

Sept. 5, 1950

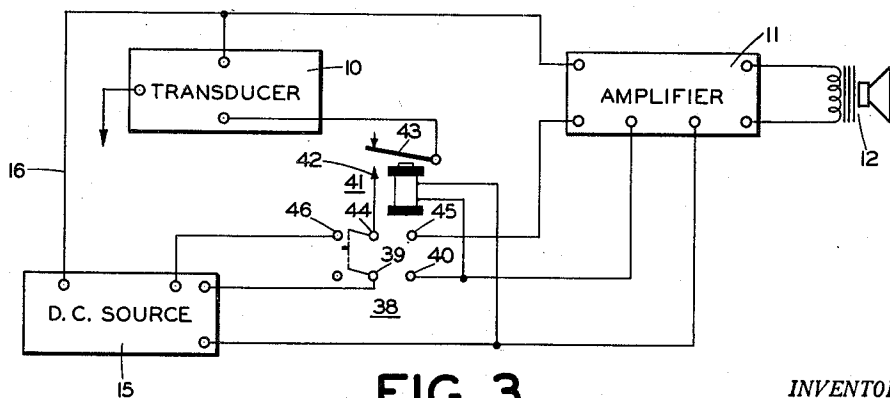
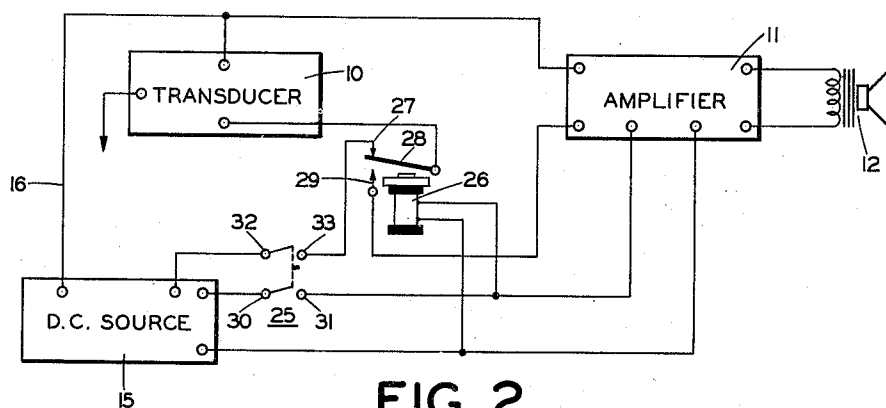
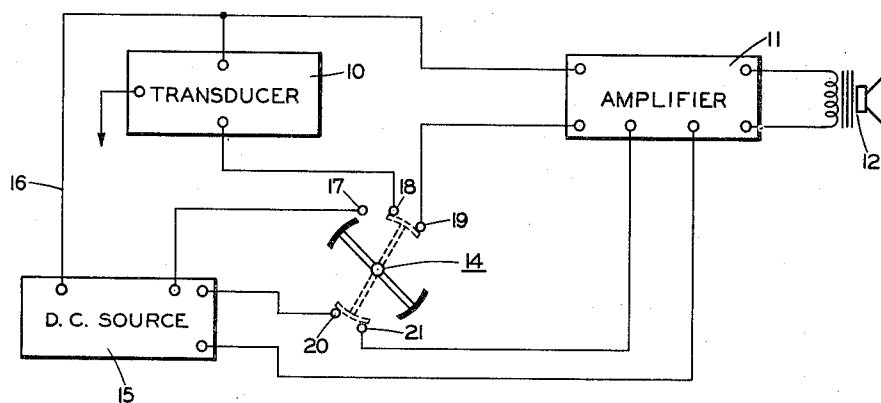
S. J. BEGUN

2,521,329

REPOLARIZED TRANSDUCER SYSTEM

Filed Aug. 15, 1947

2 Sheets-Sheet 1



INVENTOR.
SEMI JOSEPH BEGUN
BY *Harold Page*
ATTORNEY

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2 Sheets-Sheet 2

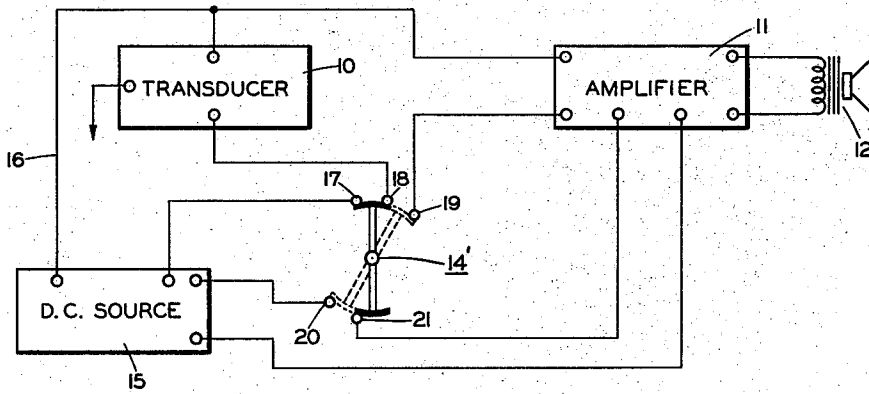


FIG. 4

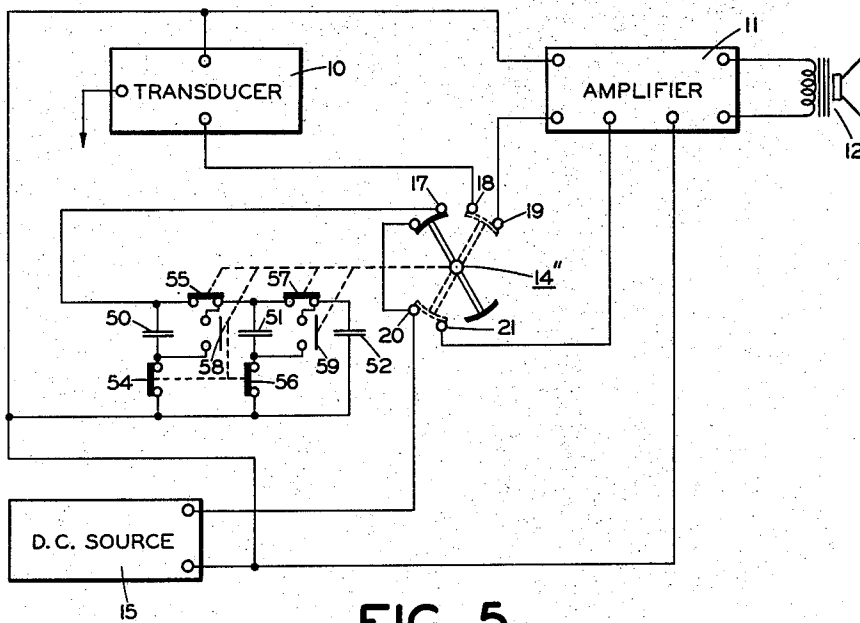


FIG. 5

INVENTOR.
SEMI JOSEPH BEGUN
BY *Samuel Page*
ATTORNEY

UNITED STATES PATENT OFFICE

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REPOLARIZED TRANSDUCER SYSTEM

Semi J. Begun, Cleveland Heights, Ohio, assignor
to The Brush Development Company, Cleve-
land, Ohio, a corporation of Ohio

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10 Claims. (Cl. 179—100.1)

1

This invention relates to a transducer system which comprises an electro-mechanical actuating element which is adapted to be polarized by the application of a high unidirectional voltage thereto and which retains the polarization for some time in normal operation in the absence of this voltage. While the invention is of general utility, it is of particular use where an actuating element comprising barium titanate and a small amount of strontium is used.

It has been found that certain ceramic materials can be utilized to provide an operating element for an electro-mechanical transducer which is generally similar to that of a piezoelectric operating element. Arrangements of this type are described and claimed in applications for United States Letters Patent Serial Numbers 740,460, filed April 9, 1947, and 740,461, filed April 9, 1947, now Patent Number 2,484,950, granted October 18, 1949, in the name of Hans Jaffe and assigned to the same assignee as the present application. In each embodiment specifically disclosed in these copending applications, a high unidirectional polarizing voltage is applied to the ceramic material during operation in order to cause the ceramic material to operate as a transducer element similar to a piezoelectric operating element. However, certain ceramic materials have the property of remaining polarized after a voltage has been applied thereto and thus, in operation, do not require a unidirectional operating voltage to be continuously applied. Such materials are said to have a "remanence" in that they retain their polarization and this effect is apparent from the fact that, when such materials are polarized, they have the property of responding substantially linearly to mechanical or electrical effects transduced thereby. However, all materials which are capable of this linear type of operation after being polarized by a high unidirectional voltage do not permanently retain this characteristic or, at least if the characteristic is retained, it is not retained in the degree in which it was present immediately after the high voltage was applied to the material. In many installations, it is, of course, undesirable to have a high unidirectional voltage applied to the operating element while it is in operation.

It is an object of this invention to provide an improved electro-mechanical transducer system.

2

It is still a further object of the invention to provide an electro-mechanical transducer system which is not subject to one or more of the disadvantages of prior-art systems mentioned above.

It is a still further object of the invention to provide a transducer system utilizing an element which is adapted to be polarized by the application of a high unidirectional voltage thereto but which, in operation, does not require any polarizing voltage to be present.

In accordance with the invention, a transducer system comprises an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by the application of a high unidirectional voltage thereto and which retains this polarization during a substantial period of normal operation in the absence of the polarizing voltage. Electrical amplifying means are provided which are operatively connected to the transducer when the system is in condition for service. The system also includes an off-on switch for the amplifying means to perform the operation of placing the system in a condition for service or to perform the operation of de-energizing the system. Means are also provided which are responsive to the operation of this switch to perform one of the above-mentioned operations for applying a high unidirectional polarizing voltage to the dielectric material while the system is not in a condition for service and for disconnecting the high unidirectional voltage from the dielectric material while the system is in a condition for service.

In accordance with another related feature of the invention, a transducer system comprises a similar electro-mechanically responsive element of dielectric material, and also apparatus for operative electrical connection in circuit with this transducer element when the system is in a condition for service. The system similarly includes an on-off switch for this apparatus. The transducer further comprises means for supplying a unidirectional voltage, and means are included responsive to the actuation of the on-off switch for applying to the dielectric material a high uni-directional polarizing voltage derived from the means for supplying a uni-directional voltage.

For a better understanding of the present in-

3

vention together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Referring now to the drawings, Fig. 1 illustrates an embodiment of the present invention in which all of the connections are made by a manually operated switch; Figs. 2 and 3, respectively, illustrate different modifications of the invention in which a time-delay relay is utilized and Figs. 4 and 5, respectively, represent further modifications utilizing manually operated switches.

Referring now to Fig. 1 of the drawings, the transducer system there illustrated comprises an electro-mechanical transducer 10 which may be of any of the types disclosed in the above-identified Jaffe applications but which includes an electro-mechanically responsive actuating element of a dielectric material adapted to be polarized by the application of a high unidirectional voltage thereto and which retains this polarization for a substantial period of time in normal operation in the absence of this voltage. Any of the actuating elements disclosed in the copending Jaffe applications which have this feature of retentivity or remanence as to polarization are suitable.

The system of Fig. 1 also includes an electrical amplifying means 11 which is operatively connected between the transducer 10 and a sound-translating device 12 when the transducer system is in condition for service. The sound-translating device 12 may be a microphone, in which case the signals amplified by the amplifier 11 are thereafter applied to transducer 10. In the case under consideration, the output of the transducer 10 comprises a mechanical vibratory motion as indicated by the arrow at the left of the transducer element 10 and this motion could be used, for example, to drive a loudspeaker to produce audible sounds. On the other hand, the sound-translating element 12 may be a loudspeaker and, in such a case, vibratory motion is applied to the arrow at the left of the transducer element 10 as would be the case if this arrow represented the needle of a phonograph. In the case now under consideration, the signal output of the transducer 10 is amplified in amplifier 11 and reproduced by the loudspeaker 12.

The system of Fig. 1 includes a manually operated off-on switch 14 for the amplifying means 11 to perform the operation of placing the system in condition for service or to perform the operation of de-energizing the system. Thus, in order to place the system in a condition for service suitable voltages from a D. C. source 15 are applied through switch 14 to the amplifier 11 and the transducer 10 is also connected to the amplifier 11 through the switch 14.

The system of Fig. 1 also comprises means responsive to one of the operations of placing the transducer system into, or out of, operation for applying a high unidirectional polarizing voltage to the dielectric material of transducer 10 only for a short interval of time while at least one of the above-mentioned operations is being performed. Thus the polarizing voltage is applied from the source 15 to transducer 10 through the conductor 16 and the switch contacts 17 and 18. The off position of the switch is illustrated in full lines in the drawing and the on-position thereof is illustrated by the dotted lines. It will be seen

4

that, when the switch is in the on-position, the transducer element 10 is connected to the amplifier 11 through the switch contacts 18, 19. Also when the switch is in the on-position, it will be seen that D. C. operating voltages are applied from source 15 to the amplifier 11 through the switch contacts 20, 21. When the switch is returned to the off position, the switch points 18, 19 are opened, as are also the switch points 20 and 21, thus performing the operation of de-energizing the system. However, it will be seen that, when the switch is in a position intermediate the on and off position, the switch contacts 17 and 18 are closed. Under these conditions a high unidirectional polarizing voltage is applied to the transducer 10. Thus in the operation of the circuit of Fig. 1, a repolarizing voltage is applied to the actuating element of the transducer 10 during the operation of placing the system in a condition for service. It will furthermore be seen that a repolarizing potential is applied to the actuating element when the switch is operated to its off position to perform the operation of de-energizing the system.

The system of Fig. 2 is generally similar to that of Fig. 1 and similar elements are designated by identical reference numerals. In Fig. 2, the switch 14 of Fig. 1 has been replaced by the combination of a double-pole single-throw switch 25 and a time-delay relay 26, which has normally closed contacts 27, 28 and normally open contacts 28, 29. The circuit of Fig. 2 is such that the amplifier 11 is energized from the source 15 through the switch points 30, 31 of the switch 25 and is also such that the operating winding of relay 26 is energized at the same time that the amplifier 11 is energized. The circuit of Fig. 2 also is such that a high unidirectional voltage can be applied to the operating element of transducer 10 through the contacts 32, 33 of switch 25 and the contacts 27, 28 of relay 26. One side of transducer element 10 is connected to the movable contact 28 of relay 25 in order that the transducer 10 can be operatively connected to the amplifier 11 through the relay contacts 28, 29. The relay 26 is of the delayed-operating type such that there is an appreciable delay in the movement of the movable contact 28 after the winding 26 has been energized.

In considering the operation of the circuit of Fig. 2 it will be seen that, upon the closing of the off-on switch 25, a high unidirectional repolarizing voltage is applied, through switch contacts 32, 33 and relay contacts 27, 28, to the actuating element of transducer 10. Also at the time the switch 25 is closed, D. C. operating voltages are applied to the amplifier 11. It will be seen that the winding of relay 26 is energized at the same time that D. C. operating voltages are applied to amplifier 11. However, because of the fact that a time delay is involved in the operation of the relay, the repolarizing voltage through relay contacts 27 and 28 remains applied to transducer 10 for an appreciable period. This period may be of the order of a major fraction of a second. After the relay picks up and relay contacts 27 and 28 are broken, the relay contacts 28 and 29 are made and transducer 10 is operatively connected to the amplifier 11. As pointed out in connection with the description of Fig. 1, the unit 12 may be either a microphone or a loudspeaker.

The system of Fig. 3 is also generally similar to those of Figs. 1 and 2 and similar elements are identified by identical reference numerals. However, the system of Fig. 3 differs from the

5

preceding embodiments of the invention in that, in the Fig. 3 embodiment, the actuating element of transducer 10 is only repolarized when the off-on switch of the system is actuated from its on position to its off position. In order to effectuate this result a double-pole, double-throw switch 38 is provided and D. C. operating voltages are applied to amplifier 11 through switch points 39 and 40. A relay 41 is also energized at the same time that the amplifier 11 is energized and this relay has a set of normally open contacts 42, 43 and is constructed to have an appreciable time delay in opening its contact when the operating winding of the relay is de-energized. The switch 38 is so connected that when switch points 44, 45 are connected at the same time and by the same throw as switch points 39 and 40 are connected, the transducer 10 is operatively connected to the amplifier 11 through the relay contacts 42 and 43 and through the switch points 44 and 45. However, when the switch is thrown to its off position thereby closing contact points 44, 46, the circuit is such that a high unidirectional voltage is applied through switch contacts 44, 46 and relay contacts 42, 43, to transducer element 10. This high unidirectional voltage remains applied to transducer element 10 until the movable armature 43 of relay 41 drops out after an appreciable time delay which may, for example, be on the order of 1 second. It is characteristic of the Fig. 3 embodiment of the invention that the transducer 10 receives no polarizing voltages after the system is de-energized, even though the switch 38 may be operated to place the system in operation. Therefore, this embodiment may be less satisfactory than those of Figs. 1 and 2 when the system may not be operated for long periods of time during which all of the polarization of the transducer 10 is lost.

The arrangement of Fig. 4 is generally similar to that of Fig. 1 and similar circuit elements have identical reference numerals while analogous circuit elements have identical reference numerals primed. The system of Fig. 4 differs from that of Fig. 1 only in that the switch involved is such that the polarizing voltage from the D. C. source 15 is always applied to the transducer 10 when the amplifier 11 is not energized. Thus the switch 14' of Fig. 4 is such that contact points 17, 18 are bridged when the switch is in the off position. The operation of the Fig. 4 arrangement is otherwise as described above in connection with Fig. 1.

In Fig. 5 there is illustrated an embodiment of the invention in which the polarizing voltage for transducer 10 is derived from the low voltage D. C. source 15 which is utilized to energize the amplifier 11. In order to accomplish this result, condensers 50, 51 and 52 are charged in parallel across the D. C. source 15 and thereafter coupled in series to provide a polarizing source for transducer 10. In order to make these connections switches 54, 55, 56, and 57 are connected as shown in the condenser circuits are uncontrolled with the operating on-off switch 14'' in such a manner that the switches are closed when the switch 14'' is in the off-position but are open in all other positions of switch 14''. Also, normally open-switches 58 and 59 are uni-controlled with switch 14'' so that they are closed when the switch contact points 17, 18 of the on-off switch 14'' are opened, and vice versa.

In considering the operation of the Fig. 5 arrangement, it will be seen that, in the off-posi-

6

tion of switch 14'' which is illustrated, the condensers 50, 51 and 52 are in parallel across the D. C. source 15. Also it will be seen that when the on-off switch 14'' is operated to place the system into operation, the condensers 50, 51 and 52 are connected in series across the transducer 10 during the interval that switch contact points 17, 18 are closed. The high voltage which is available due to the series connection of condensers 50, 51 and 52 is thus utilized to polarize the transducing material of transducer element 10. The operation of the system of Fig. 5 is otherwise the same as described in connection with Fig. 1 and will not be repeated.

It will be seen from the embodiments of the invention described above that the repolarizing contemplated by the invention can take place either as the system is being placed into operation or as the system is being taken out of service. Also as illustrated by the Fig. 1 embodiment of the invention, a repolarizing can be effectuated during each of these operations.

While there have been described what are presently considered to be the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim as my invention:

1. A transducer system comprising, an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by the application of a high unidirectional voltage thereto and which retains said polarization during a substantial period of normal operation in the absence of said voltage, electrical amplifying means operatively connected to said transducer when said system is in condition for service, an on-off switch for said amplifying means to perform the operation of placing said system in a condition for service or to perform the operation of de-energizing said system, and means responsive to the actuation of said switch to perform one of said operations for applying a high uni-directional polarizing voltage to said dielectric material while said system is not in a condition for service and for disconnecting said high uni-directional voltage from said dielectric material while said system is in a condition for service.

2. A transducer system comprising, an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by the application of a high uni-directional voltage thereto and which retains said polarization during a substantial period of normal operation in the absence of said voltage, electrical amplifying means effectively connected to said transducer when said system is in condition for service, an on-off switch for said amplifying means to perform the operation of placing said system in a condition for service or to perform the operation of de-energizing said system, and means responsive to the actuation of said switch to perform one of said operations for applying a high uni-directional polarizing potential to said dielectric material only for a short interval of time while said one of said operations is being performed.

3. A transducer system comprising, an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by

the application of a high uni-directional voltage thereto and which retains said polarization during a substantial period of normal operation in the absence of said voltage, electrical amplifying means operatively connected to said transducer when said system is in condition for service, an on-off switch for said amplifying means to perform the operation of placing said system in a condition for service or to perform the operation of de-energizing said system, and means responsive to the actuation of said switch to perform said operation of placing said system in condition for service for applying a high uni-directional polarizing voltage to said dielectric material only for a short interval of time while said last-mentioned operation is being performed.

4. A transducer system comprising, an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by the application of a high uni-directional voltage thereto and which retains said polarization during a substantial period of normal operation in the absence of said voltage, electrical amplifying means operatively connected to said transducer when said system is in condition for service, an on-off switch for said amplifying means to perform the operation of placing said system in a condition for service or to perform the operation of de-energizing said system, and means responsive to the actuation of said switch to perform said operation of de-energizing said amplifier for applying high uni-directional polarizing voltage to said dielectric material only for a short time while said operation of de-energizing said amplifier is being performed.

5. A transducer system comprising, an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by the application of a high uni-directional voltage thereto and which retains said polarization during a substantial period of normal operation in the absence of said voltage, electrical amplifying means operatively connected to said transducer when said system is in condition for service, an on-off switch for said amplifying means to perform the operation of placing said system in a condition for service or to perform the operation of de-energizing said system, a relay having a normally closed contact which opens after a time delay when the relay is energized, means dependent upon the actuation of said on-off switch to perform the operation of placing said system in a condition for service for energizing said relay, and means for applying to said dielectric material through said normally closed contact of said relay a high uni-directional polarizing voltage only for the short period of time involved in the time delay action of said relay.

6. A transducer system comprising, an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by the application of a high uni-directional voltage thereto and which retains said polarization during a substantial period of normal operation in the absence of said voltage, electrical amplifying means operatively connected to said transducer when said system is in condition for service, an on-off switch for said amplifying means to perform the operation of placing said system in a condition for service or to perform the operation of de-energizing said system, a relay having a normally closed contact and a normally open contact each of which are actuated after a time delay when the relay is energized, means dependent upon the actuation of said

switch to perform the operation of placing said system in a condition for service for energizing said relay, means for applying to said dielectric material through said normally closed contact of said relay a high uni-directional polarizing voltage only for the short period of time involved in the time delay action of said relay, and means connecting said normally open contact of said relay in the circuit which operatively connects said amplifying means to said transducer.

7. A transducer system comprising: an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by the application of a high uni-directional voltage thereto and which retains said polarization during a substantial period of normal operation and in the absence of said voltage; electrical amplifying means; a relay having a normally open contact which is opened after a time delay when the relay is de-energized; a double-throw switch; means dependent upon one throw of said switch for energizing said amplifier and said relay and for operatively connecting said electro-mechanically responsive element to said amplifier through said normally open contact of said relay; and means dependent upon the other throw of said switch for de-energizing said system and for applying a high uni-directional polarizing voltage to said dielectric material through said normally open contact of said relay only for a short period of time while said system is being de-energized.

8. A transducer system comprising, an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by the application of a high uni-directional voltage thereto and which retains said polarization during a substantial period of normal operation in the absence of said voltage, electrical amplifying means effectively connected to said transducer when said system is in condition for service, an on-off switch for said amplifying means to perform the operation of placing said system in a condition for service or to perform the operation of de-energizing said system, a plurality of condensers which are charged in parallel to provide a uni-directional source of potential, and means responsive to one of said operations for connecting said condensers in series across said dielectric material to apply a high uni-directional polarizing voltage to said material.

9. A transducer system comprising: an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by the application of a high uni-directional voltage thereto and which retains said polarization during a substantial period of normal operation in the absence of said voltage; electrical amplifying means, including means for supplying a uni-directional voltage for use in the amplifying circuits of said amplifying means, operatively connected to said transducer element when said system is in a condition for service; an on-off switch for said amplifying means to perform the operation of placing said system in a condition for service or to perform the operation of de-energizing said system; and means responsive to the actuation of said switch to perform one of said operations for applying to said dielectric material a high uni-directional polarizing voltage, derived from said means for supplying a uni-directional voltage, while said system is not in a condition for service and for disconnecting said high uni-directional voltage from said dielectric ma-

material while said system is in a condition for service.

10. A transducer system comprising: an electro-mechanically responsive element which includes a dielectric material adapted to be polarized by the application of a high uni-directional voltage thereto and which retains said polarization during a substantial period of normal operation in the absence of said voltage; apparatus for operative electrical connection in circuit with said transducer element when said system is in a condition for service; means for supplying a uni-directional voltage; an on-off switch for said apparatus to perform the operation of placing said system in a condition for service or to perform the operation of de-energizing said system; and means responsive to the actuation of said switch to perform one of said operations for applying to said dielectric material a high uni-

directional polarizing voltage, derived from said means for supplying a uni-directional voltage, while said system is not in a condition for service and for disconnecting said high uni-directional voltage from said dielectric material while said system is in a condition for service.

SEMI J. BEGUN.

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- 10 The following references are of record in the file of this patent:

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15 2,402,515	Wainer	June 18, 1946

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