for a predetermined interval on the conductor **516**, which supply voltage renders the receiver circuit **230** continuously operative for that interval to process and detect RF signals on the antenna **221**. Upon termination of the last control tone in the series, the control signal on the conductor **[416]** *516* is removed and the pulser circuit **500** again produces a series of pulses for intermittent operation of the receiver circuits **230**. A second output of the decoder **240** appears on the conductor **465** and carries a second control signal that commences essentially with the reception of the last control tone in the series of control tones, assuming the previous ones have been received in the proper order. The control signal on the conductor **465** terminates with the termination of the last control tone.

The control signal on the conductor **465** is applied to a timer switch circuit **370** which, in turn, energizes a utilization circuit such as the oscillator **540**. The series of pulses from the pulser circuit **500** is also applied to the oscillator **540**, and, in the presence of both signals, a pulsating oscillatory signal is applied to an annunciator such as the speaker **545** which generates a series of bursts of alerting tones.

The control signal on the conductor **465** is also applied to a latching switch circuit **570** which, in turn, energizes a utilization circuit such as the lamp control circuit **590**. Also applied to the lamp control circuit **590** is the series of pulses on the conductor **516**. In the presence of both the series of pulses and the enabling signal from the latching switch circuit **570**, an annunciator such as the lamp **600** blinks on and off at a rate determined by the series of pulses. Another output from the latch switching circuit on the conductor **582** is applied to a pulse extender circuit **610** which, upon termination of the last control tone, lengthens the pulses developed by the pulser circuit **500** to increase the duration of the bursts from the speaker **545** and to increase the on-time of the lamp **600**. After expiration of a predetermined time, the timer switch circuit **370** ceases to provide the enabling signal on the conductor **530** and the bursts of audio cease. When the user operates a manual switch in the latching switch circuit **570**, the lamp **600** becomes extinguished and the pulser circuit **500** reverts to producing pulses of shorter duration.

The output from the receiver circuits on the conductor **231** is applied to the decoder **240** which is shown in block form in FIG. 6. The decoder **240** is adapted to respond to a series of four control tones received in a predetermined order. The signal on the conductor **231** is applied to a pair of tone control channels, the lower tone control channel including a special tapped filter **241** of a construction to be described hereinafter. If the filter **241** is tuned to the frequency of the first control tone on the conductor **231**, it will pass to the conductor **246** and be applied to a rectifier **260**. The control tones and any noise on the conductor **231** are also applied to a reference circuit **270** which provides a reference voltage on the conductor **275**. If the first control tone on the conductor **246** exceeds the reference voltage on the conductor **275**, the rectifier **260** will operate to rectify the first control tone and provide a filtered DC voltage on the conductor **266**. The DC voltage is applied to an electronic switch **280** so as to power amplify the voltage and apply it on a conductor **285** as one input to an AND circuit **290**. A second input for the AND circuit, on a conductor **426**, is derived from an inverter **420**. If both inputs are present, an output voltage on the conductor **294** will result, which voltage is applied to a timer **300**. Upon termination of the first control tone, a DC voltage appears on the conductor **303** and persists for a duration dependent on the setting of the timer **300**. The voltage on the conductor **303** is coupled to an electronic switch **310** which provides a DC voltage pulse on its output conductor **314**. The voltage on the conductor **314** is coupled to a filter **341** in the second control tone channel and tunes the same to receive the second control tone present on the conductor **231**. If the second control tone on the conductor **231** appears immediately and is at the frequency to which the filter **341** is now briefly tuned, it will pass to the conductor **346** and will be applied to a rectifier **360**. If the second control tone on the conductor **346** exceeds the reference voltage on the conductor **275**, the rectifier **360** will operate to rectify the second control tone and provide a filtered DC voltage on the conductor **366**. The DC voltage is applied to an electronic switch **380** so as to power amplify the voltage and apply it on a conductor **385** as one input to an AND circuit **390**. The second input for the AND circuit **390** is the voltage on the conductor **314**. Thus, if the first control tone was received and has terminated so as to provide a voltage pulse on the conductor **314**, and the second control tone is being received while that pulse is present to provide a DC voltage on the conductor **385**, the AND circuit **390** will operate to produce a DC output voltage on the conductor **394**. This voltage is applied to a timer **400** which provides a DC voltage on the conductor **403** upon termination of the first control tone, persisting for a duration dependent on the setting of the timer **400**. This voltage is applied to an electronic switch **410** which produces a DC voltage on the conductor **414** for application to the inverter **420** so as to place the same in its other stable condition. The resulting output from the inverter **420** on the conductor **426** is coupled back to one input of the filter **241** which causes the filter **241** to no longer be tuned to the first control tone. Simultaneously, the voltage on the conductor **414** is applied to another input of the filter **214** to retune the same to respond to the third control tone. Finally, the voltage on the conductor **414** is applied as a first input to an AND circuit **430**.

If the proper third control tone is received on the conductor **231**, the filter **241** will pass the third control tone to the rectifier **260**. If the third control tone exceeds the reference voltage on the conductor **275**, it actuates the electronic switch **280** to provide one input to the AND circuit **290**. However, the inverter is in its second stable condition so that a second input to energize the AND circuit **290** is lacking. The third control tone, in addition, provides a second input to the AND circuit **430**. With both inputs to the AND circuit **430**, a potential is developed on the conductor **438** which is applied back to the input of the electronic switch **410** to hold it in the active condition as long as the third tone is received. A second output of the AND circuit **430** on the conductor **437** is applied to a timer **440**. Upon termination of the third control tone, a DC voltage appears on the conductor **443** and persists for a duration dependent on the setting of the timer **440**. This voltage is applied to an electronic switch **450** which produces a DC voltage on the conductor **454**. This output voltage is fed back to the filter **341** to retune the same so as to be operative to receive the fourth control tone. The signal on the conductor **454** is also applied as one of the inputs to an AND circuit **460**.

Assuming that the proper fourth tone in the sequence of tones is now received, there will be an output from the filter **341** which will be rectified in the rectifier **360** to provide a DC voltage. This voltage operates the electronic switch **380** and provides a second input, on the conductor **385**, to the AND circuit **460**. In the presence of both inputs, the AND circuit **460** provides a control signal on the conductor **465**. A hold-on potential is applied from the AND circuit **460** on the conductor **466** to the input of the electronic switch **450** to hold the latter in its active condition as long as the fourth tone is being received.

Also provided in the decoder **240** is a pulser control circuit **470** having a pair of inputs respectively coupled to the conductors **285** and **385**. The pulser control circuit **470** is operative to provide on its output conductor **473** a control signal commencing with inception of the first control tone, it being pointed out that a voltage appears on the conductor **285** throughout the first and third tones and a voltage appears on the conductor **385** throughout the second and fourth tones, so that a voltage is continually being supplied to the pulse control circuit **470** to cause a continuous control voltage to appear on the conductor **473** for the duration of the control tones.

Referring now to FIGS. 7 and 8 of the drawings, there are illustrated further details of the decoder **240**. The filter **241** includes an inductor **242** having associated therewith a magnetic core **243**, at least a portion of the core **243** being movable and adjustable, whereby the inductor **242** can be slug tuned. The inductor **242** is connected through a capacitor **245** to the conductor **231**, and a capacitor **244** is coupled from the top of the inductor **242** to ground. The ouput from the filter **241** appears on a conductor **246**. The inductor **242** has a plurality of taps thereon, two of which are identified by the numerals **247** and **248**. Associated with selected ones of the taps are two NPN transistors **250** and **253**. A resistor **249** is coupled between the base of the transistor **250** and the conductor **426**. The transistor **250** has a collector connected to the tap **248** on the inductor **242**, while the emitter is connected to ground potential. A resistor **254** is coupled between the base of the transistor **253** and the conductor **414**. The transistor **253** has a collector connected to the tap **247** on the inductor **242**, while the emitter is connected to ground potential.

The decoder **240** also includes an inverter **420** including a PNP transistor **421**, the base of which is coupled through a resistor **422** to ground and through a diode **423** and a resistor **424** to the conductor **414**. A source of B+ supply voltage is coupled to the emitter of the transistor **421** through a diode **425**. In its quiescent condition, the transistor **421** is heavily conductive so that the supply voltage appears on the conductor **426** to render the transistor **250** in the filter **241** heavily conductive, thereby effectively to ground the tap **248** on the inductor **242**. In this condition, there is defined a parallel resonant circuit in the filter **241**, composed of the capacitor **244** coupled across the top half of the inductor **242**. If the first control tone on the conductor **231** is at the frequency to which the filter **241** is now tuned, the control tone, at an increased amplitude, will appear on the conductor **246**. It should be noted that, at this time, the transistor **253** is nonconductive.

The control tone, together with the noise on the conductor **231**, is applied to a reference circuit **270** which is constructed like the reference circuit **60** in the first embodiment, and, in the interest of brevity, no further explanation will be provided, except that a referenec voltage is provided on the conductor **275** proportional in amplitude to the control tones and noise on the conductor **231**. The first control tone on the conductor **246** is applied to a rectifier **260** which has the same construction as the rectifier **70** in the first embodiment, and, again in the interest of brevity, no further explanation will be made, except that a DC voltage will be present on the conductor **266** if the control tone on the conductor **246** exceeds the reference voltage on the conductor **275**.

The next stage is an electronic switch **280** consisting of a pair of cascaded NPN transistors **281** and **283**, having their collectors coupled to a DC voltage supply respectively via resistors **282** and **284**. The DC voltage on the conductor **266** will cause the transistors **281** and **283** to conduct heavily, so as effectively to ground the collector of the transistor **283**.

The next stage is an AND circuit **290** including a PNP transistor **292** having a base coupled by way of a resistor **291** to the conductor **285**. The emitter of the transistor **292** is coupled by way of a diode **293** to the conductor **426**, and the collector is coupled to ground through a resistor **301**. There are two inputs to the AND circuit **290** from the conductors **285** and **426**. If the conductor **285** is effectively grounded, which occurs through the transistor **283** when the first control tone is present, and if the positive voltage appears on the conductor **426**, which occurs when the inverter **420** is in its quiescent condition, the transistor **292** becomes heavily conductive to place a positive voltage on the conductor **294**. A timer **300**, consisting of the resistor **301** and a capacitor **302** produces a negative DC voltage on the conductor **303** upon termination of the positive voltage on the conductor **294** which occurs upon termination of the first control tone. The next stage is an electronic switch **310** which includes a PNP transistor **311** having its emitter coupled to the source of supply voltage, having its base coupled thereto through a resistor **312** and a diode **313**, and having its collector coupled to the conductor **314**. While the first control tone is being received, the capacitor **302** is being charged through the diode **313** and the transistor **311** is not conductive. However, upon termination of the first control tone, the capacitor **302** discharges through the resistor **301** to render the transistor **311** heavily conductive to place the supply voltage on the conductor **314**. This voltage persists for a duration determined by the RC time constant of the timer **300**. The positive voltage on the conductor **314** is applied as one input to the AND circuit **390** and as an input to the second filter **341**.

The filter **341** includes an inductor **342** having associated therewith a magnetic core **343**, at least a portion of the core **343** being movable and adjustable, whereby the inductor **342** can be slug tuned. The inductor **342** is connected through a capacitor **345** to the conductor **231**, and a capacitor **344** is coupled from the bottom of the inductor **342** to ground. The output from the filter **341** appears on a conductor **346**. The inductor **342** has a plurality of taps thereon, two of which are identified by the numerals **347** and **348**. Associated with selected ones of the taps are two NPN transistors **350** and **353**. A resistor **349** is coupled between the base of the transistor **350** and the conductor **314**. The transistor **350** has a collector connected to the tap **348** on the inductor **342**, while the emitter is connected to ground potential. A resistor **354** is coupled between the base of the transistor **353** and the conductor **454**. The transistor **353** has a collector connected to the tap **347** on the inductor **342** while the emitter is connected to ground potential.

The positive supply voltage on the conductor **314** developed during the presence of the first control tone renders the transistor **350** in the filter **341** heavily conductive thereby effectively to ground the tap **348** on the inductor **342**. In this condition, there is defined a parallel resonant circuit composed of the capacitor **344** coupled across the bottom portion of the inductor **342**. If the second control tone in the series of control tones on the conductor **231** is at the frequency to which the filter **341** is then tuned, the control tone, at an increased amplitude, will appear on the conductor **346**. It should be noted that at this time the transistor **353** is nonconductive.

The second control tone on the conductor **346** is applied to a rectifier **360** which is constructed like the rectifier **260**. rectified DC voltage will appear on the conductor **366** if the second control tone exceeds the reference voltage on the conductor **275**.

The next stage is an electronic switch **380** consisting of a pair of NPN transistors **381** and **383** coupled in cascade, and respectively having their collectors coupled to the source of supply voltage by way of resistors **382** and **384**. The rectified DC voltage on the conductor **366** causes the transistors **381** and **383** to conduct heavily, thereby effectively grounding the collector of the transistor **383**.

The next stage is an AND circuit **390** comprised of an PNP transistor **391** having its base coupled to the conductor 385 by the resistor 392. The collector of the transistor 391 is coupled to ground through a resistor 402. There is further provided an NPN transistor 393 having its base coupled to the emitter of the transistor 391, and its emitter coupled to the conductor 385 by a resistor 396. The junction of the base of the transistor 393 and the emitter of the transistor 391 is coupled to the conductor 314. The two inputs for the AND circuit 390 are on the conductors 385 and 314. It will be remembered, that a positive voltage appeared on the conductor 314 after termination of the first control tone, which positive voltage, in conjunction with the grounding of the conductor 385, by immediate reception of the second tone causes both transistors 391 and 393 to conduct heavily. The collector of the transistor 393 is coupled by way of a conductor 395 back to the conductor 303. The heavy conduction of the transistor 393 permits current to flow from B+ through the base-emitter junction of the transistor 311, through the collector-emitter junction of the transistor 393, and through the collector-emitter junction of the transistor 383, to maintain the transistor 311 conductive for the duration of the second control tone. As long as the transistor 311 is conductive, one input to the AND circuit 390 is provided and, as long as the second control tone is present, the second input to the AND circuit 390 is provided. Thus a DC voltage will be present on the conductor 385 for the duration of the second control tone. A second output from the AND circuit 390 on the conductor 394 is derived from the collector of the transistor 391. A timer 400, consisting of the resistor 402 and a capacitor 401 produces a negative DC voltage on the conductor 403 upon termination of the positive voltage on the conductor 394 which occurs upon termination of the second control tone. The next stage is an electronic switch 410, which includes a PNP transistor 411 having its emitter coupled to the source of supply voltage and having its base coupled to said source by way of a resistor 412 and a diode 413. While the second control tone is being received, the capacitor 401 is being rapidly charged through the diode 413 and the transistor 411 is not conductive. However, upon termination of the second control tone, the capacitor 401 discharges through the resistor 402 to render the transistor 411 heavily conductive to place the supply voltage on the conductor 414. This voltage persists for a duration determined by the RC time constant of the timer 400.

The positive voltage on the conductor 414 is coupled to the inverter circuit 420 to render the transistor 421 nonconductive, which in turn renders nonconductive the transistor 250 of the filter 241. Also, the conductor 414 applies a positive voltage to the base of the transistor 253 to render it heavily conductive, thereby effectively placing the capacitor 244 across the top portion of the coil 242. If the third control tone in the series of control tones on the conductor 231 has a frequency to which that resonant circuit is tuned, the resonant circuit will develop a voltage on the conductor 246 which will be rectified by the rectifier 260 to provide a DC voltage to operate the switch 280, the output of which is applied as one input to the AND circuit 290. Since the voltage on the conductor 426 is no longer positive, the AND circuit 290 will not operate in spite of the presence of the voltage on the conductor 285. The DC voltage is also applied to an AND circuit 430, and AND circuit 430 including an NPN transistor 431 having its base coupled to the emitter of a PNP transistor 432. The base of the transistor 432 is coupled to the conductor 285 by means of a resistor 434, and the emitter on the transistor 431 is coupled by a resistor 435 to the conductor 285. The conductor 414 is coupled to the junction of the base of the transistor 431 and the emitter of the transistor 432. The grounded condition of the conductor 285, resulting from the presence of the third control tone, and the plus voltage on the conductor 414, resulting from the cessation of the second control tone, cause the transistors 431 and 432 to conduct heavily. The collector of the transistor 431 is effectively grounded which provides a path for current flow through the base-emitter junction of the transistor 411 to cause the transistor to continue to conduct heavily despite interruption of the second control tone. Thus, the conductor 438 is a feedback path to maintain conductive the transistor 411 for the duration of the third control tone. The heavy conduction of the transistor 432 effectively places a positive voltage on the conductor 437 which is applied to a timer 440 consisting of a resistor 441 to ground and a series capacitor 442. The timer 440 produces a negative DC voltage on the conductor 443 upon termination of the positive voltage on the conductor 437 which occurs upon termination of the third control tone. The next stage is the electronic switch 450 comprised of a PNP transistor 451 having its base coupled to the conductor 443, and its emitter coupled to B+. There is also provided a resistor 452 and a diode 453 coupled in parallel between the base of the transistor 451 and the voltage supply source. While the third control tone is being received, the capacitor 442 is being rapidly charged through the diode 453 and the transistor 451 is not conductive. However, upon termination of the third control tone, the capacitor 442 discharges through the resistor 441 to render the transistor 451 heavily conductive to place the supply voltage on the conductor 454. This voltage persists for a duration determined by the RC time constant of the timer 440. The next stage is an AND circuit 460 including an NPN transistor 462 having its base coupled to the emittter of a PNP transistor 467. The base of the transistor 467 is coupled by way of a resistor 463 to the conductor 385. The base of the transistor 462 and the emitter of the transistor 467 are connected together and to the conductor 454.

When the transistor 451 conducts heavily in response to the termination of the third control tone, the supply voltage is effectively on the conductor 454 which is coupled back to the filter 341 to cause heavy conduction of the transistor 353 thus effectively to place the capacitor 344 across a different, greater portion of the inductor 342. It should be noted that the transistor 350 is now nonconductive since the transistor 311 became nonconductive upon termination of the third control tone. If the fourth control tone in the series of control tones on the conductor 231 has a frequency corresponding to the resonant frequency of the resonant circuit, it will be rectified by the rectifier 360 and switch the electronic switch 380, thereby grounding the conductor 385 which results in the grounding of the junction between the resistors 463 and 464 in the AND circuit 460. The concurrent grounding of the conductor 385 and the presence of the supply voltage on the conductor 454 cause the transistor 467 to conduct heavily and provide on its collector and thus the conductor 465, a positive control voltage substantially equal to the B+ supply voltage. Also, the heavy conduction of the transistor 462 effectively grounds its collector, and thus the conductor 466, so that the transistor 451 remains conductive until the fourth control tone terminates thereby removing the ground from 385.

The decoder 240 also includes a pulser control circuit 470 including a PNP transistor 474 having its emitter coupled to the supply voltage and its base coupled to the input conductors 285 and 385 respectively by the resistors 475 and 476. The collector of the transistor 474 is coupled through a resistor 477 and a diode 478 to the conductor 473. There is also provided an integrating network 479 connected to the collector of the transistor 474 and including a parallel resistor and capacitor arrangement. It will be remembered that the conductor 285 is effectively grounded upon inception of the first control tone and stays grounded throughout the first control tone and also throughout the third control tone. Similarly, the conductor 385 is grounded throughout the second and fourth control tones, whereby the transistor 474 is biased on from inception of the first control tone until termination of the last control tone and is effectively saturated so as to provide on the conductor **473** a second control signal equal to the supply voltage.

Accordingly, the decoder **240** provides two control signals: a first control signal on the conductor **465** that does not appear until the commencement of the fourth tone in the series of four tones to which the decoder **240** is set, and a second control signal also equal to the supply voltage, which is derived on the conductor **473**, but appears concurrently with the appearance of the first control tone.

Referring now to FIG. 9, the signal on the conductor **473** is applied to a pulser circuit **500** which includes an astable multivibrator **501** in which there is an NPN transistor **502** having its emitter on ground its collector coupled through a resistor **503** to a supply voltage, and its base coupled to the cathode of a diode **504**, the anode of which is on ground. The multivibrator **501** also has a second NPN transistor **505** with its emitter grounded and having its base coupled through a capacitor **506** to the collector of the transistor **502**. The collector of the transistor **505** is coupled to the source of supply voltage by way of the resistor **507**. There is also provided a diode **508** coupled from ground to the base of the transistor **505**. Lastly, the multivibrator **501** includes a feedback capacitor **509** coupled from the collector of the transistor **505** back to the base of the transistor **502**.

The pulser circuit **500** also includes an electronic switch **510** having an NPN transistor **511** with its emitter grounded and its base coupled to the resistor **512** and its collector coupled by way of a resistor **513** to the source of supply voltage. The switch **510** also includes a PNP transistor **[516]** *514* having its emitter coupled to the source of supply voltage, its base coupled to the collector of the transistor **511** by way of a resistor **515** and its collector coupled to the conductor **516**. Also coupled to the base of the transistor **511** is the conductor **473**.

In operation, the multivibrator **501** serves to produce a series of pulses having a peak-to-peak value equal to the value of the supply voltage. The duration of the pulses is determined primarily by the values of the resistor **503** and the capacitor **506**, and the interval between successive pulses is determined primarily by the values of the resistor **507** and the capacitor **509**. In an operating circuit incorporating the present invention, each pulse had a duration on the order of 15-milliseconds and about 360 milliseconds elapsed between successive pulses. The series of pulses is applied to the switch **510** through the transistors **511** and **514** to provide a series of pulses on the conductor **516** having a peak-to-peak value equal to the value of the supply voltage. The series of pulses are translated along the conductor **516** to the various elements of the receiver circuits **230** (see FIG 5). It should be clear that these pulses of supply voltage render operative each element in the receiver circuits **230**, so that they are able to process RF signals appearing at the antenna **221**. Of course, if an RF signal appears at the antenna **221** between pulses, the receiver circuits **230** will not be operative and that signal will not be processed.

If an RF signal is received at an instant when a pulse is present, the signal will be processed in the receiver circuits **230**. If the composite signal on the conductor **231** contains the sequence of control tones to which the decoder **240** is tuned, a control signal will appear on the conductor **473** as previously described upon inception of the first control tone throughout the four control tones. This control signal on the conductor **473** is applied (FIG. 9) to the base of the first transistor **511** in the switch **510** to render the transistor **511** conductive, which, in turn, renders conductive the transistor **514** to place on the conductor **516** a constant DC voltage equal to the B+ supply voltage, which is applied back to each element in the receiver circuits **230**. Now the receiver circuits **230** are in condition to receive and process any RF signals impressed on the antenna **221** for the duration of the control signal

on the conductor **473**. It should be apparent that, once the control signal is removed, the pulser circuit **500** reverts back to its original state and produces the series of pulses for intermittently energizing the receiver circuits **230**. In the embodiment shown, the control signal on the conductor **473** terminates at the same time that the last control tone ends.

There is also provided a switch circuit **520** which may either be timed to maintain the pulser circuit **500** operative to generate a continuous supply voltage for a longer duration, or may be of the latching variety, in which case, the pulser circuit **500** will produce a continuous supply voltage until some positive act is effected by the user to interrupt its operation. In the embodiment shown, the switch **140** is a monostable multivibrator and functions as a timer.

The switch **520** includes an NPN transistor **521** having its emitter coupled to ground via a resistor **522** and having its base coupled to ground by way of a resistor **523** and a diode **524** coupled in parallel. There is also provided a PNP transistor **525** having its base connected directly to the collector of the transistor **521**, its collector connected through a resistor **527** to ground and its emitter connected to a source of supply voltage, a resistor **526** being connected between the base and the emitter of the transistor **525**. The collector of the transistor **525** is coupled by way of a capacitor **528** to the base of the transistor **521**. A conductor **530** is coupled to the collector of the transistor **521**. The base of the transistor **521** is coupled to the conductor **465** by way of a diode **532**.

In operation, the appearance of the control signal on the conductor **465** upon inception of the last control signal causes conduction of the transistor **521** which provides a path for current flow from the source of supply voltage through the base-emitter junction of the transistor **525** and the collector-emitter junction of the transistor **521**. This renders the transistor **525** highly conductive so as to provide current flow through the collector-emitter junction of the transistor **525** and the resistor **527** and thereby to place an enabling signal on the conductor **530**.

During the conduction periods of the transistors **521** and **525**, current flows from B+, through the collector-emitter junction of the transistor **525**, through the capacitor **528**, and through the base-emitter junction of the transistor **521** to charge the capacitor **528**. Accordingly, when the control signal on the conductor **465** is removed by virtue of the last control tone terminating, the transistor **521** remains conductive because the capacitor **528** is still being charged through the base-emitter junction of the transistor **521** and the resistors **522** and **523**. Of course, the conduction of the transistor **521** maintains the transistor **525** conductive to maintain the enabling voltage on the conductor **530** for a time interval determined by the RC time constant of the switch circuit **520**, that is, the resistors **522** and **523** and the capacitor **528**. By selecting the value of those parts, the time period that the enabling signal remains on the conductor **530** may be controlled. If desired, the switch **531** may be closed to maintain the transistors **521** and **525** conductive which causes the enabling signal to be present on the conductor **530** as long as the switch is closed. The positive voltage on the base of the transistor **521** when the time switch **520** is closed is, by virtue of the diode **532**, isolated from the latching switch **570** so as to prevent undesired operation thereof.

There is also provided an oscillator circuit **540** including a free running oscillator **541**. The oscillator **541** includes an NPN transistor **542** as a feedback network **543** the components of which are adjusted to cause the free running oscillator **541** to oscillate at an audio frequency, such as, for example, **1,000** hertz. A speaker **545** is coupled between the collector and emitter of the transistor **542** through a DC isolation capacitor **546**, and the emitter of the transistor **542** is connected to ground through a normally closed switch **547**.

There is also provided a PNP transistor **550** which functions as an AND device, its base being coupled to the conductor **530** and its emitter being coupled to the conductor **516**. The collector of the transistor **550** is direct current coupled to the base of an NPN transistor **551**, the emitter of which is coupled through a resistor **552** to the base of the transistor **542**, and the collector of which is coupled to B+. In operation, the transistor **521** will become saturated when the four control tones have been received, thereby to ground the base of the transistor **550** through the resistor **522**. The series of pulses on the conductor **516** cause the transistor **550** to be conductive for the duration of each pulse and to be nonconductive between successive pulses. The intermittent conduction of the transistor **550** causes similar intermittent conduction of the transistor **551** which in turn intermittently energizes the transistor **542**. When energized, the transistor **542** is able to oscillate at the frequency determined by the feedback network **543** to form an oscillatory signal which is converted into single, spaced bursts of an altering tone by the speaker **545**. Between pulses, when the transistor **542** has no base bias, the oscillator portion **541** does not oscillate and no altering tone is developed. It can be see, therefore, that the output of the speaker **545** will be a series of intermittent tones or beeps.

Of course, the pulses on the conductor **516** are continually developed as long as the receiver is on and the conductor **530** is grounded through the resistor **522** in accordance with the time constant of the timer switch **520**. There is provided a switch **547** from the emitter of the transistor **542** to ground which interrupts operation of the oscillator **541**. If desired, a manual switch may be provided on the conductor **530**, so that the user can open the same to disable the audio channel.

Summarizing, prior to receiving the series of control tones, the pulser circuit **500** is producing a series of pulses on the conductor **516** which is applied to the receiver circuits **230** intermittently to energize them. If an RF signal is impressed on the receiver circuits **230** while they are energized, it will be processed and detected, and, if it contains the first control tone to which the decoder **240** is to respond, a first control signal will be developed on the conductor **473**, causing the pulser circuit **500** to produce a continuous supply voltage for the receiver circuits **230**. This control signal persists as long as the correct tones are received in the proper order. The pulses and the subsequent continual supply voltage are also, of course, coupled to the emitter of the transistor **550** in the oscillator circuit **540**. However, without more, no altering tone is emitted by the speaker **545** since one of the inputs to the AND transistor **550** is not present.

If the sequence of the four control tones is that to which the decoder **240** is to respond, a second control signal will be developed on the conductor **465**, commencing with the fourth tone. The second control signal operates the timer switch **520** to provide on the conductor **530** an enabling signal. This enabling signal provides the requisite second input for the AND transistor **550** and thereby renders same conductive. As previously explained, the signal on the conductor **516** is coupled to the oscillator **541** to cause same to produce a pulsating signal for the speaker **545**. It can be seen that, during the last control tone when the supply voltage on the conductor **516** is continuous, the alerting tone generated by the speaker **545** would be continuous. After termination of the fourth control tone when the signal on the conductor **516** reverts to a series of pulses again, the output of the speaker **545** becomes a series of intermittent alerting tones.

There is also provided a second electronic switch **570**, but instead of being of the timing variety, it is a latching switch, that is, it develops an enabling signal which will last indefinitely until interrupted. The electronic switch **570** includes an NPN transistor **571** having its emitter grounded and having its base coupled to ground through a resistor **572**. The base is also coupled through a diode **573** and a resistor **574** to the conductor **465**. A resistor **575** and a capacitor **576** are coupled in parallel between the base of the transistor **571** and a switch **576**a. There is provided a PNP transistor **577** having its emitter coupled to the supply voltage and having its base coupled through a resistor **578** to the collector of the transistor **571**. The collector of the transistor **577** is coupled back to the base of the transistor **571** through a resistor **579**. In addition, there is a biasing resistor **580** between the emitter and the base of the transistor **577**. The electronic switch **570** provides an enabling signal on the conductor **581**, as will be explained, to operate a lamp control circuit **590**.

In operation, both transistors **571** and **577** are nonconductive in the absence of the second control signal on the conductor **465**. If the receiver receives a signal containing the sequence of the proper four tones, the control signal will appear on the [connector] *conductor* **465** starting with the fourth control tone. That control signal is coupled through to the transistor **571** to render same conductive which, in turn renders the transistor **577** conductive, to place a positive voltage on the collector of the transistor **577**. Part of this voltage is fed back through the resistor **579** to the base of the transistor **571** in a regenerative fashion to provide [and] *an* enabling signal on the conductor **582** equal to the supply voltage, and an enabling signal on the conductor **581** essentially equal to ground reference potential. The enabling signals on the conductors **581** and **582** will persist, even though the fourth control tone has terminated and no control signal is being applied to the electronic switch **570**, this being due to the regenerative switching action. To "unlatch" the electronic switch **570** and remove the enabling signals from the conductors **581** and **582**, the switch **576***a* is closed momentarily grounding the feedback resistor **579**. The positive voltage on the base of the transistor **571** when the latching switch **570** is "closed" is isolated from the timer switch **520** so as to prevent undesired operation thereof, by virtue of the diode **573**.

The enabling signal on the conductor **581** is applied to a lamp control circuit **590**, the lamp control circuit including a PNP transistor **591** having its emitter coupled to the conductor **516**, and its base coupled to the conductor **581**. The collector is direct current coupled to the base of an NPN transistor **592**, the collector of which is coupled to the supply voltage and the emitter of which is coupled through a resistor **593** to the base of another NPN transistor **594**. The emitter of the transistor **594** is grounded and the collector is coupled through a resistor **595** to a lamp **600**. Without the control signal on the conductor **465**, no enabling signal appears on the conductor **581** (i.e., it is not grounded), so that the lamp control circuit **590** is not operative. However, if the proper sequence of four control tones is received, when the fourth control tone commences, a control signal will be provided on the conductor **465** which will result in an enabling signal on the conductor **581** (i.e., it is grounded) to ground the base of the transistor **591**. The series of pulses on the conductor **516** will intermittently energize the transistor **591** which will, in turn, cause conduction of the transistor **592** so as to provide current flow through the collector-emitter junction thereof, through the resistor **593** and into the base-emitter junction of the transistor **594**. This will cause current to flow through the lamp, the resistor **595** and the collector emitter junction of the transistor **594**. The lamp **600** will be lit for a duration equal to the width of the pulse and will be extinguished between pulses. Thus, the lamp provides a blinking effect so as more easily to attract the attention of the user. The light will blink on and off indefinitely since the series of pulses on the conductor **516** occur indefinitely and since the enabling signal on the conductor **581** is latched in its grounded condition. If the user wishes to turn off the lamp, he closes the switch [**576**] *576a* which removes the enabling signal on the conductor **581** as previously set forth. Accordingly, the oscillator **540** may be viewed as a first oscillator for applying a first oscillator signal to the speaker **545**. The pulse **500**, together with the control circuit **[59]** *590* may be viewed as a second oscillator which, in the presence of the enabling signal on the conductor **581**, will cause a second oscillator signal to be produced for energizing the lamp **600**. Also, in this particular form, the oscillator circuit **540** may be viewed as a utilization circuit for the enabling signal on the conductor **530**, and the lamp control circuit **590** may be viewed as a utilization circuit for the enabling signal on the conductor **581**.

In order to minimize the current drain of the communication receiver **220** in its standby condition, the pulse width should be many times shorter in duration than the time between pulses. As set forth previously, in one embodiment the duration between pulses was 25 times as great as the pulse width. On the other hand, when the user is being alerted, it may be desirable to increase the duty cycle or pulse width with respect to the interval between pulses so that the alerting tone from the speaker **545** persists, and/or the lamp **600** is on, for a greater percentage of the time.

To this end, there is provided a pulse extender circut **610** having an NPN transistor **611** with its base coupled by a resistor **612** to the conductor **582**. The collector of the transistor **611** is coupled to one side of the capacitor **509** in the pulser circuit **500**, and the emitter of the transistor **611** is coupled through a capacitor **613** to the other side of the capacitor **509**.

When the last control tone in the series of control tones begins, there is provided a positive enabling signal on the conductor **582** which causes the transistor **611** to conduct and thereby place the additional capacitance of the capacitor **613** in parallel with the capacitor **509**, thereby to increase the on-time of the multivibrator circuit **501**. This results in an increased duty cycle, which is reflected on the conductor **516** as pulses of increased width and decreased time between successive pulses.

Summarizing, the pulser circuit **500** produces a series of pulses on the conductor **516**, which are used intermittently to provide a supply voltage for the various elements in the receiver circuits **230**. In a particular embodiment, the pulse width was 15 milliseconds and the time between pulses was 360 milliseconds or a 4 percent duty cycle. This means that during 96 percent of the time the communication receiver **220** was drawing essentially no current, and that during the other 4 percent of the time the receiver was drawing "stand-by" current. Accordingly, as was the case in the first embodiment described, the useful life of the battery in the communication receiver **220** may be increased theoretically by a factor of 25. However, in the embodiment described, the pulser circuit **500** may reduce this theoretical increase by about 10 percent. Also, the lamp control circuit **590** and the oscillator circuit **540**, when energized, draw additional current and contribute perhaps 5 percent additional battery drain. Finally, the first control tone, if the proper frequency, will cause the continuous supply voltage to be developed for a time sufficient to examine the second tone. If the second tone received is not the proper one, the pulser circuit reverts to producing pulses. This may contribute an additional **10** percent drain. Even with these additional losses, the useful battery life can be extended by a factor of 18, in this example, over the life of the same battery in a standard receiver. With the communication receiver **220**, battery drain is minimized so as to conserve battery life, not only during standby, but also while the alerting tone is generated.

Reference is made to the graph of FIG. 10 wherein the waveform **620** represents the signal appearing on the conductor **516** which is the output of the pulser circuit **500**, and consists of a series of pulses **621**. For purpose of illustration, the duration of each pulse is 15 milliseconds, and 360 milliseconds lapses between pulses. Accordingly, the receiver circuits **230** are rendered operative for the duration of each pulse **621** and are inoperative between the pulses **621**. If the RF signal impressed on the antenna **221** includes one or more contol tones, they will be detected in the receiver circuits **230** and will appear on the conductor **231**, if the receiver circuits are supplied with a DC voltage. The waveform **625** consists of a series of four control tones **626**, **627**, **628** and **629**, it being assumed that these control tones, in this order, will activate the decoder **240** to produce control signals on the conductors **465** and **473**. The first control tone **626** commences at t_1, and for purpose of illustration it is assumed that it lasts for 400 milliseconds. Further, it is assumed that, each of control tones **627**, **628** and **629** lasts for 25 milliseconds, and there being substantially no time lag between successive ones of the control tones.

At t_1 when the control tone commences, the receiver circuits **230** are inoperative since no pulse **621** is applied thereto. The first control tone persists until t_2 when the next pulse **621** is generated, at which time the receiver circuits **230** become energized to process and detect the RF signal, including the first control tone **626**, which is then coupled to the decoder **240**. If the first control tone **626** is at the frequency to which the first filter in the decoder **240** is tuned, a control signal, represented by the waveform **630** will commence on the conductor **473**, at t_3, which is a few milliseconds after t_2. This control signal is applied to the electronic switch **510** in the pulser circuit **500**, causing the same to close and provide a continuous supply voltage, which is indicated by the numeral **622** on the waveform **620**. The continuous supply voltage is applied to the receiver circuits **230** to permit the rest of the first control tone **626** in the RF signal to be processed by the receiver circuits **230** and to be applied to the decoder **240**. When the first control tone **626** terminates at t_4, the control signal on the conductor **473** will persist beyond the time when the second control tone is to commence, thereby to maintain the receiver circuits **230** operative to process and detect the RF signal containing the second control tone **627**, which is then coupled to the decoder **240**. If the second control tone **627** is at the frequency to which the second filter in the decoder **240** is tuned, the control signal **630** on the conductor **473** will persist and maintain closed the electronic switch **510** so that it continues to provide the continuous supply voltage. The continuous supply voltage applied to the receiver circuits **230** permits the third control tone **628** in the RF signal to be processed by the receiver circuits **230** and applied to the decoder **240**. When the second control tone **627** terminates, the control signal on the conductor **473** persists beyond the start of the third control tone, thereby to maintain the receiver circuits operative to process and detect the RF signal containing the third control tone which is then coupled to the decoder **240**. If the third control tone **[627]** *628* is at the frequency to which the returned first filter in the decoder **240** is tuned, the control signal **630** will persist beyond the time when the fourth control tone is to commence, thereby to maintain the receiver circuits **230** operative to process and detect the RF signal containing the fourth control tone which is then coupled to the decoder **240**. If the fourth control tone **629** is at the frequency to which the retuned second filter in the decoder **240** is tuned, the control signal on the conductor **473** will be extended to the termination of the fourth control tone at t_6. Accordingly, the continuous supply voltage **622** will similarly terminate at t_6. It should be noted, that, if after the control signal **630** is developed on the conductor **473**, the correct next control tone is not received, the control signal and the continuous supply voltage **622** will terminate.

If the proper tones are received in the proper sequence, a second control signal represented by the waveform **631** will appear on the conductor **465** commencing at t_5, during the reception of the last control tone **629**, and will terminate with the completion of the last control tone at t_6. The control signal **631** is applied to the timer switch **520** to cause same to produce an enabling signal represented by the waveform **632** commencing at the same time, t_5, as the signal **631**. The enabling signal **632** lasts until t_8 which is determined by the RC time constant of the timer switch **520** as previously explained. The control signal **631** is also applied to the latching switch **570** to cause same to produce a second enabling signal represented by the waveform **633** commencing at the same time, t_5, as the signal **631**. The enabling signal **633** lasts until t_9 which is when the user operates the reset switch **576a**.

Also, the latching switch **570** produces on the conductor **582** a further enabling signal represented by the waveform **634**, of a polarity opposite to the enabling signal **633**, but with the same duration. The enabling signal **634** operates the pulse extender circuit **610**, effectively to couple the capacitor **613** into the pulser circuit **500**. This causes the duration of the pulses developed by the pulser circuit **500** to increase in duration by an amount dependent on the value of the capacitor **613**. The pulses of increased duration, represented by the numeral **623** in the waveform **620**, make it easier for the user to see the flashing lamp **600** and/or to hear the "beeps" from the speaker **545**. These increased-duration pulses **623** occur only for the duration of the enabling signal **634**. As shown in the waveform **620**, at t_{10}, after termination of the enabling signal **634**, the pulser circuit **500** again reverts to producing the narrower-duration pulses **621**.

As is the case in the first embodiment described, the duration of the first control tone **626** should be longer than the lapsed time interval between successive pulses **621**. So, in the example given, if the time between pulses is 360 milliseconds, a control tone that lasts for 400 milliseconds will necessarily be present during the occurrence of pulses **621**, and still provide for receiver and transmitter variations. Also, as is the case in the first embodiment, the receiver **220** will not respond to carrier signals alone, but require, in addition, the presence of the proper sequence of control tones.

In FIG. 9, the lamp **600** will blink on and off and the speaker **545** will produce a series of beeps, both dependent on the frequency of the series of pulses generated by the pulser circuit **500**. In certain situations, it may be desirable to have the lamp **600** and the speaker **545** produce alerting signals pulsed at one rate to page one individual and produce alerting signals of a different pulse character to page another individual or to transmit a second message. This may be accomplished by causing the series of pulses to have a given repetition rate and characteristics when a series of control tones of one character is transmitted, and to have a different repetition rate and characteristic when a series of control tones of another character is transmitted.

Reference is now made to FIG. 11 to describe a system that operates with the receiver **220** to achieve this change in frequency characteristic of the series of pulses. The conductor **465** is coupled to an electronic switch **650** of the latching variety, that is, it develops an enabling signal which lasts indefinitely until interrupted. The electronic switch **650** includes an NPN transistor **651** having its emitter grounded, its collector coupled through a resistor **652** to the source of supply voltage and its base coupled through a resistor **653** to ground. The base is coupled to the conductor **465** by way of a diode **654** and a resistor **655**. The electronic switch **650** further includes a PNP transistor **656** having its emitter coupled to the conductor **582** by way of a diode **657**, and its collector coupled to a conductor **662**. The collector of the transistor **656** is coupled back to the base of the transistor **651** through a feedback resistor **658**. A timing network **659** couples the collector of the transistor **651** to the base of the transistor **656**, and consists of a series resistor **660** and a capacitor **661** coupled to the supply voltage.

In operation, without the control signal on the conductor **465**, the transistor **651** is biased into its off condition. Also, there is no voltage applied to the emitter of the transistor **656** since no enabling signal is produced by the electronic switch **570** without the control signal on the conductor **465** applied thereto. If the proper sequence of control tones is received, an enabling signal will appear on the conductor **582**, as explained previously, soon after commencement of the fourth control tone, whereby a positive voltage is applied to the emitter of the transistor **656**. Simultaneously, the control signal on the conductor **465** turns on the transistor **651** to permit charging of the capacitor **661** through the resistor **660** and the collector-emitter of the transistor **651**. After a predetermined time determined primarily by the value of the resistor **660** and the capacitor **661**, the capacitor **661** becomes sufficiently charged to turn on the transistor **656** and thereby place a positive voltage on its collector which serves as an enabling signal on the conductor **662**. A portion of the positive voltage on the collector of the transistor **656** is fed back through the resistor **658** to the base of the transistor **651** to reinforce the "on" condition thereof and thereby regeneratively "close" the electronic switch **650** and provide an enabling signal on the conductor **662**. The positive voltage on the base of the transistor **651** when the electronic switch **650** is "closed," is isolated from the electronic timer switch **520** so as to prevent undesired operation thereof by virtue of the diode **654**. The diode **657** provides a drop in the voltage derived from the conductor **582**.

It should be noted that if the control signal on the conductor **465** does not persist long enough to permit the capacitor **661** to charge up, the transistor **656** will not be rendered conductive so that the enabling signal will not appear on the conductor **662**. Thus, by transmitting a relatively short fourth control tone, the electronic switch **650** will not close, whereas transmitting a fourth control tone longer than a predetermined duration controlled by the time constant of the resistor **660** in the capacitor **661**, the electronic switch **650** will close and an enabling signal on the conductor **662** will be developed.

The conductor **662** is coupled to a second pulser circuit **670**, including a first NPN transistor **671** having its emitter grounded and its collector coupled to the conductor **662** by way of a resistor **672**. In order to use the system of FIG. 11 with the receiver **220**, the connection between the conductor **516** and the emitter of the transistor **550** in the oscillator circuit **540** is broken as is the connection between the emitter of the transistor **591** in the lamp control circuit **590**. The conductor **516** is coupled through a diode **673** and a pair of resistors **674** and **675** to the base of the transistor **671**, a capacitor **676** being coupled from the junction of the resistors to ground. There is also provided a transistor **677** having its emitter grounded, its base being coupled through a capacitor **678** to the collector of the transistor **671** and its collector coupled through a resistor **679** to the source of supply voltage. There is also provided a PNP transistor **680** having its base coupled through a resistor **681** to the collector of the transistor **677**, and its emitter coupled to the supply voltage. The collector is coupled, by a conductor **682**, to the emitters of the transistors **550** and **591**. Also, a diode **683** is coupled between the conductors **516** and **682**.

In operation, the pulses from the pulser circuit **500** are applied via the conductor **516** through the diode **673** and the resistors **674** and **675** to the transistor **671**. If the fourth control tone in the series of control tones is not present for a sufficiently long duration, so that an enabling signal is provided on the conductor **662**, no supply voltage is provided for the transistor **671** and the series of pulses is not conveyed to the succeeding stages. On the other hand, if the fourth control tone is on for longer than the predetermined duration, an enabling signal on the conductor **662** is provided to furnish supply voltage for the transistor **671**. The pulses on the conductor **416** are delayed by an amount determined by the values of the capacitor **676** and the resistors **674** and **675**, and are amplified in the transistor **671** and again amplified in the transistors **677** and **680** to provide on the collector of the transistor **680** a series of pulses each having essentially the same duration as the series of pulses produced by the pulser circuit **500** and being spaced in time by the same amount. However, due to the delay provided by the capacitor **676** and the resistors **674** and **675**, the series of pulses on the collector of the transistor **680** is out of phase with the series of pulses on the conductor **516**. The pulses on the conductor **516** are also applied to the conductor **682** through a diode **683**, to combine with the out-of-phase series of pulses, thereby to generate a third series of pulses of a higher frequency than either of its two component series. The combined series consists of recurrent pairs of adjacent pulses and is applied to the emitter of the transistor **591** to cause the lamp **600** to flash in a different manner than that resulting from the series of single, spaced pulses. Similarly, the alerting tone generated by the speaker **545** will have a different characteristic. The diode **683** prevents the delayed series of pulses from being applied back to the pulser circuit **500**. By properly selecting the value of the capacitor **678** and the resistor **672**, the width of the delayed pulses can be changed with respect to the nondelayed pulses.

Summarizing, a series of four control tones, with the fourth control tone being relatively long, can be transmited, in which case the alerting tone is a series of "beep beeps" and the visual alerting signal is a series of spaced pairs of flashes, so that a given individual can be paged. If it is desired to page a different individual, or give the same individual a different "message," the same frequency tones can be transmitted, but a shorter fourth tone is transmitted, so that the alerting tone is a series of "beeps," and the visual alerting signal is a series of flashes.

It is to be understood that the system shown in FIGS. 9 and 11 is easily adapted to utilize a single control tone, a different plurality of control tones than four, or a plurality of simultaneously received control tones. Similarly, the first embodiment is usable, not only with a single control tone, but with a plurality of sequentially or simultaneously received control tones. Also, the various numerical examples as to values of parts and time durations, etc. were merely given for the purpose of illustration and should not in any way limit the scope of the invention described. It is contemplated that various combinations of the functions may be used, such as paging only with audio and/or visual alerting, voice only (FIG. 1), or paging plus voice.

From the above, it will be seen that there has been provided an improved communication receiver with a pulser circuit therein that operates to save battery life and provides additional useful functions.

Although there have been illustrated and described certain preferred embodiments of the invention, it is to be understood that various changes and modifications can be made therein without departing from the spirit and scope of the invention, and it is intended that all such changes and modifications be covered as fall within the scope of the appended claims.

What is claimed is:

1. A communication receiver for receiving carrier signals modulated by at least one control tone, said receiver comprising a processing circuit for receiving the modulated carrier signals and detecting the control tone therein, a pulser circuit coupled to said processing circuit and operative to produce a series of pulses for intermittently rendering said processing circuit operative, a decoder circuit coupled to said processing circuit and having first and second outputs, said decoder circuit producing at said first output a first control signal commencing with the initiation of the control tone and producing at said second output a second control signal commencing a predetermined time after initiation of the control tone, said pulser circuit having an input coupled to the first output of said decoder

circuit and responsive to the application thereto of said first control signal to furnish a continuous supply voltage for said processing circuit for an interval substantially longer than the duration of each pulse in said series of pulses, an electronic switch circuit coupled to the second output of said decoder circuit and responsive to said second control signal to provide an enabling signal, a utilization circuit having an input coupled to said switch circuit and responsive to the enabling signal to provide an output signal, and an annunciator coupled to said utilization circuit for converting the output signal into usable form.

2. A communication receiver for receiving carrier signals modulated by at least one control tone, said receiver comprising a processing circuit for receiving the modulated carrier signals and detecting the control tone therein, a pulser circuit coupled to said processing circuit and operative to produce a series of pulses for intermittently rendering said processing circuit operative, a decoder circuit coupled to said processing circuit and responsive to the control tone for generating at the output thereof a control signal, said pulser circuit having an input coupled to the output of said decoder circuit and responsive to the application thereto of said control signal to furnish a continuous supply voltage for said processing circuit for an interval substantially longer than the duration of each pulse in said series of pulses, an electronic switch circuit coupled to the output of said decoder circuit and responsive to the control signal to provide an enabling signal, an oscillator circuit having an input coupled to said switch circuit and a second input coupled to said pulser circuit, said oscillator circuit being responsive to the concurrent presence of the enabling signal, and the series of pulses to provide an oscillatory signal during each of said pulses, and an annunciator coupled to the output of said oscillator circuit and intermittently generating an alerting signal in accordance with said oscillatory signal.

3. A communication receiver for receiving carrier signals modulated by at least one control tone and intelligence, said receiver comprising a processing circuit for receiving the modulated carrier signals and detecting the control tone and the intelligence therein, a pulser circuit coupled to said processing circuit and operative to produce a series of pulses for intermittently rendering said processing circuit operative, a decoder circuit coupled to said processing circuit and responsive to the control tone for generating at the output thereof a control signal, said pulser circuit having an input coupled to the output of said decoder circuit and responsive to the application thereto of said control signal to furnish a continuous supply voltage for an interval substantially longer than the duration of each pulse in said series of pulses, an electronic switch circuit coupled to the output of said decoder circuit and responsive to the control signal to provide an enabling signal, said electronic switch circuit including *timing* means to cause said enabling signal to persist for a *predetermined limited* duration following termination of the control tone, a feedback circuit coupled between said switch circuit and a point in the electrical path defined by said [receiver] *processing* circuit and [feed] *said* decoder circuit and said pulser circuit and responsive to said enabling signal to increase the duration of the supply voltage beyond cessation of said control tone, an audio amplifier circuit having a first input coupled to said processing circuit and a second input coupled to said switch circuit, said audio amplifier being rendered operative by said enabling signal to amplify the detected intelligence from said processing circuit, and a speaker coupled to the output of said audio amplifier circuit to convert the amplified detected intelligence into sound waves.

4. The communication receiver set forth in claim **3**, wherein said feedback circuit is coupled between said electronic switch circuit and said pulser circuit.

5. The communication receiver set forth in claim **3**, wherein said means including a timer to provide said enabling signal for a limited duration to render said audio amplifier operative for said limited duration, a manual override switch to provide said enabling signal after said limited duration has lapsed.

6. A communication receiver for receiving carrier signals modulated by at least one control tone, said receiver comprising a processing circuit for receiving the modulated carrier signals and detecting the control tone therein, a pulser circuit coupled to said processing circuit and operative to produce a series of pulses for intermittently rendering said processing circuit operative, a decoder circuit coupled to said processing circuit and responsive to the control tone for generating at the output thereof a control signal, said pulser circuit having an input coupled to the output of said decoder circuit and responsive to the application thereto of said control signal to furnish a continuous supply voltage for said processing circuit for an interval substantially longer than the duration of each pulse in said series of pulses, an electronic switch circuit coupled to said decoder circuit and responsive to the control tone to provide an enabling signal, said electronic switch circuit including *timing* means to cause said enabling signal to persist for a *predetermined* duration following termination of the control tone, a feedback circuit coupled between said switch circuit and a point in the electrical path defined by said [receiver] *processing* circuit and said decoder circuit and said pulser circuit responsive to said enabling signal to increase the duration of the supply voltage beyond cessation of said control tone, a utilization circuit having an input coupled to said switch circuit and responsive to the enabling signal to provide an output signal, and an annunciator coupled to said utilization circuit for converting the output signal into usable form.

7. The communication receiver set forth in claim **6**, wherein said feedback circuit is coupled between said electronic switch circuit and said pulser circuit.

8. A communication receiver for receiving carrier signals modulated by at least one control tone, said receiver comprising a processing circuit for receiving the modulated carrier signals and detecting the control tone therein, a pulser circuit coupled to said processing circuit and operative to produce a series of pulses for intermittently rendering said processing circuit operative, a decoder circuit coupled to said processing circuit and responsive to the control tone for generating at a first output thereof a first control signal and for generating at a second output thereof a delayed second control signal, said pulser circuit having an input coupled to said first output of said decoder circuit and responsive to the application thereto of said first control signal to furnish a continuous supply voltage for said processing circuit for an interval substantially longer than the duration of each pulse in said series of pulses, a first electronics switch circuit coupled to said second output of said decoder circuit and responsive to said second control signal to provide a first enabling signal, a first oscillator circuit coupled to said first electronic switch circuit and responsive to the presence of the first enabling signal to provide a first oscillatory signal, a speaker coupled to the output of said first oscillator circuit for intermittently generating an alerting tone according to said first oscillatory signal, a second electronic switch circuit coupled to said second output of said decoder circuit and responsive to said second control signal to provide a second enabling signal, a second oscillator circuit coupled to said second electronic switch circuit and responsive to the presence of the second enabling signal to provide a second oscillatory signal, and a lamp coupled to the output of said second oscillator circuit and intermittently turned on thereby according to said second oscillatory signal.

9. The communication receiver set forth in claim **8**, wherein said first electronic switch circuit includes timing means to provide said first enabling signal for a limited duration to render said first oscillator circuit operative for said limited duration, said second electronic switch circuit including latching means to cause said second enabling signal to exist indefinitely to render said second oscillator circuit operative indefinitely, said second electronic switch circuit further including reset means to interrupt said latching means and thus said second enabling signal.

10. The communication receiver set forth in claim **8**, wherein each of said first and second oscillator circuits has a further input coupled to said pulser circuit to cause said speaker to produce an intermittent alerting tone and to cause said lamp to flash on and off.

11. The communication receiver set forth in claim **8**, and further comprising a pulse extender coupled to said second electronic switch circuit and responsive to the termination of said control signals to cause said series of pulses to have an increased duration.

12. A communication receiver for receiving carrier signals modulated by at least one control tone, said receiver comprising a processing circuit for receiving the modulated carrier signals and detecting the control tone therein, a first pulser circuit coupled to said processing circuit and operative to produce a first series of pulses for intermittently rendering said processing circuit operative, a decoder circuit coupled to said processing circuit and responsive to the control tone for generating at the output thereof a control signal, said first pulser circuit having an input coupled to the output of said decoder circuit and responsive to the application thereto of said control signal to furnish a continuous supply voltage for said processing circuit for an interval substantially longer than the duration of each pulse in said first series of pulses, a second pulser circuit having an input coupled to the output of said decoder circuit and responsive to the control signal subsisting for more than a selected duration for producing a second series of pulses out of phase with said first series of pulses, means combining said first and second series of pulses to provide a third series of pulses of higher frequency than either of said first and second series, an electronic switch circuit coupled to the output of said decoder circuit and responsive to the control signal to provide an enabling signal, an oscillator circuit having a pair of inputs respectively coupled to said last mentioned means and to said switch circuit and responsive to the presence of the series of pulses applied thereto and the enabling signal to provide an oscillatory signal frequency dependent on the series of pulses applied thereto, an annunciator coupled to the output of said oscillator circuit and intermittently generating an alerting signal in accordance with said oscillatory signal.

13. The communication receiver set forth in claim **12**, and further comprising a further electronic switch circuit having an input coupled to said decoder circuit and responsive to the control tone subsisting for said selected duration to provide a further enabling signal, said further electronic switch circuit including means for delaying production of said further enabling signal until said control signal has subsisted for longer than said selected duration, said second pulser circuit having a pair of inputs respectively coupled to the output of said further electronic switch circuit and to said first pulser circuit.

14. The communication receiver set forth in claim **12**, wherein the duration of said control signal is related to the duration of said control tone.

15. A communication receiver for receiving carrier signals modulated by at least one control tone, said receiver comprising a processing circuit for receiving the modulated carrier signals and detecting the control tone therein, a pulser circuit coupled to said processing circuit and operative to produce a series of pulses for intermittently rendering said processing circuit operative, a decoder circuit coupled to said processing circuit and responsive to the control tone for generating at the output thereof a control signal, said pulser circuit having an input coupled to the output of said decoder circuit and responsive to the application thereto of said control signal to furnish a continuous supply voltage for said processing circuit for [an] *a predetermined* interval substantially longer than the duration of each pulse in said series of pulses, a pulse extender coupled to said pulser circuit and responsive to the

termination of said predetermined interval to cause said series of pulses to have an increased duration, an electronic switch circuit coupled to the output of said decoder circuit and responsive to the control signal to provide an enabling signal, an oscillator circuit having a pair of inputs respectively coupled to pulser circuit and said switch circuit and responsive to the enabling signal to provide an oscillatory signal during said pulses, and an annunciator coupled to the output of said oscillator circuit and intermittently generating an alerting signal in accordance with said oscillatory signal.

16. The communication receiver set forth in claim **15**, wherein said pulse extender includes a reactance and electronic switch coupled in series, said switch being closed upon termination of said interval to coupled said reactance in said pulser circuit to increase the duration of the pulses generated thereby.

17. The communication receiver set forth in claim **15**, wherein said pulse extender includes means to at least double the duration of each of said pulses in said series of pulses.

18. A communication receiver for receiving carrier signals modulated by a series of sequential control tones, said receiver comprising a processing circuit for receiving the modulated carrier signals and detecting the series of modulated control tones therein, a pulser circuit coupled to said processing circuit and operative to produce a series of pulses for intermittently rendering said processing circuit operative, and a decoder circuit including a pair of channels coupled to said processing circuit and alternately responsive to said series of control tones for generating at the output thereof a substantially continuous control signal terminating with the last control tone, said pulser circuit having an input coupled to the output of said decoder circuit and responsive to the application thereto of said control signal to furnish a continuous supply voltage for said processing circuit for an interval at least until the termination of the last control tone in the series of control tones.

19. A communication receiver for receiving carrier signals modulated by a series of control tones, said receiver comprising a processing circuit for receiving the modulated carrier signals and detecting the series of modulated control tones therein, a pulser circuit coupled to said processing circuit and operative to produce a series of pulses for intermittently rendering said processing circuit operative, a decoder circuit coupled to said processing circuit and responsive to the first control tone in said series of control tones for generating at a first output thereof a first control signal and responsive to a subsequent control tone for generating at a second output thereof a second control signal, said pulser circuit being coupled to said first output and responsive to the application thereto of said first control signal to furnish a continuous supply voltage for an interval substantially longer than the duration of each pulse in said series of pulses, an electronic switch circuit coupled to said second output of said decoder circuit and responsive to said second control signal to provide an enabling signal, a utilization circuit having an input coupled to said switch circuit and responsive to the enabling signal to provide an output signal, and an annunciator coupled to said utilization circuit for converting the output signal into usable form.

20. The communication receiver set forth in claim **[14]** *19* wherein said decoder circuit is responsive to the last control tone in said series of control tones for generating said second control signal.

21. The communication receiver set forth in claim **[14]** *19* wherein said second control signal terminates essentially at the same time that the last control tone in the series of control tones terminates.

22. A communication receiver for receiving carrier signals modulated by at least one control tone, said receiver comprising a processing circuit for receiving the modulated carrier signals and detecting the control tone therein, a pulser circuit coupled to said processing circuit and operative to produce a series of pulses for intermittently renderig said processing circuit operative, a decoder circuit coupled to said processing circuit and responsive to the control tone for generating at the output thereof a control signal, said pulser circuit having an input coupled to the output of said decoder circuit and responsive to the application thereto of said control signal to furnish a continuous supply voltage for said processing circuit for a predetermined interval substantially longer than the duration of each pulse in said series of pulses, an electronic switch circuit coupled to the output of said decoder circuit and responsive to the control signal to provide an enabling signal, said electronic switch circuit including *timing* means to cause said enabling signal to persist for a *predetermined limited* duration following termination of the control tone, a utilization circuit having an input coupled to said switch circuit and responsive to the enabling signal to provide an output signal, and an annunciator coupled to said utilization circuit for converting the output signal into usable form.

[23. The communication receiver set forth in claim **22**, wherein said means is a latching device to cause an enabling signal to have an indefinite duration, said electronic switch circuit further including reset means to interrupt said latch and thus said enabling signal.**]**

[24. The communication receiver set forth in claim **22**, wherein said means is a timer to cause the enabling signal to have a limited duration.**]**

25. The communication receiver set forth in claim **[24]** *22*, wherein said switch circuit includes a manually operable bypass switch to provide said enabling signal beyond the termination of said limited duration.

26. The communication receiver set forth in claim **22**, wherein said utilization circuit includes an audio amplifier and said annunciator includes a speaker.

27. The communication receiver set forth in claim **22**, wherein said utilization circuit includes an oscillator and said annunciator is a speaker.

28. The communication receiver set forth in claim **22**, wherein said utilization circuit includes lamp control means and said annunciator is a lamp.

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ALBERT J. MAYER, Primary Examiner

U.S. Cl. X.R.

325—391, 392, 395, 478

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. Re. 28,222 Dated November 5, 1974

Inventor(s) Keith H. Wycoff

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 45, after "control" there should be inserted -- tone or tones for generating at the output thereof a control --.
Col. 2, line 62, "the" should be deleted.
Col. 6, line 29, "The" should be -- This --.
Col. 7, line 22, "conductor" should be -- conductive --.
Col. 8, line 3, "potentionmeter" should be -- potentiometer --.
Col. 11, line 13, "circuit" should be -- circuits --.
Col. 13, line 12, "pulse" should be -- pulser --; line 57, "referenec" should be -- reference --.
Col. 14, line 64, before "rectified" should be inserted -- A --; line 74, "an", second occurrence, should be -- a --.
Col. 15, line 64, "and" should be -- the --; line 68, "on" should be -- of --.
Col. 16, line 45, "the", first occurrence, should be -- that --.
Col. 19, line 20, "altering" should be -- alerting --; line 23, "altering" should be -- alerting --; line 49, "altering" should be -- alerting --.
Col. 21, line 1, "pulse" should be -- pulser --.
Col. 22, line 54, "returned" should be -- retuned --.
Col. 25, line 29, "mited" should be -- mitted --.
Col. 27, line 21, after "predetermined" should be inserted -- limited --.
Col. 29, line 15, "coupled" should be -- couple --.

Signed and sealed this 7th day of January 1975.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents