May 25, 1965 R. J. HAMMOND 3,185,968

ELECTRICAL SIGNAL DELAY APPARATUS

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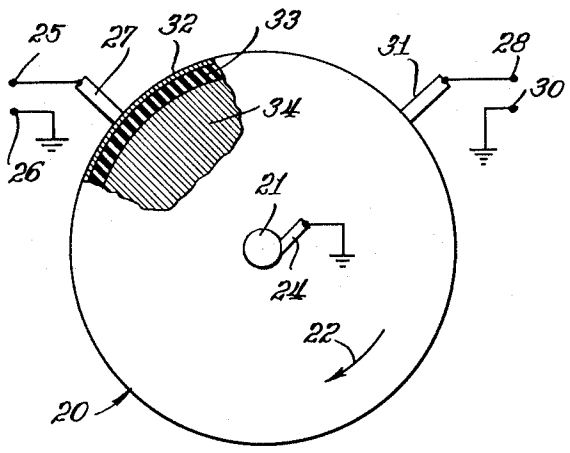


Fig. 1.

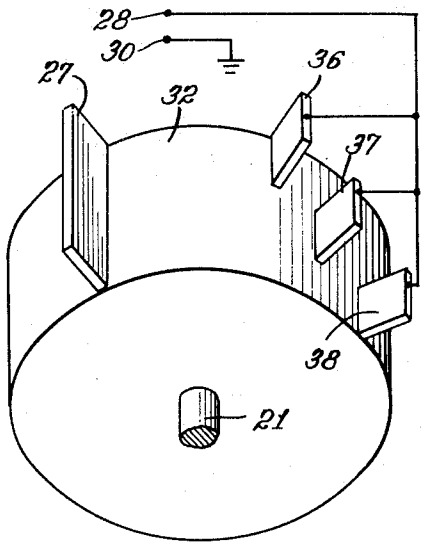


Fig. 2

Fig. 4a.

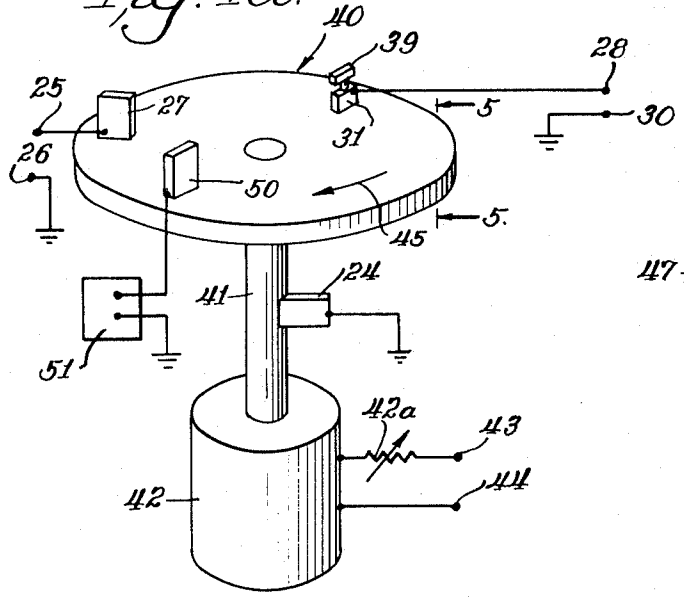
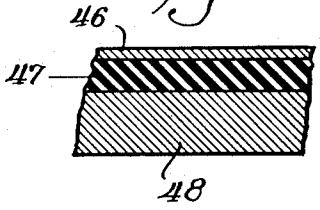


Fig. 4B.



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Fig. 3

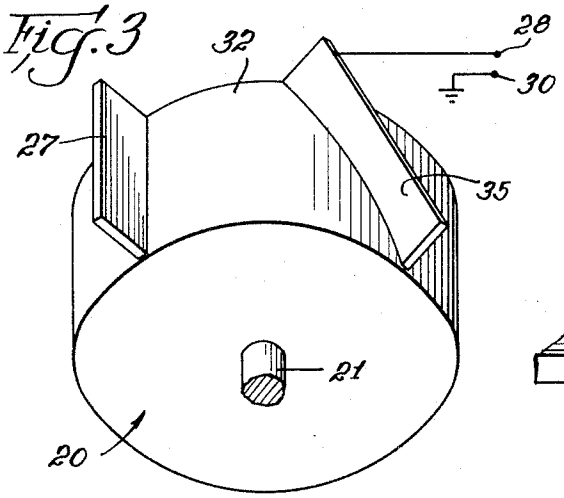


Fig. 5

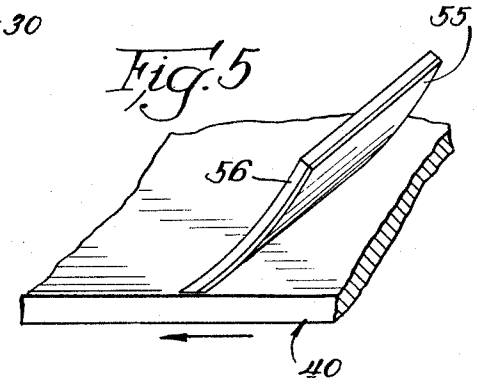


Fig. 6a.

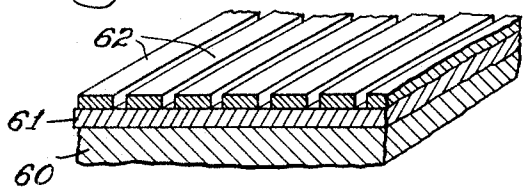


Fig. 6B.

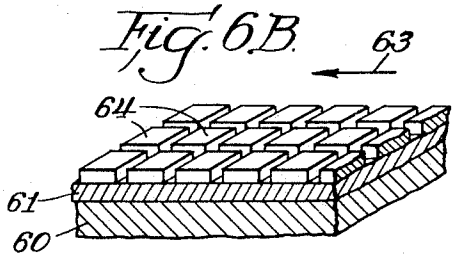


Fig. 6C.

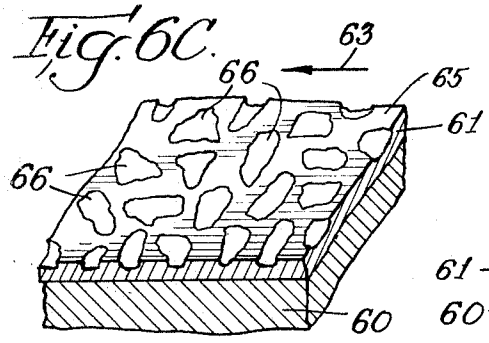
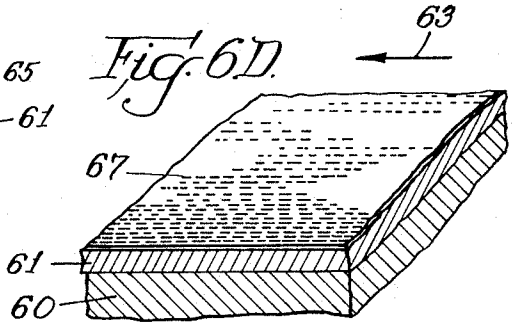


Fig. 6D.



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Fig. 7

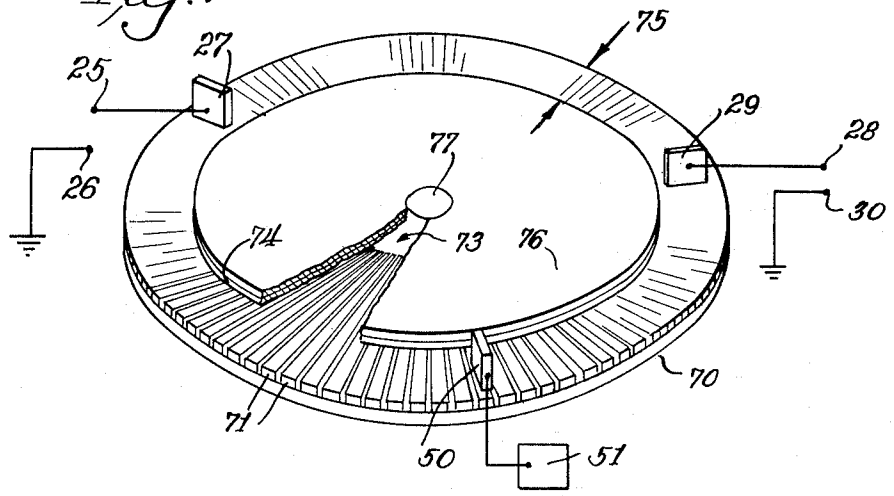


Fig. 8

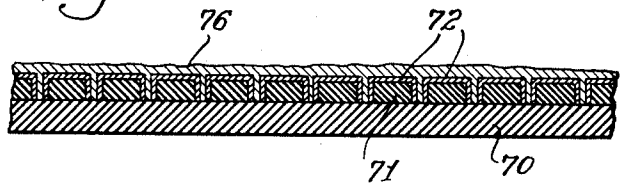
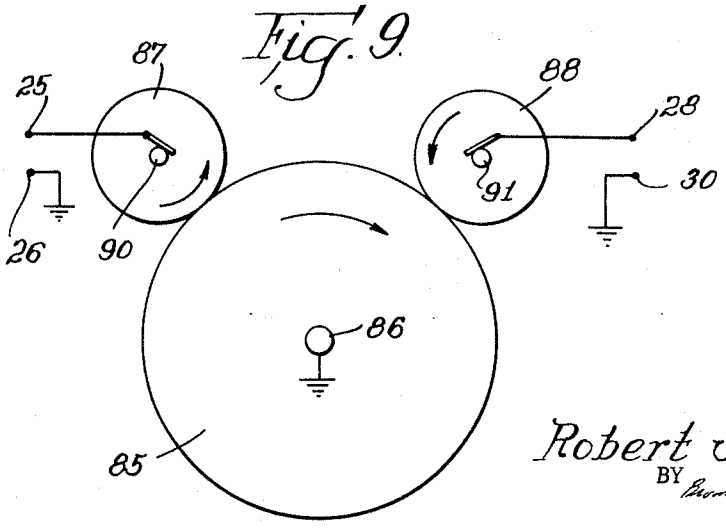


Fig. 9



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ELECTRICAL SIGNAL DELAY APPARATUS

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Filed Apr. 9, 1962, Ser. No. 185,963
23 Claims. (Cl. 340—173)

This invention is directed to electrical signal delay means, and more particularly to such apparatus in which electrical signal information is efficiently stored on a moving medium for removal at a predetermined subsequent time.

Various forms of signal delay devices have been known heretofore, and the use thereof for the purpose of providing reverberation in audio systems is well known. One such device comprises a base, such as a disc or a drum, which is moved at a constant speed past a reference input point and subsequently past a reference output point. A dielectric substance is affixed to the outer portion of the disc or drum, and a varying electrical input signal applied at the input point is effective to transfer a charge to the dielectric outside surface of the composite storage member. As the area of the storage member carrying the deposited charge subsequently moves past the reference output point, the charge level is sensed by a brush or other detector means to provide an output electrical signal, which is delayed in time relative to the input signal by a time interval related both to the distance of displacement between the input and output points, and to the speed of movement of the storage member.

Although such system has been used to provide reverberation effects, the equipment has not proved to be entirely satisfactory. One problem in such arrangement, for example, is the excessive wear which the input means or brush causes in its direct and continuous engagement with the rather thin dielectric layer. Further, an electrode placed in close proximity with the dielectric presents difficult mechanical tolerances. If, as in some systems, an electron stream is controlled to impinge on the dielectric surface to reduce the wear, the equipment becomes unreasonably costly for many applications.

It has been further found that in a system in which the charge representing the input signal is only deposited on the surface of the dielectric, irregularities in the outer portion of the dielectric surface effect disturbances in the charge distribution. In a similar manner, extraneous electric fields, water ions in the atmosphere, and other like external conditions can and will act upon the charge. Attempts to overcome these shortcomings by driving the charge into the dielectric unfortunately increases the problems of erasing or removing the information.

It is therefore a primary object of the present invention to provide an improved signal storage apparatus which obviates the difficulties posed with prior art devices utilizing dielectric material on the outer portion of the storage member.

An important object of the invention is the provision of such an apparatus which lends itself to utilization as a delay device.

A more specific object of the invention is the provision of such a signal storage apparatus which includes a conductive surface on the storage member, and effects signal storage by modulating the electrical charge in the adjacent portion of the conductive surface.

The foregoing and other objects are realized, in one embodiment of the invention, by utilizing a rotating drum or disc which moves at a uniform velocity and which comprises a layered device including a conductive base member, a dielectric layer on the base member, and a conductive layer on the dielectric layer. Each incremental portion of the outer conductive layer, dielectric layer and

conductive base member acts as a capacitor unit. The input signal information is applied by utilizing input means, such as a "write" brush, which directly engages a portion of the outer conductive layer as it passes under the brush, and modulates the electric distribution in the adjacent portion of the capacitor unit or segment. That is, the number of the many free electrons in the outer conductive layer is either increased or diminished, resulting in repulsion or attraction of the charge across the intervening dielectric to the conductive base member. After movement of the drum through a predetermined angular distance, a similar "read" brush engages such portion of the outer conductive layer, and produces an output electrical signal varying in accordance with the stored charge. An "erase" brush can be utilized, if desired, to restore the segment to a reference charge level before the next passage of the segment under the write brush.

In another embodiment of the invention, a disc-type arrangement is used with a plurality of radial bars comprising the main conductive surface. A dielectric material and a conducting layer are deposited in layered relation on the inner portion of such bars. The input signal is deposited with a write brush or electrode engaging the outer exposed portions of the bars, thereby to alter the charge in each bar. A readout electrode angularly displaced relative to said write electrode engages the outer bar ends in a similar manner to pick off the stored signal as the bar rotates from a position adjacent the write electrode to a position adjacent the readout electrode.

In one modification of such arrangement, a dielectric layer on a conductive base supports a plurality of randomly disposed conductive segments which are used as storage members for the information bits. Preferably, the segments are isolated from each other, and are of a narrow dimension in the direction of travel of the storage device.

The best mode contemplated for practicing the invention will now be described in conjunction with the embodiments depicted in the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIGURE 1 is a side schematic view, partly broken away, of an embodiment of the invention;

FIGURES 2 and 3 are partial perspective views of embodiments related to the showing of FIGURE 1;

FIGURES 4A and 4B are perspective and partial sectional views, respectively, of another embodiment of the invention;

FIGURE 5 is a partial perspective illustration useful in explaining the invention;

FIGURES 6A–6D are partial perspective views of different storage member configurations;

FIGURE 7 is a perspective showing, partly broken away, of another embodiment of the invention;

FIGURE 8 is a partial sectional view useful in understanding the embodiment of FIGURE 7; and

FIGURE 9 is a side view of another embodiment of the invention.

As shown in FIGURE 1, a drum **20** is mounted on an axle or shaft **21** for rotation in the direction indicated by the arrow **22**. Shaft **21** is coupled over a brush **24** to electrical ground potential. A pair of input terminals **25** and **26** are provided for accepting an input or write signal. Terminal **25** is coupled to a write brush **27**, which directly engages the surface of drum **20**, and input terminal **26** is grounded. Likewise, a pair of output terminals **28** and **30** are provided, with terminal **28** coupled to a read brush **31** and terminal **30** coupled to electrical ground potential.

In accordance with the inventive principles, the outer periphery of drum **20** includes a conductive layer **32** spaced by a layer of insulation **33** from an inner conduc-

tive portion 34 of the drum. The cylindrical drum may be solid, in which case the conductive inner portion 34 extends to center shaft 21, or the drum may be hollow, in which instance the conductive area 34 is only a narrow conductive area adjacent insulation 33. Likewise, the insulation need not be continuous, but air can be provided as the dielectric between the conductive layers 32 and 34, with only intermittent insulating posts or areas to maintain the mechanical separation of the two different conducting portions. Such a construction is possible because the stored charge is confined in the outer conductive surface, where it is immune to disturbances such as normally affect devices in which the charge is stored in the dielectric layer, and the charge can readily be drawn off from the outer surface as the area carrying the charge passes under read brush 31.

The apparatus of FIGURE 2 is generally similar to that of FIGURE 1, except that the single read brush 31 is replaced by three read brushes 36, 37 and 38. Brushes 36–38 are staggered in echelon manner, being spaced laterally and circumferentially along the periphery of the drum to minimize "beating," the term "beating," the term "beating" being used to describe the known phenomenon produced by a sharply defined periodic reoccurrence of a signal with a gradually diminishing amplitude. A similar effect is achieved with a single brush skewed across the periphery of the drum, as depicted by read brush 35 in FIGURE 3. The write brush can also be skewed, or replaced by a plurality of brushes in echelon array, to minimize beating, or such modification can be applied to both the input and output brushes.

A turntable, such as used on conventional record players is also readily adapted to such use. As shown in FIGURE 4A a turntable or disc 40 is supported on one end of a shaft 41, which is coupled to a motor 42 which in turn receives energy over input terminals 43 and 44 to effect angular displacement or rotation of turntable or disc 40 in the direction indicated by arrow 45. Input and output terminals, as well as a grounding connection for shaft 41, are provided in a manner analogous to that of the embodiment depicted in FIGURE 1.

As better shown in FIGURE 4B, disc 40 includes from top to bottom a first conductive layer 46, an intermediate insulating layer 47, and a lower conductive area 48. Accordingly, as a portion of conductive area 46 passes under input or write brush 27 with the potential varying thereon, a corresponding variation in the charge distribution in the adjacent portion of layer 46 is produced. This charge variation is retained as the charged portion traverses a curvilinear path between brushes 27 and 31, at which point an electrical signal varying in accordance with the net charge on the adjacent portion of layer 46 is produced at output terminals 28 and 30.

Knob 39 affixed to read brush 31 represents means for varying the position of read brush 31 with respect to the position of write brush 27, and thus a means of regulating the extent of the signal delay. Alternatively, the extent of signal delay may be varied by providing suitable means 42A for adjusting the speed of the drive motor 42 for the disc 40 to different values. If desired, an erase brush 50 can also be provided, and coupled to a source of potential 51 to insure that the net charge on the conductive layer 46 is returned to a reference level as the conductive surface passes thereunder, prior to the next passage under write brush 27.

The brushes can be constructed of any suitable conductive material consistent with the requirements of affording a uniform contact area and exhibiting low friction properties. Referring to FIGURE 5, the brush may comprise a conductive portion 55, constituted by relatively thin conductive coating, and supported from a nonconductive backing layer 56 of material having a low coefficient of friction upon engagement with the surface of disc 40. The backing material should have suitable stiffness and wear properties, such as can be provided with a thin nylon backing layer. The conductive layer 55 can be provided on the nylon by affixing a film of conductive molybdenum disulfide thereto.

Although the term "surface" has been used herein to describe the continuous outer conductive portion of the storage member, it is also possible to utilize a plurality of separate conductive areas or strips, placed close together but electrically insulated from each other, which give the same effect. Accordingly the term "surface," as used in the appended claims, is considered to describe not only to a continuous physical area but a plurality of individual areas.

Examples of several other different types of conductive surfaces are set forth in FIGURES 6A–6B. In FIGURE 6A there is shown an inner conductive support layer 60, an intermediate dielectric layer 61, and an outer conductive surface comprised of a plurality of individual bar or strip conductors 62. The direction of movement of the conductors is indicated by arrow 63. Conductors 62 must be short in the direction of motion, and can be subdivided in the other direction to provide a plurality of individual conductive areas 64 as depicted in FIGURE 6B. In each of the surface configurations of FIGURES 6A and 6B, the dimension of each conductive area in the direction of surface movement is small as compared to the shortest signal wave length desired to be stored, and each conductive area is insulated from the adjacent conductive areas.

Alternatively, a dielectric, such as that indicated by numeral 65 in FIGURE 6C, can be provided, in which the dielectric itself defines a plurality of irregular apertures or cavities. These cavities can be filled with a plurality of individual conductive segments 66, for example, by mechanically placing them therein or by wiping a conductive liquid over the periphery of the dielectric material and thus filling the cavities.

In still other embodiments randomly disposed conductive areas are provided on the surface of the dielectric layer by applying a conductive layer over the dielectric by painting, plating, evaporating, bonding foil, or some other similar process, and dividing the conductive material into small areas by photo etching, cutting, shrinking, or other similar methods. Alternatively small random or planned conductive areas may be applied for support by the dielectric layer by a silk screen process, printing, sputtering, mechanical placement and the like. If desired, insulating material may be deposited or placed between the randomly disposed conductive areas, and the resultant apparatus will have the appearance of the member shown in FIGURE 6C.

In yet another embodiment, shown in FIGURE 6D, a layer of conductive liquid 67 can be directly applied to the dielectric to provide a very thin conductive coating on the outer periphery of the arcuate member.

The several embodiments illustrated above provide a rugged, wear resistant and low friction apparatus which exhibits considerable freedom from static charges due to brush friction, and exhibits a much longer life than has been possible with prior art devices. In accordance with the important characteristics set forth above, the thin conductive surface, such as that in FIGURE 6D and the embodiments of the other figures as well, may be any homogeneous conductive surface material in the form of a thin film. With such a film, the resistance from the brush contact area to the dielectric surface is much lower, because of the thinness of the film, than is the resistance across a portion of the surface of the film in the direction of surface movement. One such film, for example, may be a conductive molybdenum disulfide film, although many other forms of commercially available conductive materials which may be used will be readily apparent to parties skilled in the art.

The drum, discs or other arcuate plate, for example, could be constructed of, or coated with, aluminum with an anodized surface in contact with a suitably dispersed electrolyte contacting the conductive surface to thus pro-

vide a structure with a higher electrical capacity than could be realized with copper.

In another embodiment, shown in FIGURE 7, a non-conducting circular base **70** supports a plurality of radial bars **71**, each of which extends from an outer point adjacent the circumference of base **70** to an inner point, spaced from the center post **77** by a distance referenced by numeral **73**. A thin layer of dielectric material **74** (which may be aluminum oxide or the like) is deposited on top of bars **71** from the center post outwardly to a point spaced from the periphery of base **70** to thereby leave the extremities of bars **71** exposed for a radial distance indicated by numeral **75**.

A common conductor **76** which may be a conductive coating is applied to the dielectric **74**. Write brush **27** is positioned to contact the extremities of the bars along the exposed terminal portions. The read brush **29** may include a small conductor or conductive area angularly disposed relative to the write brush **27** and positioned in engagement with the extremities of the bars **71**, as shown in FIGURE 7.

As angular displacement of base **70** and bars **71** is effected, a charge is deposited in the outer portions of the bars passing under write brush **27**. As each charged bar passes under read brush **29**, the charged bar and conductor **76**, together with the portion of dielectric **74** therebetween, functions as an electrical capacitor, and the stored information is thus translated over brush **29** and appears as an electrical signal at output terminals **28** and **30**.

The bars **71** and base **70** can readily be provided by photoetching an aluminum clad printed circuit board. The layer of dielectric material **74** can be an anodized film on the aluminum and the surface conductor can be a conductive coating **76** of a material such as "Electro-Lube," or a suitable electrolyte and conductor which can be provided in accordance with well known principles of electrolytic capacitor fabrication. Such a construction is shown in FIGURE 8, wherein board **70** supports bars **71**, over which the anodized film **72** (or aluminum oxide) and surface conductive layer **76** are applied. In one embodiment approximately 1440 radial bars are provided on a 12-inch disc which rotates at approximately 1800 r.p.m.

Yet another embodiment is shown in FIGURE 9, wherein a storage member or drum **85** having a grounded shaft **86** is engaged by a write wheel **87** and a read wheel **88**. The diameter of each wheel is small, compared to the diameter of drum **85**, and the wheels can be of conductive rubber. Such a construction reduces the wear problem where a thin conductive coating is used on a dielectric, for example, as shown in FIGURE 6D. The various species of conductive layers described heretofore may also be used in the present embodiment.

Other embodiments will no doubt be suggested to those skilled in the art, once the important concept of applying the charge directly to a conductive storage area is appreciated in a configuration characterized by a conductive member exhibiting good electrical conductivity from the exposed outer surface down to the dielectric material, but very low conductivity across the outer surface in the direction of the surface movement with respect to the brushes. That is, in all of the embodiments described herein, the conductive surface which carries the charge exhibits relatively high electrical conductivity from the outer surface thereof down to the adjacent layer of dielectric material, and very low electrical conductivity in a direction corresponding to the direction of relative movement between the storage member and the write-in and read-out means. For example, assuming the write-in and read-out means are stationary and the storage member moves, the conductive surface which carries the charge exhibits very low conductivity in a direction corresponding to its direction of movement. In certain embodiments such as shown for example in FIGURE 7, the electrical conductivity in the direction of movement is negligible because the conductive surface comprises a rotatable member formed by a plurality of narrow radial bars or the like which are spaced from one another and thus in effect are electrically insulated from one another. Thus, a charge deposited on one of the conductive bars will not be conducted in the direction of movement of the storage member to an adjacent bar. In certain other embodiments the conductive surface which carries a charge is a continuous surface, as shown for example in FIGURE 1 where a continuous conductive layer **32** is provided. However, in all embodiments of the latter type the conductive layer is sufficiently thin that it will exhibit only very slight conductivity in a tangential direction or a direction along the surface, and will thus conduct appreciably only in a direction perpendicular to the surface. Accordingly, due to the fact that wherever a continuous conductive surface is provided to carry a charge, such surface will be very thin, the charge will be localized thereon to substantially the same extent as when separate spaced conductive elements are provided.

Summary

Practice of the invention provides an apparatus which operates more efficiently and at lower noise levels than do prior art devices. Erasure is simply provided by utilizing an erase brush to restore a reference conductive level. Good fidelity is realized with a low cost apparatus by providing a conductive surface which exhibits a high resistance along its circumference, so the highs are not shorted out, and also exhibits a resistance of a value less than one megohm in the radial direction, through the conductive layer down to the dielectric. The low friction attained by the various embodiments provides rugged, wear resistant operation with freedom from static charges due to brush friction.

While only particular embodiments of the invention have been described and illustrated, it is apparent that modifications and alterations may be made therein. Accordingly it is the intention in the appended claims to cover all such modifications and alterations as may fall within the true spirit and scope of the invention.

What is claimed is:

1. A signal storage arrangement comprising storage members having a first and a second electrically conductive surface separated by a dielectric, input means for engaging at least one portion of one of said surfaces including write means for modulating the electrical charge distribution on said one portion in accordance with the value of an electrical input signal, and output means including readout means operative to derive an output electrical signal related to the charge distribution at said one portion on said storage surface as said one portion and said readout means are moved into engagement with each other, said one of said conductive surfaces possessing relatively high conductivity from its exposed outer surface down to the dielectric and very low conductivity across said surface in the direction of surface movement with respect to said write-in means and read-out means.

2. A signal storage arrangement according to claim 1 which includes drive means for moving said storage member relative to said input and output means, and which further comprises means for adjusting the position of said output means relative to the position of said input means along the path of movement of said storage member.

3. A signal storage arrangement according to claim 1 which further comprises a neutralizing electrode, positioned between said output and input means for placing the layer of conductive material at a reference charge level prior to each passage adjacent the input means.

4. A signal storage arrangement as set forth in claim 1 which includes drive means for effecting relative movement of the storage member and the input and output means, and speed control means for adjusting the velocity of said relative movement.

5. A signal storage arrangement according to claim 1

in which said one electrically conductive storage surface is comprised of a coating of electrically conductive liquid.

6. A signal storage arrangement comprising a storage member having a first and a second electrically conductive surface separated by a dielectric, at least one of said conductive surfaces being comprised of a plurality of small conductive areas, electrically separated from each other, input means for engaging at least one of said smaller areas including write means for modulating the electrical charge distribution on said one area in accordance with the value of an electrical input signal, and output means including readout means operative to derive an output electrical signal related to the charge distribution on said one area as said one area and said readout means are moved into engagement with each other.

7. A signal storage arrangement as set forth in claim 6 which includes drive means for moving said areas successively into conductive relation with said write means, and thereafter into engagement with said readout means, and in which said smaller areas comprise predetermined segments disposed in an orderly predetermined pattern substantially perpendicular to the direction of movement of the storage member relative to said write means and readout means.

8. A signal storage arrangement as set forth in claim 6 in which said smaller areas comprise a plurality of conductive segments randomly disposed relative to the path of movement of the member in relation to said write and readout means.

9. A signal storage arrangement according to claim 6 in which said smaller areas are comprised of a plurality of electrically conductive, spaced-apart rectangular elements, said elements being disposed in a first plurality of rows in a given direction, each row being substantially parallel the adjacent rows, and said elements further being aligned in rows in another direction substantially parallel with the direction of movement of said storage surface.

10. A signal storage arrangement according to claim 6 in which said dielectric material defines a plurality of irregular, spaced-apart indentations on one side thereof, and in which said smaller areas are comprised of electrically conductive material disposed in said indentations in the dielectric material.

11. In a signal storage arrangement having storage means, input means over which signals are received for storage on said storage means, and output means over which signals are derived from said storage means for transmission to associated equipment, said signal storage means comprising a first electrically conductive layer, a dielectric layer, and a second electrically conductive layer, said dielectric layer being disposed between said conductive layers, and at least one of said conductive layers having a surface disposed for successive engagement with said input and output means comprised of a plurality of distinct, small conductive areas electrically separated from each other, and of small dimension in the direction of travel thereof relative to said input and output means.

12. A signal storage arrangement comprising a storage member having a first and a second electrically conductive surface separated by a dielectric, input means including write brush means having a writing surface for engaging at least one portion of one of said surfaces to modulate the electrical charge distribution on said one portion in accordance with the value of an electrical input signal, and output means for engaging said one portion on said storage surface as said one portion and said output means are moved into relative engagement with each other, including readout brush means for deriving an output signal having a value related to the charge distribution on said one portion, said one of said conductor surfaces possessing relatively high conductivity from its exposed outer surface down to the dielectric and very low conductivity across said surface in the direction of surface movement with respect to said write brush means and readout brush means.

13. A signal storage arrangement as set forth in claim 12 in which at least one of said brushes is comprised of a thin conductive film supported on a non-conductive backing of material of small friction and wear characteristics.

14. An apparatus according to claim 12 in which at least one of said brush means includes an elongated brush having one dimension greater than the width of said storage members, said elongated brush being skewed with respect to a line perpendicular to the direction of travel of said outer conductive surface to minimize beating.

15. An electromechanical signal delay arrangement comprising a dielectric member, an electrically conductive storage member having a first portion abutting one side of said dielectric member and a second portion spaced from said dielectric member, a layer of electrically conductive material disposed on the other side of said dielectric member to form a capacitor unit with said dielectric member and said storage member, input means in direct contact with said second portion of the storage member for affecting the electrical charge distribution in said storage member responsive to the application of an electrical input signal to said input means, output means disposed adjacent said second portion for providing an output electrical signal related to the electrical charge distribution on the adjacent portion of said storage member, and means for effecting relative movement between said storage member and each of said input and output means, thereby to provide a signal delay path including said input means, said storage member, and said output means, said second portion of said storage member possessing very low conductivity across its exposed outer surface in the direction of surface movement with respect to said input means and said output means.

16. A reverberation structure comprising: a non-conductive, disc-shaped base member, a first electrically conductive surface, including a plurality of spaced-apart, radially disposed conductive bars, each bar extending from a point near the center of said base member to the circumference of said base member, a layer of dielectric material disposed on the inner portion of each of said bars, leaving the outer portion of each bar exposed, a second electrically conductive surface, disposed on said dielectric material, and comprising a capacitor storage unit with said dielectric material and said bars, means for applying an electrical input signal to the exposed outer portions of said bars to correspondingly vary the charge distribution in said storage unit, and means positioned adjacent said second conductive surface for providing an electrical output signal corresponding to the charge distribution in said storage unit and delayed in time with respect to said electrical input signal.

17. In a signal storage arrangement having storage means, input means over which signals are received for storage on said storage means and output means over which signals are derived from said storage means for transmission to associated equipment, said signal storage means comprising a first electrically conductive layer, a dielectric layer, and a second electrically conductive layer, said dielectric layer being disposed between said conductive layers, and at least one of said conductive layers having a surface disposed for successive engagement with said input and said output means, said one of said conductive layers possessing relatively high conductivity from its exposed outer surface down to said dielectric layer and very low conductivity across said surface in the direction of surface movement with respect to said input means and said output means.

18. A signal storage arrangement including a rotatably supported storage member comprising an electrically conductive storage surface, a layer of dielectric material disposed contiguous to at least a portion of said storage surface, and an electrically conductive layer of material disposed on said dielectric material, whereby an electrical

capacitor is provided by said storage surface, said dielectric material, and said conductive layer, drive means for said storage member, input means for engaging said storage surface and modulating the electrical charge distribution on successive portions thereof in accordance with an electrical input signal, as the storage member is rotated by said drive means, and output means positioned adjacent said storage surface, and angularly displaced relative to said input means, to derive output electrical signals from said surface related to the charge distribution on the successive portions of said storage surface as moved adjacent thereto, said storage surface possessing relatively high conductivity from its exposed outer surface down to the dielectric material and very low conductivity across said surface in the direction of surface movement with respect to said input means and said output means.

19. A reverberation apparatus for providing a time delay between an electrical output signal as related to an electrical input signal, including a storage member comprising an electrically conductive storage surface of arcuate conformation, dielectric material disposed on at least a portion of said storage surface, an electrically conductive layer of material disposed on said dielectric material, whereby an electrical capacitor is provided by said storage surface, said dielectric material, and said conductive layer; drive means for rotatably driving said storage member, input means disposed for engagement with successive portions of the storage surface for adding to and subtracting from the number of free electrons in said successive portions of the storage surface in accordance with the characteristics of said input signal, and output means, disposed adjacent said storage surface, and angularly displaced from said input means, to derive electrical output signals as a function of the number of free electrons on the portions of said storage surface moved adjacent to said output means, said storage surface possessing relatively high conductivity from its exposed outer surface down to the dielectric material and very low conductivity across said surface in the direction of surface movement with respect to said input means and said output means.

20. An electrical signal storage apparatus comprising an electrically conductive drum member, a layer of dielectric material affixed to said drum member, an outer layer of electrically conductive material affixed to said dielectric layer, drive means for effecting rotation of said drum member, an input brush positioned in contact with said outer conductive layer, whereby the application of an electrical input signal to said input brush modulates the charge distribution in the different portions of said outer conductive layer as moved adjacent thereto, and an output brush disposed in contact with said outer conductive layer, and spaced along the circumference of said apparatus from said input brush, to produce corresponding electrical output signals responsive to the adjacent passage of the different portions of said outer conductive layer with said modulated charge distribution thereon, said outer layer of conductive material possessing relatively high conductivity from its exposed outer surface down to the dielectric material and very low conductivity across said surface in the direction of surface movement with respect to said input brush and said output brush.

21. An electrical signal storage apparatus according to claim 20 in which each of said input and output brushes is a wheel journalled for rotation, a peripheral portion of each wheel being disposed to engage the outer layer of conductive material on said drum member, the diameter of each wheel being small with respect to the diameter of said drum member.

22. An apparatus as set forth in claim 21, in which each of said wheels is comprised of electrically conductive rubber.

23. An electrical signal reverberation structure comprising an electrically conductive disc base member, a layer of dielectric material on said conductive base member, a layer of electrically conductive material disposed on said dielectric material to form a capacitor unit with said dielectric material and said conductive base member, an input electrode disposed in abutting relation with said layer of conductive material, thereby to modulate the number of free electrons in the adjacent portion of said conductive layer responsive to receipt of electrical input signals, an output electrode displaced from said input electrode and positioned in engagement with said conductive layer, for producing an output electrical signal related to said input signal in response to the modulated electron distribution in the conductive layer passing adjacent said output electrode, and drive means for effecting rotation of said disc base member, thereby to displace a given segment of the reverberation structure from said input electrode through a given angular displacement to said output electrode and provide a reverberation effect of predetermined characteristics, said layer of conductive material possessing relatively high conductivity from its exposed outer surface down to said dielectric material and very low conductivity across said surface in the direction of surface movement with respect to said input electrode and said output electrode.

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