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B. A. PROCTOR ET AL

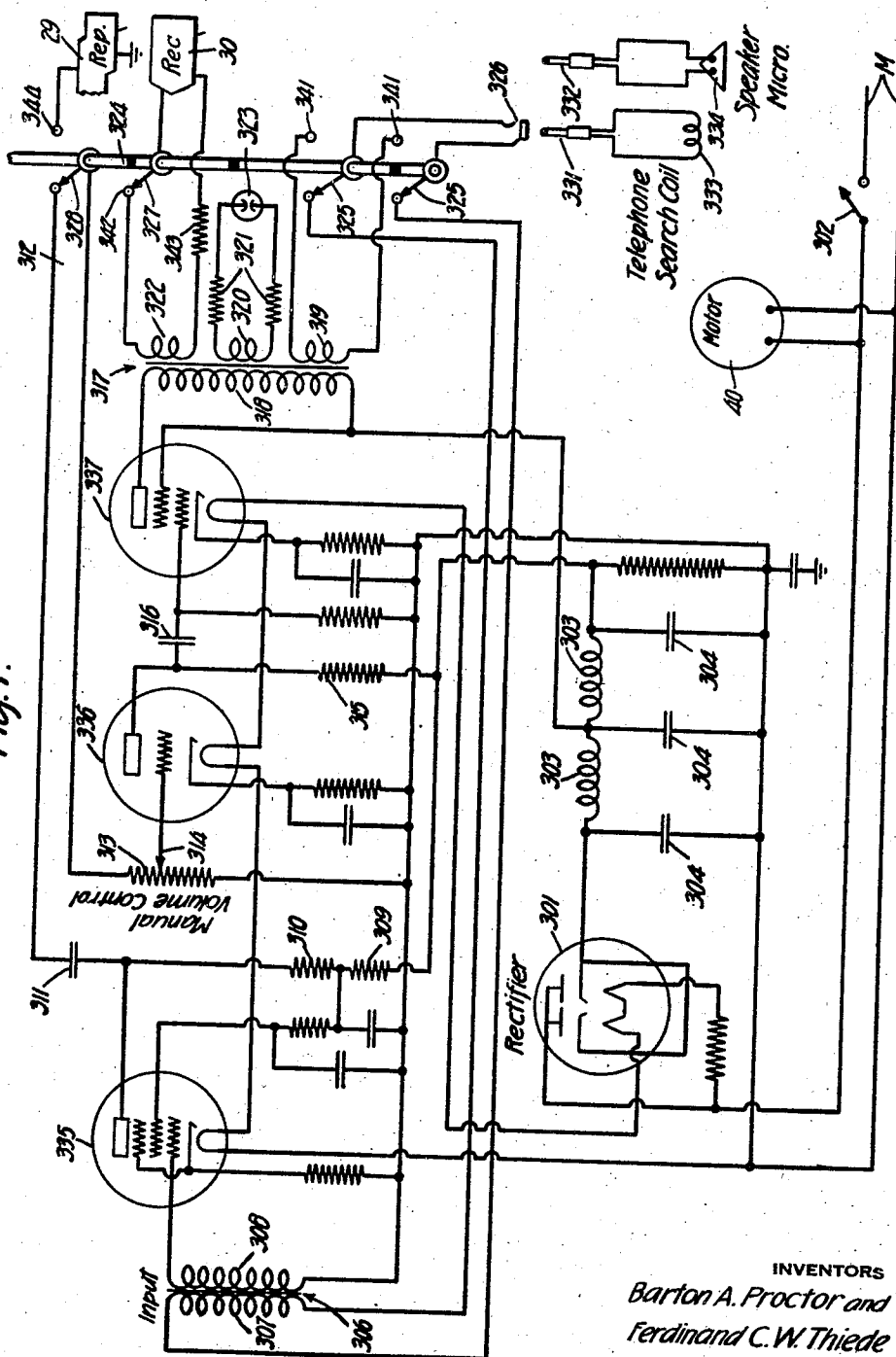
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SOUND RECORDING AND REPRODUCING

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Fig. 1.



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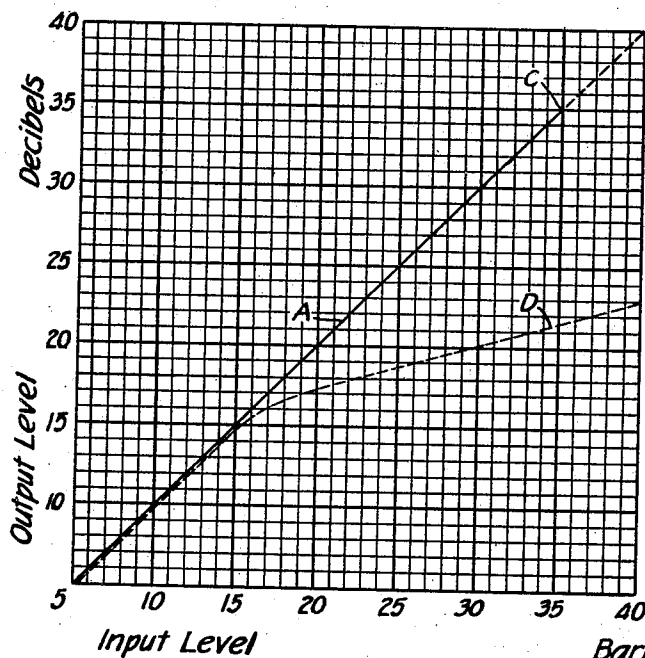
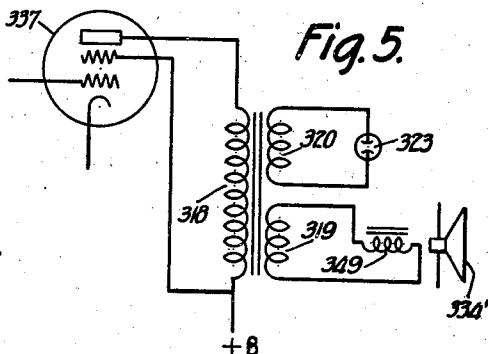
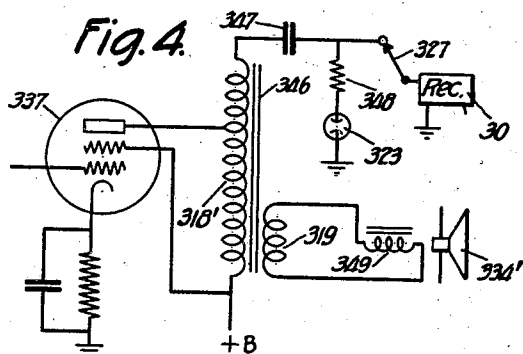
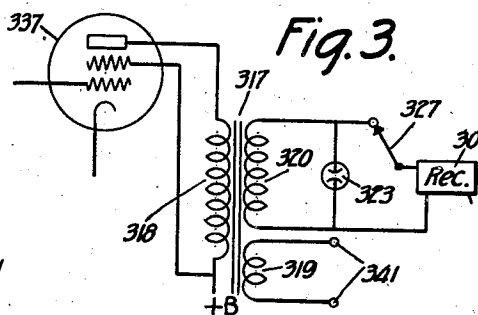
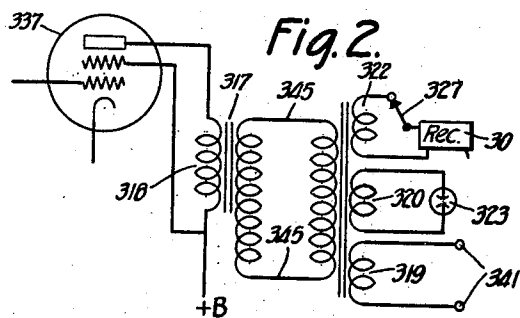
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SOUND RECORDING AND REPRODUCING

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11 Claims. (Cl. 179—100.4)

This invention relates to sound recording and reproducing and more particularly to a machine employing an amplifying device for amplifying electrical currents generated by the sound to be recorded and for applying the amplified currents to a recording unit which is provided with a stylus which forms a sound track in a record corresponding to the original sound. The mechanical features of such a machine in which the sound is recorded on thin, flexible disc records are disclosed and claimed in patent application Serial No. 218,082, filed July 8, 1938, now Patent No. 2,296,870, of which the present application is a continuation in part. In said machine, means for reproducing the recorded sound is also provided, such reproducing means comprising a reproducing unit which also has a stylus engageable with the record. The recording and reproducing units are preferably of the piezo-electric type, such devices being ideally suited to the purpose because of the powerful drive which may be transmitted to the recording stylus and because of the delicate and accurate responsiveness to the reproducing stylus which may be secured.

When shifting over from recording to reproducing it is highly desirable that only a single amplifying device be utilized for both operations and it is a feature of the present invention that a simple switching arrangement is provided whereby the same electron discharge tube amplifier is used for both recording and reproducing.

In the illustrative embodiment of the invention, the record material is deformed during the recording operation, so that it is necessary to supply a substantial amount of energy or power to the recording unit, whereas no deformation of the record material occurs during reproduction so that a lesser amount of energy is adequate for operating the reproducing device or loud speaker. In order to supply such energy in proper amounts, the electron discharge tube amplifier is constructed of a plurality of stages connected in cascade and the switching device is arranged and constructed so that three stages of amplification are used for recording while only two stages are used for reproducing. As disclosed in the aforementioned application, the switching device is preferably operated by the same manual control handle or finger piece which shifts the recording and reproducing styluses alternatively into and out of engagement with the record.

In accordance with a further object of the invention, provision is made in the form of an overload protective device for limiting the amplitude

of the energy impulses applied to the recording unit, and hence of the reproduced sound. This device consists of a glow tube connected inductively to the input of the recorder circuit and to the output of the amplifier circuit. A circuit including such a tube has the characteristic that it will absorb no energy from the primary or input circuit with which it is inductively coupled unless and until the conditions of the primary circuit are such as to induce a potential across the tube in excess of a definite, predetermined value. When such value is exceeded, however, the tube will glow, and the circuit will substantially modify the current flowing in the primary circuit with which the glow tube circuit is coupled and limit the amplitude of the current variations therein.

For a better understanding of the invention reference is made to the following description taken in connection with the accompanying drawings in which;

Fig. 1 is a schematic circuit diagram showing the electrical connections between the various parts of the machine;

Figs. 2 to 5 show schematic circuit diagrams illustrating different circuit arrangements for limiting the output level of the amplifier to a predetermined value and,

Fig. 6 shows curves illustrating the manner in which the output level of the amplifier is limited by the action of the glow discharge tube.

The thin flexible disc record 70 is shown as being driven by upper and lower feed rollers 130 and 102 and the stylus 165 of the recording unit 30 being in engagement with the upper face of the record, the distance between the stylus and the feed rollers being exaggerated for the purpose of clarity. The feed rollers 130 and 102 are driven in opposite directions by an electric motor 40 through suitable driving connections (not shown) which are shown and fully described in the aforementioned application. The driving motor 40 may be connected to the alternating current supply mains M through the "on-off" switch 302, the mains M also supplying the current to the amplifier tubes 335, 336 and 337 and the rectifier 301. The rectifier 301 supplies unidirectional current to the circuits of the amplifier tubes through a filter circuit of known type comprising the inductors 303 and condensers 304. The current corresponding to the sound to be amplified is applied across the end of primary winding 307 of transformer 306 whose secondary winding 308 is connected across the grid and cathode of tube 335, as shown. Resistance coupling is used to

transfer this amplified current from the plate circuit of one tube to the grid circuit of the succeeding tube, resistors 309, 310 in the plate circuit of tube 335 being connected through condenser 311, transmission line 312 and resistor 313 to the grid and cathode of tube 336. A contact 314 adjustable along resistor 313 serves as a manual volume control permitting the user to operate the device at any desired volume level so as to secure optimum results in either recording or reproducing. Resistor 315 and condenser 316 transfer the amplified current to the grid circuit of tube 337, the current corresponding to the amplified sound or signal passing through primary winding 318 of the output transformer 317.

As shown, transformer 317 preferably has three secondary windings 319, 320 and 322, winding 320 being connected through resistors 321 to the two electrodes of a neon tube 323 which functions as an automatic volume control device, as will be described later. One end of secondary winding 322 is connected to one terminal of the recording unit 330 through a resistor 343 and its other end to a switch contact 342 engageable by a switch blade 327 carried by a switch control shaft 324. The ends of secondary winding 319 are connected to a pair of switch contacts 341 adapted to be engaged by the switch blades 325 also operated by the shaft 324. The switch blades 325 connect to the terminals of a jack 326 in which may be inserted the jack plugs 331 or 332. Jack plug 331 is shown connected to the ends of a telephone search coil 333 and plug 332 to a unit 334 functioning as either a loud speaker or a microphone transmitter. The reproducer unit 29 has its high potential terminal connected to a switch contact 344 engageable by a switch blade 328 also connected to shaft 324, switch blade 328 serving to complete the circuit across transmission line 312 in the position shown.

With the switches in the position shown, the sound received by the microphone 334 may be recorded by inserting plug 332 in jack 326 after closing switch 302 to start the motor 40. Current corresponding to the sound waves passes through primary winding 307, is amplified by tubes 335, 336 and 337 and transferred to recorder 30 through secondary winding 322 of the output transformer and switch blade 327. This causes the stylus of the recorder to move back and forth sidewise and form a groove in the record which corresponds to the sound waves. In forming the groove, the stylus merely displaces the material of the record; that is, the material is not removed from the record as when a cutting action is used. We have found when a glow tube, such as one containing neon or argon gas, is connected as shown, if the microphone is subjected to very loud sounds, the gas in the tube breaks down or glows and causes a substantial decrease in the voltage applied to the recorder. The sounds of low and medium or normal intensity, however, do not produce sufficient voltage to cause tube 323 to glow so that the fully amplified voltage corresponding thereto is impressed on secondary winding 322 and the recorder. The glow tube thus serves to limit the energy applied to the recorder from a sound of excessive intensity, whereas that corresponding to a sound of low or normal intensity is not limited but applied with full effect.

With the glow tube disposed within sight of the operator, it thus acts as an indicator, the intense glowing of the tube indicating that the output voltage of the amplifier is too high. The oper-

ator should, therefore, lower the volume control 314 to a point where the neon tube just glows faintly for the louder passages of the voice. This volume level is found to give substantially the best results in recording. If, on the other hand, the volume control 314 was initially set too low, it should be raised to a point where the neon tube commences to glow faintly and left at that setting until the recording is completed.

To record a message passing over a telephone line the plug 331 is inserted in jack 326 and the search coil 333 placed close to the line and inductively coupled therewith as closely as possible. The currents induced in the search coil are then amplified and recorded in the manner above described.

To produce the sound recorded on a record, a handle (not shown) is moved to the "reproduce" position which causes the reproducer stylus to engage the record and also rotates shaft 324 clockwise by means of connections shown in the aforementioned application, thereby disconnecting recorder 30. Engagement of contact 344 by switch arm 328 causes the output voltage of 29 to be impressed on the grid of tube 336. The voltage is amplified in tubes 336 and 337 and is transferred to switch terminals 341 by primary 318 and secondary winding 319. Switch arms 325 being now in engagement with these terminals, the sound, as reproduced, may be heard from speaker 334 whose plug 332 is in position in jack 326. It thus appears that the switching arrangement is such that three stages of amplification are used for recording the signal, whereas for its reproduction only two stages of amplification are used. The switching arrangement disclosed thus effects the proper circuit connections with the amplifier to secure the desired degree of amplification.

Fig. 2 shows an alternative arrangement for connecting the glow tube 323, the recorder 30 and the loud speaker terminals 341 to the output circuit of the amplifier 337. In this case instead of the secondary windings 319, 320 and 322 being directly inductively coupled to the primary winding 318 as in Fig. 1, they are indirectly coupled thereto by means of a closed link circuit 345, as shown.

In the arrangement shown in Fig. 3, only two secondary windings are provided in the transformer 317, both the glow discharge tube 323 and the recorder 30 being connected in parallel across the ends of the secondary winding 320 when the switch 327 is in the recording position shown.

In the arrangement of Fig. 4, the coil 318', which is in the plate circuit of amplifier tube 337, not only serves as a primary winding for the secondary winding 319 which supplies current to the loud speaker 334', but also forms part of a step up auto-transformer 346. The amplified signal voltage is supplied to both the glow discharge tube 323 and the recorder 30, which are connected in parallel, through the circuit shown. This circuit includes a blocking condenser 347, one side of which is connected to the high potential terminal of the auto-transformer 346. A single resistor 348 is shown connected in series with the glow discharge tube for limiting the current therethrough.

The invention also has utility where the amplified signal is not to be recorded but is used merely to operate a loud speaker having a high sound output capacity. Such an embodiment is shown in Fig. 5, in which the secondary winding 319

is connected to the movable voice coil 349 of the electrodynamic loud speaker 334'. By using a neon tube 323 of suitable size as the signal voltage applied to the grid of the amplifier tube 337 is increased to a value at which the neon tube commences to glow, the tube acts as a bleeder resistor and as the energy in the output circuit of the amplifier is further increased, a greater proportion of it is consumed in lighting the neon tube. The result is that for signals above a certain level, the voltage applied to the secondary winding 319 remains substantially constant at a value at which the loud speaker 334' operates satisfactorily and is not overloaded. For weak signals, the amplified signal current in the primary winding 318 is insufficient to cause the neon tube 323 to glow so that the tube has substantially no effect on the current in the primary winding. Weak signals are therefore reproduced at their proper levels by the loud speaker 334'.

In all of the illustrated embodiments of the invention, the amount of energy loss to be introduced into the controlled circuit or the level at which the glow tube is to become effective may be controlled by the use of glow tubes of different sizes or by the use of resistors of different values in series with the glow tube.

Fig. 6 illustrates the action of the glow tube in limiting the output level of the amplifier and the voltage applied to the recorder. The full line A represents the output level of the amplifier for different levels of signal voltage applied to its grid when the glow tube is not used. It will be noted that the line is straight and that the output level and the voltage applied to the recorder are proportional to the input level of the amplifier, the point C indicating the maximum output of the amplifier.

The dotted curve D represents the output level of the amplifier when the neon control tube is used. It will be noted that for signal levels up to 15, the two curves practically coincide showing that for low signal levels the neon tube has substantially no effect on the amplifier. At a level of approximately 15 the tube starts to glow, however, and it will be noted that as the signal level is increased above 15, the spacing between the curves C—D progressively increases, indicating that a larger proportion of the available energy is consumed in lighting the neon tube. By designing the neon tube of the proper size, the maximum output level and the voltage applied to the reproducer or loud speaker may be limited to any desired value.

We have described what we believe to be the best embodiments of our invention. We do not wish, however, to be confined to the embodiments shown, but what we desire to cover by Letters Patent is set forth in the appended claims.

We claim:

1. In a sound translating device, the combination of at least three coupled amplifier stages each having input and output circuits, a reproducing device, a recording device, a combined microphone and speaker, a circuit including a switch for connecting said recording device to the output circuit of the third stage for recording, a circuit including a second switch for connecting said reproducing device to the input circuit of the second stage for reproducing, circuit means including switch mechanism for connecting the combined microphone and speaker alternatively to the input circuit of the first stage for recording and to the output circuit of

the third stage for reproducing, and a single control means for said switches and switch mechanisms to cause the switch over from recording to reproducing and the switch over from reproducing to recording each to be completely effected instantaneously and at a single operation.

2. In a sound translating device, the combination of an electron discharge amplifier device having input and output circuits, a source of currents of audio frequency connected to said input circuit, a record, means for rotating said record, a recording device having a stylus in engagement with said record, a circuit coupling said recording device to said output circuit, and a glow discharge tube coupled to said output circuit and arranged to glow when the current variations in said output circuit exceed a predetermined, normal value.

3. In a sound translating device, the combination of an electron discharge tube amplifier having input and output circuits, a source of currents of audio frequency connected to said input circuit, a record, means for moving said record, a recording device having a stylus for engaging said record, a circuit coupling said recording device to said output circuit, a coil inductively coupled to said output circuit, a neon tube having two spaced apart electrodes, and circuit connections between said electrodes and the ends of said coil, said neon tube being constructed to glow only in response to the impression on its electrodes of a voltage above a predetermined value.

4. In a sound translating device, the combination of an electron discharge amplifier having an input circuit and an output circuit including a transformer having at least three secondary windings, a glow discharge device connected across one of said windings, a recording device, a circuit including a first switch arranged to connect said recording device to a second one of said windings, a sound translating device, a circuit including a second switch arranged to connect said translating device to the third of said windings and means for opening said first switch and closing said second switch substantially simultaneously.

5. In a sound translating device, the combination of an amplifying device having a plurality of stages connected in cascade, an acoustic translating device, a recording device, a reproducing device, electrical circuit connections comprising a plurality of movable switch blades arranged to selectively connect said reproducing device to the input of one of said amplifying stages other than the first and said acoustic device to the output of the last amplifying stage whereby the acoustic device generates the reproduced sound waves; or to connect said recording device to the output circuit of the last amplifying stage and said acoustic device to the input of the first amplifying stage whereby to record sounds impressed on the acoustic device, and a common control means for said switch blades to cause the switch over from recording to reproducing and the switch over from reproducing to recording each to be completely effected instantaneously and at a single operation.

6. In a sound translating device, the combination of an amplifying device having a plurality of stages connected in cascade, an acoustic translating device, a recording device, a reproducing device, and electrical circuit connections comprising a plurality of movable switch blades ar-

ranged to selectively connect said reproducing device to the input of one of said amplifying stages other than the first and said acoustic device to the output of the last amplifying stage whereby the acoustic device generates the reproduced sound waves; or to connect said recording device to the output circuit of the last amplifying stage and said acoustic device to the input of the first amplifying stage whereby to record sounds impressed on the acoustic device and a glow tube continually connected to the output of the last amplifying stage, said glow tube being arranged to limit the current variations in the output of the last amplifying stage to a predetermined maximum value.

7. In a sound translating device, in combination, an electron discharge amplifier device having a plurality of stages connected together in cascade, a source of currents of audio frequency connected to the input of the first stage, a record, means for rotating the record, a recording device having a stylus in engagement with the record, a circuit coupling said recording device to the output of the last amplifying stage, a glow discharge tube coupled to the output of the last amplifying stage, and an adjustable volume control device connected to one of the amplifying stages and adapted to increase the amplitude of the current in the last stage to a level at which the said discharge tube commences to glow faintly.

8. In a sound translating device, in combination, an electron discharge tube amplifier device having a plurality of stages connected together in cascade, a source of currents of audio frequency connected to the input of the first stage, a record, means for rotating the record, a re-

5 cording device having a stylus in engagement with the record, a glow discharge tube having a pair of spaced electrodes, a circuit connecting the terminals of the recording device and the electrodes of the glow tube in parallel and means coupling said circuit to the output of the last amplifying stage, said glow tube being arranged to glow in response to an increase in the output current of the last stage to a predetermined value.

10 9. A sound translating device as claimed in claim 8 in which the coupling means comprises an auto-transformer having a coil disposed in the output circuit of the last amplifying stage.

15 10. A sound translating device as claimed in claim 8 in which the coupling means comprises an auto-transformer having a coil disposed in the output circuit of the last amplifying stage and a condenser having one side thereof connected to the high potential point on said transformer coil.

20 11. In a sound translating device, in combination, an electron discharge tube amplifier device having a plurality of stages connected together in cascade, a source of currents of audio frequency connected to the input of the first stage, an electro-dynamic loud speaker having its voice coil coupled to the output of the last stage and control means comprising a glow discharge tube having at least two spaced apart electrodes coupled to the output of the last stage, said discharge tube being arranged to glow and limit the current in the voice coil to a desired value in response to an increase in the output current of the last stage to a predetermined value.

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