April 8, 1969 W. R. STEWART 3,438,028

AUDIO AMPLIFYING AND TRANSDUCING APPARATUS FOR PRODUCING AND EMITTING A HIGH-AMPLITUDE, HIGH-ENERGY SOUND OUTPUT

Filed March 10, 1966 Sheet 1 of 2

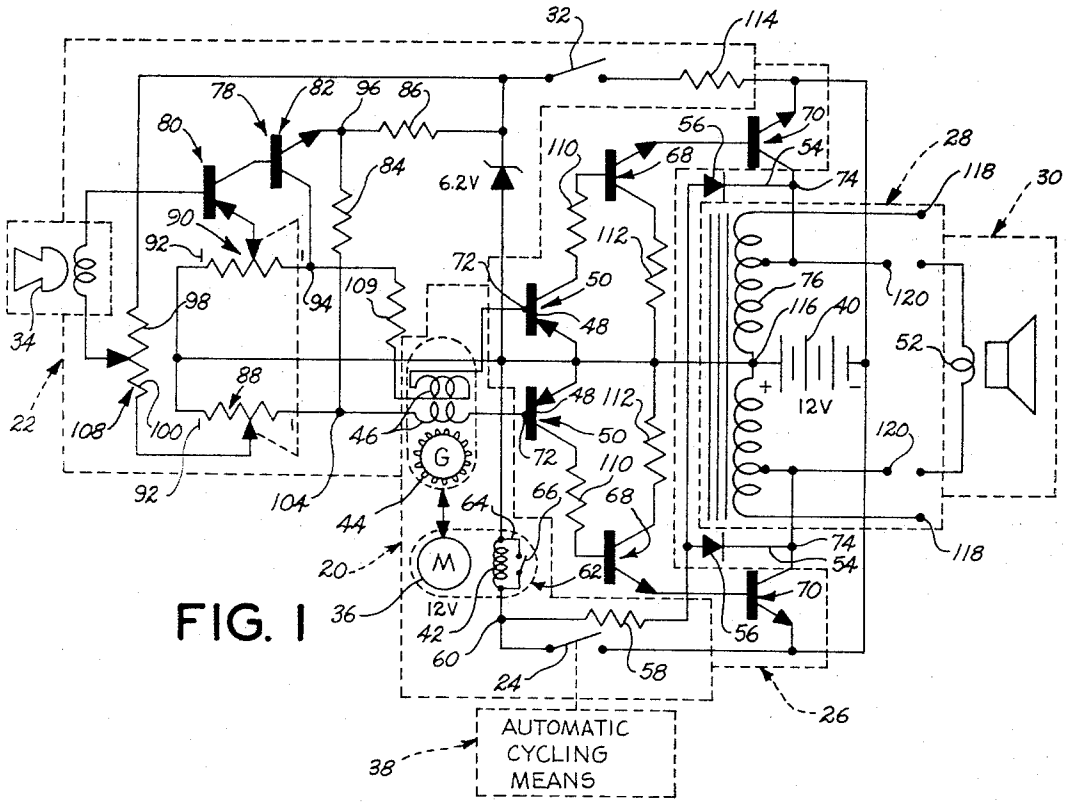


FIG. 1

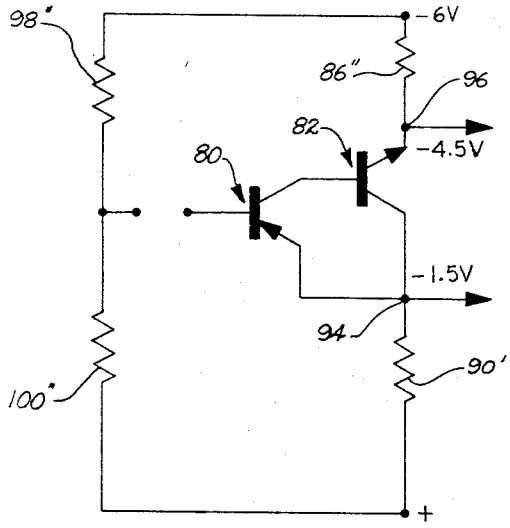


FIG. 2

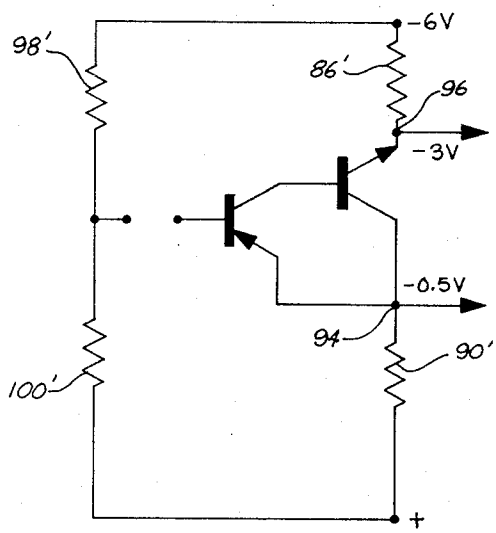


FIG. 3

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Filed March 10, 1966 Sheet 2 of 2

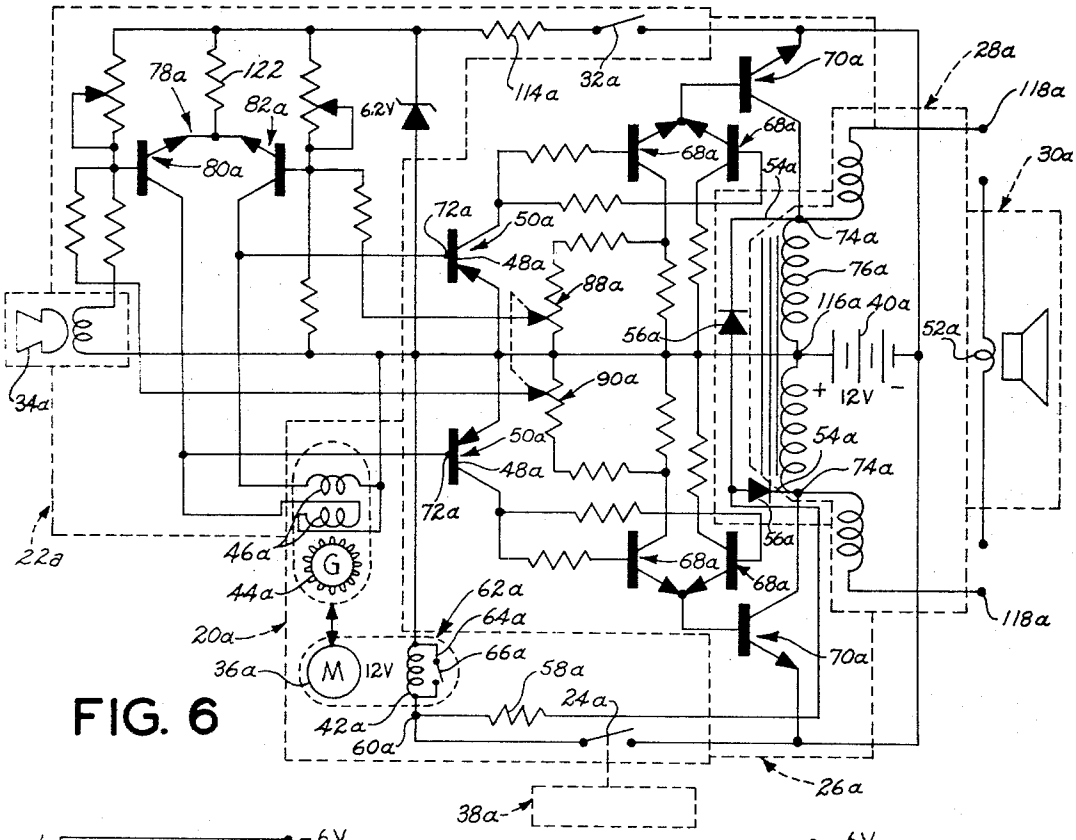


FIG. 6

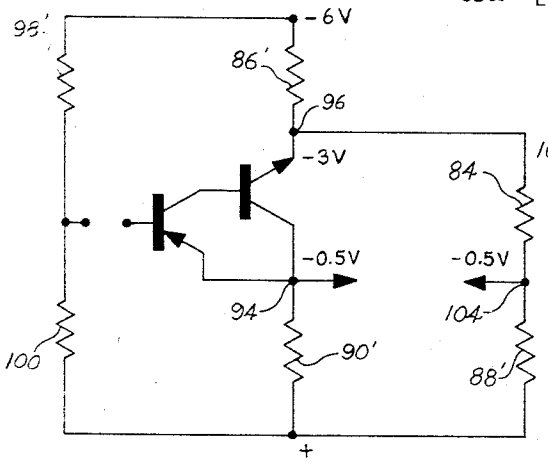


FIG. 4

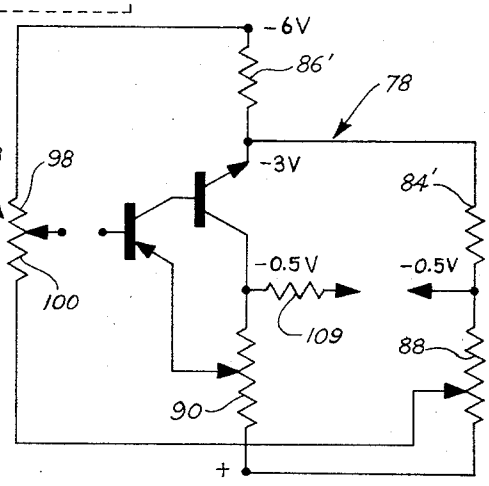


FIG. 5

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AUDIO AMPLIFYING AND TRANSDUCING APPARATUS FOR PRODUCING AND EMITTING A HIGH-AMPLITUDE HIGH-ENERGY SOUND OUTPUT

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Int. Cl. G08b 3/10
U.S. Cl. 340—384 9 Claims

ABSTRACT OF THE DISCLOSURE

The specification discloses an audio amplifying and transducing apparatus for producing and emitting a high-amplitude, high-energy sound output which may comprise a siren type of signal and/or an oral or vocal type signal and wherein the means for producing the siren type signal is completely self-contained and the means for producing an oral or vocal type signal is completely self-contained except for an audio input thereto so that it may be said that in this mode the apparatus comprises a public address signal producing and amplifying system. The dual purpose apparatus is embodied in an extremely small, compact, rugged unit adapted to be mounted on an emergency vehicle and to function efficiently during the rather severe environmental conditions to which it will be subjected while so mounted.

Generally speaking, the present invention relates to an audio amplifying and sound producing system which, in one of its preferred forms, may comprise a siren signal producing and amplifier system and/or a public address signal producing and amplifying system, both embodied in a small, compact unit adapted to be mounted on an emergency vehicle, such as a police motorcycle, police car, an ambulance, a fire engine, a rescue unit vehicle, a civil defense vehicle, a military vehicle, or the like, and which is capable of producing a very high-powered and high-amplitude acoustic output of sufficient magnitude to comprise an output sound of an undulating siren type, a steady-state siren type, or a greatly amplified voice in the public address mode of operation of the apparatus, which is adapted to be publicly acoustically broadcast and easily heard by persons over a wide special area.

It should be noted that, while the apparatus of the present invention has been referred to hereinbefore as being particularly adapted to be mounted on an emergency vehicle such as a police motorcycle, police car, ambulance, fire engine, rescue unit vehicle, civil defense vehicle, military vehicle, or the like, it should be clearly understood that the invention is not specifically so limited and, indeed, may be carried by virtually any type of vehicle whether of a ground-borne type, a water-borne type, or an air-borne type such as a helicopter, for example. Also, the apparatus may be employed in the public address mode of operation thereof wherever a public address system would be desirable, such as in a ball park, sports arena, or the like, for example.

In certain forms of the invention, the siren signal producing portion of the apparatus may be employed for producing conventional siren output sound signals of the undulating type normally employed by emergency vehicles. This form and application of the invention is particularly suitable for police motorcycles, and the like. However, the siren signal producing portion of the apparatus may also be employed for producing a nonundulating siren type output sound, where such is desired. Additional reference to this will be made hereinafter.

Also, as pointed out above, the apparatus may be employed as a very effective public address system for amplifying the human voice, or the like, where such is desired. This is most often employed in police cars, and other emergency cars, or the like. However, it should be noted that any of the subcombination, or complete combination, forms and modes of application of the present invention may be employed on virtually any type of vehicle where it is desired, or elsewhere, and all such arrangements are intended to be included and comprehended within the broad scope of the present invention.

The siren signal producing portion of the apparatus is provided with a siren signal generator means and controllably operable siren activation means for effectively causing said siren signal generator means to be in operative input relationship with respect to an audio output amplifier portion of the apparatus. Said siren activation means may be controllably manually operated in a manner such as to cause an undulating siren output sound or may be provided with automatic cycling means for causing such undulations in the siren output sound at a desired frequency and/or for a desired length of time if automatic termination is desired after a certain elapsed time.

This may be accomplished by any conventional cycling apparatus, such as a clock-operated cycling switch, various types of cycling relays, or the cycling means more particularly disclosed and claimed in my co-pending patent application Ser. No. 477,901, filed Aug. 6, 1965, and reference is made thereto for the details of one representative, but nonspecifically limiting, type of such a cycling apparatus which may be used for this purpose.

Also, the timer or timing means disclosed in my said copending application may be employed for causing an automatic termination of the operation of the siren signal producing portion of the apparatus, whether in the undulating or steady-state mode of operation, after a predetermined period of time. However, it should be understood that said timer or timing means disclosed in my said co-pending patent application is exemplary only of many other such timers which may be employed for this purpose within the broad scope of the present invention.

It should be noted that various proposals have been made for providing proper warning to the public of both civil and military emergencies, which may include civil and military disasters and military attacks. In certain cases, these proposals have specified that a siren type output sound of the undulating type be employed and should terminate after a specified period of time, such as three to five minutes and, in certain other cases, these proposals have specified that a siren type output sound of a steady state or undulating type be employed and automatically terminate after a predetermined period of time such as three to five minutes.

Either of the above-mentioned proposed emergency or attack and disaster warning signals may be readily produced by the siren signal producing portion of the apparatus of the present invention by merely controlling the siren activation means thereof by the above-mentioned cycling means and/or timing means disclosed in detail in my above-identified copending patent application and, therefore, it is clearly apparent that the apparatus of the present invention is widely adaptable to virtually all types of emergency vehicle broadcasting purposes, whether for the purpose of producing and broadcasting a conventional emergency vehicle undulating type output siren sound, or either an undulating, automatically terminating, or a steady state, automatically terminating civil disaster or military disaster warning siren type output sound, or for producing a greatly amplified voice-type output sound when operated in the public address mode, and this is accomplished in a very small, compact, rela-

tively foolproof, and yet extremely high-powered type of amplifying system by reason of the novel constructional features employed therein.

It should be noted that the present invention and the present application are directed to the complete combination form of the invention and subcombination thereof as referred to hereinbefore and that the novel amplifier means and/or the novel preamplifier means may be collectively or individually used, per se, for a variety of purposes other than those specifically set forth in detail herein, and all such arrangements are intended to be included and comprehended within the broad scope of the present invention.

It should be noted that the transistors and diodes employed in a preferred form of the invention are of an all-silicon construction, that no coupling capacitors are required, and that there is zero stand-by current for the siren unit, thus making it unnecessary to provide any on-and-off switch.

It should further be noted that in a preferred form of the invention, no sudden cut-off of siren sound output at the low frequency end of the siren wail cycle occurs because of the provision of novel siren wail cut-off retarding means, which acts to produce a frequency fall rate effectively prolonged so as to simulate that produced by a conventional mechanical air siren.

It should also be noted that, in one preferred form of the invention, a quick-acting electromagnetic siren brake is provided for the purpose of quickly stopping the siren when desired.

Siren wail may also be terminated abruptly by deactivating the previously mentioned audio output amplifier portion of the apparatus to which the siren signal generator is coupled, or this may be accomplished by interrupting the coupling of the siren signal generator with respect to said audio output amplifier portion of the apparatus. It is not possible to provide such an abrupt termination of a siren output signal in a conventional air siren.

Another feature of the invention is the ability to use the public address mode of operation of the apparatus, or the siren signal mode of operation of the apparatus, at any time without the use of a changeover switch. Activation of a microphone switch only is sufficient for effectively placing the apparatus in condition for operation in the public address mode of operation, producing only a small, almost negligible current drain from a battery adapted to supply power to the apparatus until desired audio information appears at the microphone.

Even when the apparatus is still in the siren signal mode of operation, closure of the microphone switch will automatically withdraw the previously mentioned audio output amplifier from a square-wave saturated signal condition, and the siren tone will become a subdued background sine wave sound, capable of being easily overridden by the public address signal produced by an acoustic input into the microphone.

A preferred form of the apparatus employs a multiple-stage, direct-coupled, push-pull audio output amplifier means, which, when the siren activation means is operating, is directly coupled thereto and bias is applied to said audio output amplifier means whereby to cause it to operate as a class C amplifier means which is fully protected against dissipation due to overdriving.

The audio output amplifier means is coupled to a push-pull audio output transformer means which, in one preferred form of the invention, comprise a tape-wound highly-efficient autotransformer which drives an output electroacoustic transducing loudspeaker at the appropriate voltage for desired power output.

All transistors in said multiple stage audio output amplifier means are driven fully into saturation except when operated as a class B amplifier means in the public address system mode of operation to be described hereinafter whereby to minimize power dissipation within the transistors.

The public address system preamplifier, in one preferred form of the invention, is a two-stage, direct-coupled, phase-splitting preamplifier means provided with a unique apparatus and method for automatically producing the proper biases and equal out-of-phase signals at the input terminals of the hereinbefore-mentioned multiple stage audio output transformer means without the use of coupling capacitors. The bias which appears when the public address system activation switch (the microphone switch) is closed, changes the apparatus to class B operation for good voice reproduction.

Output sound volume from the loudspeaker means is controlled by a novel DC balanced negative feedback circuit, without frequency discrimination. This allows maximum possible inverse feedback when volume is set at a minimum value so that reproduction fidelity at low volume is of very high quality. Volume increases as the negative feedback is controllably gradually reduced until a mechanical stop on the control sets the maximum volume and the corresponding minimum (but not zero) inverse or negative feedback.

In a preferred form of the invention, the siren input signal may be a sine wave generated by a permanent magnet multiple-pole rotor moving relative to, and in opposite polarity electromagnetic relationship with respect to, a pair of similar output coil means whereby to cause similar electrical signals of opposite phase to be produced therein by rotation of said rotor. These output coils feed the high-impedance input of the multiple-stage audio output amplifier means, which is biased to the class C operating condition, and overdrive the input stage by something of the order of a twenty to one factor. This produces very fast switching times in the square-wave output produced thereby and, thus, results in low transistor dissipation and high circuit efficiency.

In a preferred form of the invention, wail is produced through the use of a small DC motor which is mechanically coupled in driving relationship to the previously mentioned multiple-pole rotor which, in one specific exemplary form, may comprise a fifteen-pole generator adapted to be driven by said DC motor to a maximum speed of approximately 4,000 r.p.m. This will, of course, produce fifteen times 4,000 r.p.m. or 60,000 cycles per minute, which is 1,000 cycles per second, thus causing a maximum frequency of approximately 1,000 cycles per second to be produced and fed to the output loudspeaker means. The output audio transformer is suitable for this frequency and the apparatus, when operated in the manner described hereinbefore, produces a large number of high harmonics, which appear at the speaker voice coil and which give the sound output a startling similarity to the sound produced by a conventional mechanical air siren.

The small DC motor may be sequentially and alternately energized and de-energized by a siren activation switch operated manually or by an automatic cycling means of any desired type, as mentioned hereinbefore or as set forth with great particularity in one exemplary form in my hreinbefore-identified co-pending patent application.

When the siren activation switch energizing the siren driving motor is repetitively energized and de-energized in the manner mentioned above, the rate of frequency rise is controlled by inertia of the rotating portion of the motor and the multiple rotor of the sine wave generator and the applied motor voltage.

In one preferred form of the invention, frequency fall rate is prolonged over that due to natural friction in the rotating system, by rectifying a portion of the square-wave audio output from the output audio amplifier means and feeding a controlled amount of this DC voltage back to the siren rotor drive motor in a positive feedback sense. As the speed of rotation of said motor and said rotor reaches zero, said feedback signal also drops to zero and consequently current to the motor becomes completely cut off and the motor and the multiple-pole rotor of the siren generator come to a complete stop. This produces

an output siren sound very similar to that produced by a conventional mechanical air siren.

In one preferred form of the invention, the siren rotor driving motor is provided with controllably operable motor braking means for positively and rapidly stopping rotation of the siren rotor upon operation of said braking means. In one preferred form, said braking means may comprise a shorting circuit and switch connected across a winding of the motor (although alternatively it may be similarly connected relative to the magnetic poles of the siren generator), which produces an induced current load and a consequent back emf as a result of rotation thereof whereby to bring about a quick and positive stop thereof.

With the above points in mind, it is an object of the present invention to provide novel apparatus having any of the advantages and/or features referred to herein, generically and/or specifically, and individually or in combination, and which is of relatively inexpensive, small, lightweight, foolproof construction adapted for ready mass manufacture at low cost whereby to be conducive to widespread use of the invention.

Further objects are implicit in the detailed description which follows hereinafter (which is to be considered as exemplary of, but not specifically limiting, the present invention), and said objects will be apparent to persons skilled in the art after a careful study of the detailed description which follows hereinafter.

For the purpose of clarifying the nature of the present invention, several exemplary embodiments of the invention and/or various modified portions thereof, are illustrated in the hereinbelow-described figures of the accompanying drawings and are illustrated in detail hereinafter.

FIG. 1 is an electrical schematic view of one exemplary combination form of the invention and illustrates the actual electrical circuit thereof, but does not show the real physical appearance and/or structure of certain of the physical components associated therewith. Also, various portions of the complete combination shown in FIG. 1 are indicated by being enclosed in broken line—such portions corresponding to certain identifying expressions used throughout this application and being done for purposes of convenience in clarifying what portions of the complete circuit means are meant by said identifying expressions as used throughout this application.

FIG. 2 is a fragmentary, electrical schematic view which I employ as an aid in illustrating the advantages of, and the operation of, the novel two-stage preamplifier means of the present invention as illustrated in the complete combination form of the invention shown in FIG. 1. It should be clearly understood that this view does not illustrate the preamplifier means of FIG. 1 but merely illustrates a preliminary approach thereto which is useful in understanding the advantages of the novel preamplifier means of FIG. 1.

FIG. 3 is a view similar to FIG. 2, after a slight modification of the circuit of FIG. 2 has been effected, which brings about a modification of the gain thereof and which is also preliminary to the novel preamplifier means of FIG. 1, but is not identical thereto.

FIG. 4 is a view similar to FIGS. 2 and 3 but illustrates a further modification of the electric circuitry of FIG. 3 which brings about an effective division of the gain factor of the circuitry of FIG. 3 whereby to produce two opposite-phase signals, each having a unity gain. This view also is preliminary to, but not identical to, the novel preamplifier means of FIG. 1.

FIG. 5 is a view similar to FIGS. 2, 3, and 4 but illustrates a further slight modification of the arrangement illustrated in FIG. 4 which finally results in the novel preamplifier means of FIG. 1.

FIG. 6 is an electrical schematic view very similar to FIG. 1, but illustrates a slight modification thereof in two respects: first, as to the preamplifier means, which is somewhat different in this modified form of the invention; and, second, as to the middle stage of the three-stage audio output amplifier means which, in this modified form of the invention, is an effectively doubled or parallel-connected intermediate stage for the purpose of increasing the power-handling capacity thereof.

One exemplary combination form of the invention is illustrated in electrical schematic form in FIG. 1, wherein it is shown as comprising input electrical signal-producing means coupled to an audio output amplifier means which, in turn, is coupled to an audio output transformer means driving an output electroacoustic transducing loudspeaker means.

In the exemplary arrangement illustrated in FIG. 1, the above-mentioned input electrical signal producing means comprises two different portions of the apparatus as shown within the broken-line enclosures generally designated at **20** and **22**. Broadly speaking, either one of said circuit portions designated at **20** and **22** may be said to comprise an input electrical signal producing means which is controllably operable for producing a varying electrical input signal (an input signal with respect to the succeeding portions of the apparatus) comprising two similar signal portions of opposite-phase relationship varying in accordance with a desired sound output of the loudspeaker means and, when operative, in effective direct-coupled input relationship with respect to the input side of the previously-mentioned audio output amplifier means.

In the exemplary form of the invention illustrated in FIG. 1, the input electrical signal producing means portion indicated generally at **20** comprises a siren signal generator means provided with controllably operable siren activation means comprising the siren switch **24**, which is operable when closed to effectively cause the siren signal generator means **20** to be in operative direct-coupled input signal producing relationship with respect to the previously mentioned audio output amplifier means which, in the exemplary form of the invention illustrated, is designated generally by the reference numeral **26**.

Since the audio output amplifier means **26** is coupled to the output transformer means, which is generally designated by the reference numeral **28**, and which, in turn, is coupled to the loudspeaker means, which is generally designated by the reference numeral **30**, it will be understood that closure of the siren activation switch means **24** will result in the broadcasting of a high-amplitude high-energy output sound from the loudspeaker means **30** of a siren-type sound corresponding to the operation of the siren signal generator means **20**.

The other input electrical signal producing means generally indicated at **22** comprises a public address system input portion provided with controllably operable public address activation means, comprising a public address switch **32** which is operable, when closed, to effectively cause the public address system input portion **22** to effectively be in operative direct-coupled input electrical signal producing relationship with respect to the previously mentioned audio output amplifier means **26** so that a voice-operated input microphone **34** will cause said public address input portion **32** to supply input to the audio output amplifier means **26**, which will effectively amplify same and feed same to the output audio transformer means **28**, which will operate the loudspeaker means **30** whereby to broadcast over a wide area the amplified initial voice input to the microphone **34**.

The foregoing brief description generally defines the exemplary form of the invention illustrated in electrical schematic form in FIG. 1. More detailed descriptions of the various elements thereof follow hereinafter.

The previously mentioned siren signal generator means, generally indicated at **20**, comprises a small motor **36**, which, in the example illustrated, is a DC motor, and which is adapted to be energized normally, intermittently, and repetitively when the siren generator means **20** is intended to produce a conventional undulating siren sound

of the kind normally employed by emergency vehicles as a warning signal, by intermittently closing and opening the previously mentioned siren activation switch **24**, which may be done manually or by an automatic cycling means such as that shown in phantom at **38** in FIG. 1 and indicated as being coupled to said siren activation switch **24**. Said automatic cycling means may be a clock-operated cycling switch, any of various types of automatic cycling relays, various other functional equivalents or it may be an automatic cycling means of the type disclosed and claimed with greater particularity in my copending patent application Ser. No. 477,901, filed Aug. 6, 1965.

In any event, the siren activation switch **24** is adapted to be repetitively opened and closed, which will correspondingly repetitively connect the storage battery **40** in series with the winding **42** of the DC motor **36** whereby to cause the motor to be correspondingly repetitively power-rotated and de-energized.

The DC motor **36** is mechanically coupled in driving relationship with respect to a multiple-pole permanent magnet rotor **44**, which is mounted for rotation by the motor **36** and is in oppositely directed electromagnetically coupled relationship with respect to a pair of similar output coil means **46**, each of which is of the same impedance and resistance, and each of which is coupled at the right end thereof, as indicated at **72**, to a corresponding base element **48** of a corresponding transistor **50** of the input pair of transistors of the previously mentioned audio output amplifier means **26**.

The above-described arrangement is such that the motor **36** may be adapted to rotate the multiple-pole rotor **44** (which, in a preferred form, comprises a fifteen-pole rotor), to a maximum speed of 4,000 r.p.m. when the siren activation switch **24** is temporarily closed. Each magnetic pole of the multiple-pole rotor **44**, when it passes the two coils **46**, will produce similar sine waves therein, each of which is of equal magnitude and opposite phase and will apply said equal, opposite phase, sine waves to the corresponding bases **48** of the corresponding input transistors **50** of the audio output amplifier means **26** at the input terminals **72** thereof.

Thus, it will be seen that for each revolution of the multiple-pole rotor **44**, each coil **46** will produce fifteen equal but oppositely phased sine waves and that, since the rotor **44** is rotated at 4,000 r.p.m., this will result in a frequency of 60,000 cycles per minute or 1,000 cycles per second being produced in each of said coils **46**. This maximum 1,000 cycles per second input signal to the audio output transformer means **26** will result in a greatly amplified and extremely loud siren-type output signal from the loudspeaker means **30** of a corresponding maximum frequency of approximately 1,000 cycles per second, which is correct for the type of siren output sound desired. The output audio transformer means **28** is designed to handle this frequency effectively, and a large number of high harmonics will be found to appear at the loudspeaker voice coil **52**, thus giving the output siren sound a startling similraity to the sound produced by a conventional mechanical air siren.

The rate of frequency rise of the siren generator **20** is controlled by the inertia of the rotor **44** and the voltage applied to the winding **42** of the motor **36**.

The frequency fall rate of the siren generator **20** may be prolonged over that due to natural friction in the system in order to more closely simulate the output sound of a conventional mechanical air siren, by rectifying the square wave audio output of the audio output amplifier means **26** and feeding a controlled amount of this rectified DC voltage back to the winding **42** of the siren driving motor **36**. This is accomplished by the two circuit leads **54** and the two half-wave rectifiers **56** which are connected together and are fed through the resistance **58** to the terminal **60** at one end of the winding **42** of the motor **36**.

The elements just referred to above may be said to effectively comprise a siren wail cutoff retarding means comprising positive feedback means coupled to the audio output amplifier means **26** and feeding back a feedback signal proportionate to the output thereof to the siren rotor driving motor **36** in a direction such as to extend the period of rotation thereof after the siren activation switch **24** has been opened. This causes the cutoff end of the undulating siren sound to simulate that produced by a conventional mechanical air siren. It should be understood that as the speed of rotation of the rotor **44** and the motor **36** reaches zero, so does the above-mentioned feedback signal and, therefore, current through the winding **42** of the motor **36** becomes completely cutoff and the siren generator **20** becomes completely inactivated until subsequent closure of the siren activation switch **24** again occurs.

In some cases, it may be desirable to be able to stop the siren generator **20** very quickly and, where such is desired, an optional motor braking means may be provided for positively and extremely rapidly stopping the rotation of the siren rotor **44** and the motor **36**. One exemplary form of such a motor braking means is indicated at **62** where it merely comprises a shorting circuit **64** and a normally open shorting switch **66** connected across the winding **42** of the motor **36** in a manner such that temporary closure of the normally open shorting switch **66** will effectively short-circuit the motor winding **42** so that it effectively sees an induced current load and a consequent back emf as a result of rotation of the motor **36** and the rotor **44** and thus causes same to come to a quick stop. However, it should be noted that the braking means **62** is an optional feature and may be eliminated entirely in certain forms of the invention. This is also true of the previously mentioned siren wail cutoff retarding means for prolonging the frequency fall rate of the siren output signal, as described in detail hereinbefore.

The audio output amplifier means **26**, in the exemplary first form of the invention illustrated, comprises a three-stage, direct-coupled, push-pull amplifier, which is operated as a class C amplifier when the siren activation control switch 24 is closed, but which acts as a class B amplifier when the previously mentioned public address system activation switch **32** is closed.

The above-mentioned three-stage audio output amplifier **26** comprises the first or input stage shown at the left thereof in FIG. 1 (which includes the previously mentioned pair of transistors **50**) connected in input relationship with respect to the second or intermediate stage of said audio output amplifier means **26** (which includes a second pair of transistors generally indicated at **68**) connected in input relationship with respect to the third or last stage of said audio output amplifier means **26** (which includes a third pair of transistor means generally indicated at **70**).

Each of the three stages just defined of the audio output amplifier means **26** and the three pairs of transistors **48**, **68**, and **70** thereof are connected in effective push-pull relationship with respect to the input terminals **72** thereof and with respect to the output terminals **74** thereof, which, in turn, are connected to the transformer winding **76** of the audio output transformer means generally indicated at **28**, in push-pull relationship whereby to provide a high-amplitude, high-power output audio signal having a minimum of distortion and coupled to the previously mentioned loudspeaker voice coil **52** for producing a very high volume output sound and for doing so with great efficiency. The system just described may readily produce an output ranging from 75 watts to 150 watts peak output, which is entirely adequate for the purposes of the present invention.

The amount of drive at the input terminals **72** of the audio output amplifier means **26** is normally high enough to maintain saturation down to about 200 cycles per second. Below this frequency, the square wave begins to lose sharpness of the peaks and the transition time becomes

progressively longer. As zero frequency is approached, the output of the siren generator means **20** falls off rapidly, thus preventing excessive currents from damaging the loudspeaker means **30** or any of the various transistors because of the lowering of the reactance of the transformer means **28** at such lower frequencies.

The other input electrical signal producing means, generally designated at **22**, and comprising the previously mentioned public address system input portion, includes the previously mentioned input microphone means **34**, which, broadly speaking, may comprise any type of acoustic-electric transducing means which is coupled in input relationship with respect to the two-stage, direct-coupled, phase-splitting input audio signal preamplifier means, which comprises that portion of the circuit shown in FIG. 1 contained in the broken-line enclosure generally designated by the reference numeral **22** and exclusive of the microphone **34**. Said preamplifier means will be generally designated by the reference numeral **78** hereinafter, and it should be understood as comprising the elements just mentioned.

Said preamplifier means **78**, in the first exemplary form of the invention illustrated, includes a first transistor **80** and a second transistor **82**, each comprising one of the stages of said two-stage preamplifier means which are connected in complementary, direct-coupled, phase-splitting relationship so that two equal signals of opposite phase will be applied therefrom and through the associated circuit elements to the input terminals **72** of the previously mentioned audio output transformer means **26**. These equal and opposite phase signals are of the proper voltage (usually of the order of ½ volt) to properly bias the input transistors **50** of the audio output amplifier means **26** for class B operation instead of their previous class C operation, when the siren activation switch **24** was closed. This biasing into a class B mode of operation occurs when the public address activation switch **32** is closed.

The novel preamplifier means **78** includes novel gain-modifying resistance means **84** and **86** and gain-modifying variable resistance means **88** and **90** taking the form of a pair of controllably adjustable coupled or ganged variable potentiometers coupled in a controllably variable negative feedback manner with respect to the preamplifier means **78** such as to effectively define a DC balanced negative feedback circuit without frequency discrimination which is operable for controlling the volume of output sound produced by the loudspeaker means **30** as an inverse function of said negative feedback. Therefore, it will be understood that coupled operation of the two potentiometers **88** and **90** by a volume-adjusting knob, or the like, (not shown since such knobs are well-known in the art), in a direction such as to increase the negative feedback will reduce the volume of output sound produced by the loudspeaker means **30**, while operation thereof in a direction such as to decrease the negative feedback will increase the volume of the output sound produced by the loudspeaker means **30**. Appropriate mechanical stops such as are indicated diagrammatically at **92** (although a lesser number than shown on FIG. 1 may actually be required in actual practice) act to limit the adjustment of the coupled potentiometers **88** and **90** so that the maximum volume setting, corresponding to minimum (but not zero) negative feedback, will be automatically determined, as will the corresponding opposite condition with minimum volume and maximum negative feedback. However, this latter stop may be eliminated, if desired.

FIGS. 2 through 5 illustrate in successively modified steps the operation of the novel preamplifier means **78** of FIG. 1 (and, also, of FIG. 5, which is substantially equivalent thereto), and it should be understood that the showings of FIGS. 2–4 are merely illustrative and are not the novel preamplifier means **78** of the present invention. These figures will now be described in sequence, and parts thereof which correspond to those of the novel preamplifier means **78** of FIG. 1 are designated by the same reference numerals. However, in the case of parts which have been modified from the showings of any of FIGS. 2–5 to their final showings in the novel preamplifier means **78** of FIG. 1, said parts are indicated by similar reference numerals, which, however, are primed, and double primed, in the case of resistors **86″**, **98″**, and **100″** in FIG. 2, in accordance with the number of the modifications thereof.

FIG. 2 shows a conventional phase-splitting circuit using two transistors **80** and **82** in a complementary connection. These act in combination similar to a single PNP transistor having a beta equal to approximately the product of the separate betas. This type of arrangement produces an in-phase output signal at the terminal **94** and an out-of-phase output signal at the terminals **96**. Both output signals have unity gain. Bias resistors **98″** and **100″** are chosen with values such as to allow maximum swing of the output voltages. The two output signals at **94** and **96** are at DC levels of −1.5 volts and −4.5 volts, respectively, and normally would have to be capacity-coupled to any succeeding or following push-pull amplifier.

FIG. 3 shows a modification of the value of the resistor **86″** of FIG. 2 (which, because of said modification, is indicated by the reference numeral **86′**) and comprising an effective multiplication thereof by a factor of six and, in the arrangement illustrated, a constant gain of six is produced in the out-of-phase output signal at the terminal **96**, said gain being practically independent of the transistor characteristics. Voltage swing in this case is limited to approximately 0.5 volt input and 3 volts output. It should be noted that, in this case, the out-of-phase output signal at the terminal **96** has a value of −3 volts while the in-phase output signal at the terminal **94** has a value of −0.5 volt. Since the voltage swing determined by the modified resistors **98′** and **100′** is limited to 0.5 volt input, this means that the in-phase output signal at the terminal **94** is only said −0.5 volt (thus having a gain of unity) and that the out-of-phase output signal at the terminal **96** has said voltage of −3 volts (based upon a gain of six).

FIG. 4 divides the out-of-phase signal at the terminal **96** by a factor of six so that the effective gain thereof is again equal to unity and comprises −0.5 volt at the terminal **104** while the in-phase output signal at the terminal **94** remains −0.5 volt. In other words, the resistances **84′** and **88′** produce the effective division or modification of gain of the out-of-phase output signal so that the in-phase output signal at **94** and the out-of-phase output signal at **104** are of equal amplitude (each having a gain of unity) and are of opposite phase. In other words, the DC levels at each of said terminals **94** and **104** is of the proper value for biasing an input transistor of a push-pull amplifier for class B operation and, therefore, the output signals at the terminals **94** and **104** can be directly coupled to such a push-pull amplifier and do not need to be capacity-coupled thereto in the manner of the circuit arrangement illustrated in FIG. 2, as previously described. In other words, with respect to FIG. 4, it should be noted that when the gain factor is numerically equal to the supply voltage, the bias will always be −0.5 at balance (balance being controlled by the resistors **98′** and **100′**, as previously mentioned).

FIG. 5 illustrates the replacement of the two resistors **90′** and **88′** of FIG. 4 by a corresponding pair of coupled or ganged potentiometers **88** and **90** of linear taper and the addition of resistor **109**. Adjustment of said potentiometers **88** and **90** in a manner effecting a decrease in negative feedback will cause a corresponding increase in gain and, therefore, in volume of the sound produced by the loudspeaker means **30** of FIG. 1. Conversely, adjustment of the ganged potentiometers **88** and **90** of FIG. 5 and of FIG. 1 in the opposite direction for increasing

the negative feedback, will cause a corresponding decrease in volume of output sound. DC voltages throughout the preamplifier circuit means **78** of FIGS. 1 and 5 remain essentially constant and all frequencies are treated alike up to the limitations of the transistors employed.

It should be noted that the balance resistors **98'** and **100'** of FIG. 4 have also been modified and effectively combined into a corresponding balance potentiometer **108** including a corresponding two resistance portions **98** and **100** clearly illustrated in both FIG. 5 and FIG. 1.

For the purpose of enhancing the disclosure, a partial specification of certain of the circuit elements or components employed in the exemplary first form of the invention illustrated in FIG. 1 are listed hereinbelow. The values listed are to be considered as exemplary of one form of the invention which has been built and which is fully operative but are not to be construed as specifically limiting the invention to the particular specification set forth below as follows:

Potentiometer **108**	ohms	500,000
Potentiometer **88**	do	1,000
Potentiometer **90**	do	50
Resistor **84**	do	5,600
Resistor **86**	do	330
Each coil **46**	do	300
Resistor **109**	do	1,000
Each resistor **110**	do	220
Each resistor **112** (3 watts)	do	25
Resistor **114**	do	330
Resistor **58**	do	220
Transistor **80** and the pair of transistors **50**		2N3638
Transistor **82** and the pair of transistors **68**		2N3405
Pair of transistors **70**		2N3372
Battery **40**	volts	12

The winding **76** of the audio output transformer **28** includes twenty turns in the portion between the terminal **74** on each side of the center tap **116** connected to the positive terminal of the battery **40** and eight turns in the winding portion positioned outwardly thereof between the terminal **74** and the terminal **118** on each side of the transformer winding. This provides two pairs of output terminals **120** and **118**, respectively, adapted for connection to an 8-ohm voice coil **52**, a 16-ohm voice coil, any other type of voice coil, or to multiple such voice coils of virtually any type.

In addition to the above, resistor **86''** in FIG. 2 is 50 ohms, and when modified to comprise resistor **86** in FIGS. 3, 4, and 5 is 300 ohms. The resistor **90'** in FIGS. 2–4 is 50 ohms prior to its modification into the potentiometer **90** of FIGS. 5 and 1 where it comprises a 50-ohm potentiometer. The resistor **88'** of FIG. 4 has a value of 1,000 ohms prior to its modification, as shown in FIGS. 5 and 1, into the 1,000-ohm potentiometer **88**.

FIG. 6 illustrates a modified form of the invention very similar to the first form of the invention illustrated in FIG. 1, with certain portions thereof modified to some extent and corresponding parts are designated by corresponding reference numerals, followed by the letter "*a*," however.

It will be noted that in the FIG. 6 modification of the invention the preamplifier means **78***a* is somewhat different from the preamplifier means **78** of the first form of the invention and the two transistors **80***a* and **82***a* thereof are no longer in the complementary connection illustrated in the first form of the invention, but, rather, are connected as a differential amplifier in which the out-of-phase signal is produced in transistor **82***a* by means of the coupling effected by the common emitter resistor **122**. This configuration allows the input connection of the microphone **34***a* to have one side at effectively ground potential. Other advantages are so-called "common mode rejection," a term well-known in the art, and the provision for symmetry in the negative feedback circuits. Proper choice of resistance values and replacement of the usual collector load resistors by the siren generator coils **46***a* produces two equal and oppositely phased output signals at the input terminals **72***a* of the two input transistors **50***a* of the audio output amplifier means **26***a* for subsequent operation of the remainder of the circuit in a manner very similar to that described hereinbefore in connection with the first form of the invention illustrated in FIG. 1, although the ganged potentiometers **88***a* and **90***a* are somewhat differently arranged than in the first form of the invention and are embodied in the audio output amplifier means **26***a* rather than in the preamplifier means **78***a*, as in the first form of the invention. Also, in the FIG. 6 modification of the invention, a second pair of transistors **68***a* is effectively connected in parallel with respect to the first pair of transistor means **68***a* in the second stage of the audio output amplifier means **26***a*. However, this is merely to increase the power-handling capacity of said second stage and each such doubled pair of transistors might have a single transistor capable of handling a larger power substituted in lieu thereof. Also, it should be noted that, if desired, the second stage transistors **68** of the first form of the invention of FIG. 1 may be effectively doubled and parallel connected in the manner of the transistors illustrated at **68***a* in the FIG. 6 modification of the invention. Otherwise, the FIG. 6 modification of the invention is very similar to, and functions in a manner substantially equivalent to, the first form of the invention illustrated in FIG. 1, although the novel preamplifier means **78** of the first form of the invention illustrated in FIG. 1 has a number of advantages over the modified preamplifier means **78***a* of the modified FIG. 6 form of the invention for various of the reasons noted at various locations hereinbefore.

It should be noted that while a single loudspeaker means **30** is shown in the first form of the invention in FIG. 1 and is shown at **30***a* in the FIG. 6 modification of the invention, actually one or more loudspeakers may be employed and multiple-choice output terminal connections of the type illustrated in FIG. 1 may be employed for connecting one or more such loudspeakers or for connecting loudspeakers having voice coils of different values of impedance or resistance.

Also, it should be noted that any of the forms of the invention may be powered by suitable transformer and rectifier power supply means in lieu of the storage battery **40** of FIG. 1 and **40***a* of FIG. 6 so that any conventional source of alternating current of any available voltage may be transformed into a desired voltage value and appropriately rectified (and, if desired, filtered) to comprise a functional equivalent to the storage battery **40** or **40***a* and, since such arrangements are well-known in the art, they are not illustrated.

Additionally, it should be noted that a conventional radio of either an AM or FM type, such as is found in many emergency vehicles may, if desired, be coupled to either the audio output amplifier means **26** of FIG. 1 (or **26***a* of FIG. 6) and provided with controllably operable switch means for operatively coupling same together, or provided with barrier means operative for the same coupling purposes when the audio output signal amplitude of such a radio exceeds a predetermined value, so that under such conditions the loudspeaker means **30** of FIG. 1 (or **30***a* of FIG. 6) will act as an output speaker for the radio and will broadcast the signal therefrom. Also, if desired, the audio output signal from such a conventional radio may be coupled directly into the audio output transformer **28** and/or loudspeaker means **30** of FIG. 1 or the corresponding elements **28***a* and/or **30***a* of FIG. 6, if desired, for the same purpose.

I claim:

1. An audio amplifying and transducing apparatus for producing and emitting a high-amplitude, high-energy sound output, comprising: a multiple-stage direct-coupled push-pull audio output amplifier means having multiple audio output amplifier stages in sequential direct-coupled relationship with each audio output amplifier stage in-

cluding a pair of power amplifying transistors; an audio output transformer means coupled in push-pull relationship with respect to the output side of said audio output amplifier means; an output electro-acoustic transducing loudspeaker means coupled to the output of said audio output transformer means; and input electrical signal producing means controllably operable for producing a varying electrical input signal comprising two similar signal portions of opposite phase relationship varying in accordance with a desired sound output and effectively in direct-coupled input relationship with respect to the input side of said audio output amplifier means, said input electrical signal producing means comprising a siren signal generator means provided with controllably operable siren activation control means for effectively causing said siren signal generator means to be in operative direct-coupled input relationship with respect to said audio output amplifier means and for causing said audio output amplifier means to be biased for class C operation said siren signal generator means comprising a motor provided with and driving a multiple pole magnetic rotor means provided with and in oppositely directed electromagnetically coupled relationship with respect to a pair of similar output coil means adapted to have similar electric signals of opposite phase produced therein by rotation of said rotor means.

2. Apparatus as defined in claim 1, wherein said siren rotor means driving motor is provided with controllable operable braking means for positively stopping rotation of said siren rotor means upon operation of said braking means and comprising a shorting circuit and switch connected across a winding of said motor which effectively produces an induced current load and a consequent back emf as a result of rotation thereof whereby to bring about a quick stop thereof.

3. Apparatus as defined in claim 1, wherein said siren signal generator means is adapted to be intermittently and repetitively activated and inactivated by said controllably operable siren activation control means and is provided with siren wail cutoff retarding means operable for preventing abrupt cutoff of output sound from said loudspeaker means when said siren signal generator means is inactivated by de-energization of said motor driving said rotor.

4. Apparatus as defined in claim 3, wherein said siren wail cutoff retarding means comprises positive feedback means coupled to the output of said audio output amplifier means and including rectifier means for rectifying same and feeding back a signal proportionate thereto to said siren rotor driving motor in a direction such as to extend the period of rotation thereof after inactivating operation of said siren activation control means, thus preventing abrupt cutoff of output sound from said loudspeaker means.

5. Apparatus as defined in claim 1, wherein said input electrical signal producing means also comprises a public address system input portion provided with controllably operable public address activation control means for effectively causing said public address system input portion to be in operative direct-coupled input relationship with respect to said audio output amplifier means and for causing said audio output amplifier means to be biased for class B operation.

6. Apparatus as defined in claim 5, wherein said public address system input portion comprises an input acousto-electric transducing means provided with and coupled in input relationship with respect to a multiple-stage direct-coupled phase-splitting input audio signal preamplifier means.

7. Apparatus as defined in claim 5, wherein said public address system input portion comprises an input acousto-electric transducing means provided with and coupled in input relationship with respect to a two-stage direct-coupled phase-splitting input audio signal preamplifier means having two input audio signal preamplifier stages in complementary direct-coupled phase-splitting relationship, with each of the two input audio signal preamplifier stages including a power amplifying transistor connected in effective complementary relationship with respect to the transistor of the other input audio signal preamplifier stage.

8. Apparatus as defined in claim 7, wherein said input audio signal preamplifier means has output circuit means connected thereto and is provided with gain-modifying variable resistance means operable to cause the no-input-signal voltage outputs of said preamplifier means direct-coupled to said audio output amplifier means to be of equal magnitudes optimum for class B operation thereof.

9. Apparatus as defined in claim 8, wherein said gain-modifying variable resistance means includes a pair of controllably adjustable coupled variable potentiometers coupled in a controllably variable negative feedback manner with respect to said preamplifier means and effectively defining a DC balanced negative feedback circuit without frequency discrimination operable for controlling the volume of output sound as an inverse function of negative feedback.

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