April 27, 1954 C. W. JACOB 2,676,868

ELECTRONIC SIGNAL CONTROLLED RECORDING SYSTEM AND APPARATUS

Filed June 10, 1952

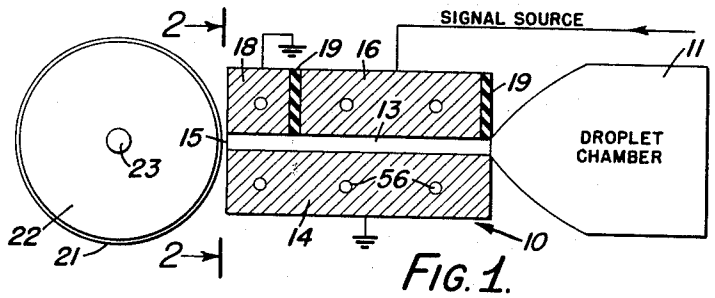

FIG. 1.

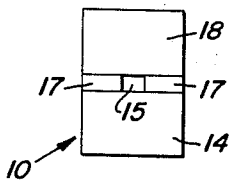

FIG. 2.

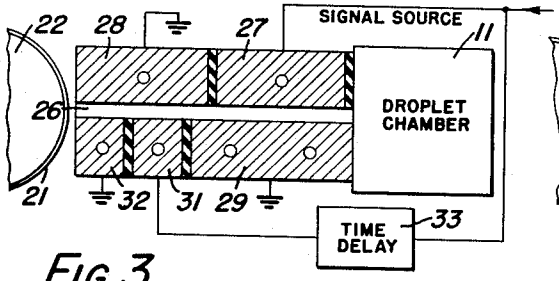

FIG. 3.

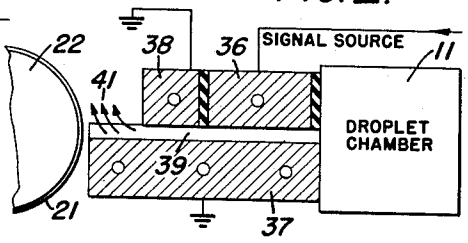

FIG. 4.

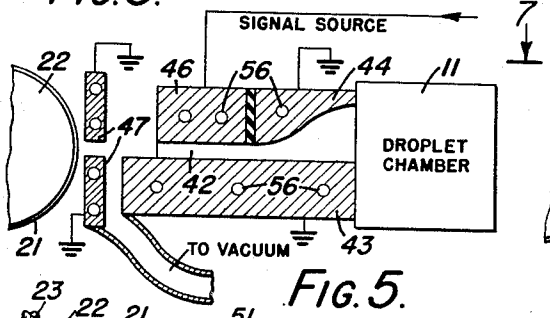

FIG. 5.

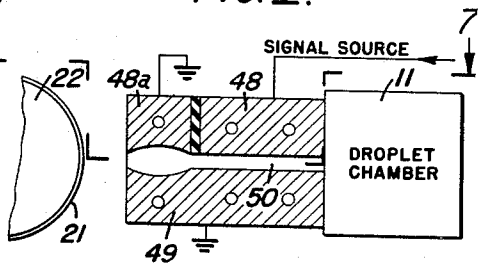

FIG. 6.

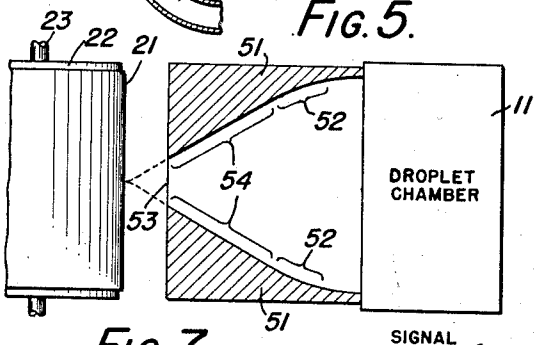

FIG. 7.

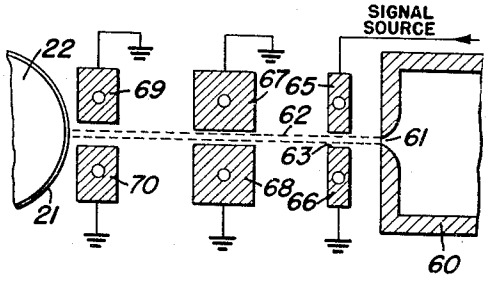

FIG. 8.

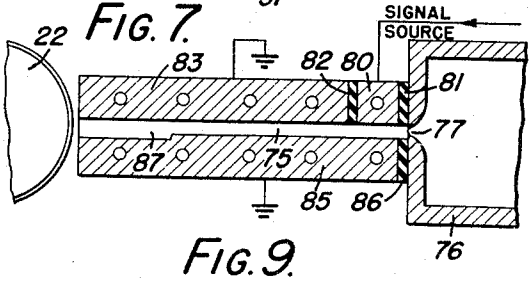

FIG. 9.

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ELECTRONIC SIGNAL CONTROLLED RECORDING SYSTEM AND APPARATUS

Carlyle W. Jacob, Rochester, N. Y.

Application June 10, 1952, Serial No. 292,611

33 Claims. (Cl. 346—75)

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The present invention relates primarily to electronic signal-controlled recording systems and apparatus, and more particularly to improvements in and refinements of some of the components and elements of my copending application entitled "Electronic Signal Recording System and Apparatus," Serial No. 2624, filed January 16, 1948, which has now matured into U. S. Patent No. 2,577,894, granted December 11, 1951. The above-mentioned application is made a part hereof by reference. The present application is a continuation-in-part of my copending application Serial No. 88,385, filed April 19, 1949.

In the above-mentioned Patent No. 2,577,894 there is disclosed a system and apparatus wherein a stream of air or a gas containing suspended ink particles or corresponding marking particles is electrically or electrostatically charged and passed through a precipitating unit or region where the particles are selectively precipitated in accordance with signals applied to the precipitating unit, and the resultant stream directed to a record-receiving sheet movable with respect to the stream discharged from the unit. In this manner each elemental area of the record-receiving sheet is subjected to the stream of air and is marked or not marked, or marked to a varying degree, depending upon the extent to which the marking particles are precipitated from the stream prior to the impingement thereof against the record-receiving sheet.

It is one principal object of the present invention to refine and improve some of the components disclosed in the above-mentioned patent, particularly the so-called precipitating and discharge duct or recording head, to enable improved and faster operation thereof.

Another object of the invention is to provide an improved recording head whereby the ink or marking particles in a stream of air are focused toward an area on the recording sheet, said area being termed the focal spot, and which is considerably smaller in at least one dimension than the opening or discharge orifice at the end of the precipitating and discharge duct. This permits, other things being equal, a much larger or wider orifice at the end of the precipitating and discharge duct with less likelihood of the particles of the marking medium clogging or interfering with the passage of the air stream therethrough. Furthermore, the concentration of the particles of the marking medium from a wide stream to a relatively small area on the record receiving sheet or blank permits scanning of the elemental areas thereof at a much faster

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rate while still having each elemental area receive an adequately large amount of the marking medium.

A further object of the invention resides in an improved recording head of the above character, whereby increased sharpness or definition in the recording on the record-receiving medium is achieved.

Another object of the invention is to provide a recording head that will be suitable for use where a solid pencil of ink or other marking liquid is used as the marking medium in order to deposit larger quantities of the marking medium on the recording surface than can be deposited where the marking medium comprises marking particles suspended in a gas.

Another object of the invention resides in improvements in recording heads of the character described to prevent enlargement of or recording outside the focal area or spot on the record receiving sheet. This is accomplished by preventing marking particles, or the marking stream, near the discharge orifice, which may be initiated into movement in a precipitating direction and not precipitated before emerging from the precipitating duct but still having transverse momentum, from impinging upon the record receiving sheet at some point outside the normal focal area.

The above and further objects of the invention will be more apparent from the following detailed description wherein reference is made to the accompanying drawings, in the latter of which:

Fig. 1 is an illustration of one of the features of the present invention applied to what is hereinafter referred to as the precipitating unit or precipitating and discharge duct or head;

Fig. 2 is a front end view of the precipitating and discharge head of Fig. 1;

Figs. 3 and 4 are illustrations of other features or improvements in the precipitating and discharge duct or head of the recording unit;

Fig. 5 illustrates the principles of a modified precipitating and discharge duct or head;

Fig. 6 illustrates the principles of a still further modified precipitating and discharge duct or head;

Fig. 7 is a view taken substantially on line 7—7 of Fig. 6;

Fig. 8 is a more or less diagrammatic section of a precipitating and discharge head constructed according to a still further modification of the invention and designed especially for directing

a solid pencil of marking liquid at a recording medium; and

Fig. 9 illustrates a still further modification of the invention especially intended for use with a solid pencil of marking liquid.

Referring first to Figs. 1 and 2, a so-called recording head together with its associated components is shown and it includes a so-called droplet chamber which may be of the type shown in Figs. 3 and 4 of the above-mentioned patent. In the droplet chamber, which is indicated generally by reference numeral 11, a marking medium such as a dye or ink is atomized by a stream of gas or air to form a suspended mixture in the droplet chamber. The droplet chamber 11 is of sufficient size to enable the atomized particles to lose most of their high blast momentum caused by the atomizing jet or jets and to float through the chamber as a fine suspension or mist. The mixture or mist in the droplet chamber is subjected to a high potential applied from one or more corona discharge electrodes whereby the individual particles thereof are electrically or electrostatically charged. The charge may be either negative or positive and for the purpose of the present description it will be assumed that these particles are positively charged.

Following the charging of the marking particles in the droplet chamber 11, the mist or mixture is directed into the duct 13. Preferably this is effected by gradually decreasing the discharge area of the droplet chamber 11 so that turbulence in the mist as it passes into the duct 13 is at a minimum and the mist flows smoothly into said duct.

The charged particles or mist next encounter what is referred to generally as the precipitating unit. Such a unit is indicated by reference numeral 10 and includes the precipitating and discharge duct 13 formed by a lower precipitating block or electrode 14, and a signal block or electrode 16 spaced from the lower block by spacing elements 17. In the arrangement of Fig. 1 the lower precipitating electrode 14 is at or near ground potential and the signal electrode 16 has the signals applied thereto which may consist of varying positive potentials although negative potentials may also be used. The signal electrode 16 is somewhat shorter than the grounded electrode 14 and is separated from the droplet chamber and a second grounded electrode 18 above the duct 13 by insulated spacing elements or sheets 19.

In operation of the unit, the mixture of air and marking particles or mist passing along the duct 13 is thereby directed toward a record receiving sheet 21 supported on a drum 22. When the particles are not precipitated as they pass along the duct, they impinge upon the sheet 21 to be deposited thereon and mark the same. The application of a signal on the electrode 16 creates an electric field between it and the lower electrode 14 or that portion or zone of the duct including the electrode 16 whereby the marking particles in the mixture passing through this zone of the duct will be drawn downwardly and deposited on the lower electrode 14. The number of particles deflected or drawn downwardly and precipitated on the lower electrode 14 is determined by the magnitude of the signal applied to the upper electrode, and the greater the signal, the greater the number of particles precipitated. The system is so arranged that when the signal is at a maximum, all the marking particles will be precipitated from the air stream and deposited on the lower electrode, and obviously for this condition none of the particles will reach the recording sheet 21 to produce a mark thereon.

Precipitating and discharge units, such as the unit 40, Fig. 3, of the above-mentioned patent, where the so-called signal electrode or block, or the element to which the signal is applied, is of the same length as the lower grounded electrode on which the marking particles are precipitated, or, in other words, where the extremities of these electrodes or blocks form a part of the discharge orifice of the precipitating and discharge duct, have some disadvantages. In this connection it has been found in such units that when the voltage to the signal plate is suddenly increased from a low value, say zero potential, to a high value, for example, 1000 v., a marking particle near the discharge orifice of the duct will be deflected in a downward direction and acquire considerable downward momentum and before such a particle has had time to reach the lower precipitating electrode, it will have been discharged from the duct with its downward momentum still effective. Such a particle will continue moving in this direction and be deposited on the record receiving sheet at some point outside the normal focal area of the discharge duct, the focal area in this instance being the area on the record receiving blank on which the marking particles undischarged by precipitating signals would strike and be deposited. To prevent the marking particles from striking the record receiving blank outside the focal area of the discharge orifice 15, the lower electrode 14 is somewhat longer than the signal electrode 16 and another grounded electrode 18, electrically separated from the electrode 16, forms one of the upper surfaces of the duct 13 near the discharge end thereof. Thus the electrode 18 is included in another zone or portion of the duct 13 and in the embodiment of Fig. 1 this zone is a zero signal zone.

With this arrangement the marking particles initiated in a downward direction by the sudden increase in the field between the electrodes 16 and 14 from a low value to a high value, will be completely precipitated on the block 14 before any of these particles have a chance to issue from the duct. This will result in no enlargement of the focal area of the duct by the marking particles not precipitated, since these non-precipitated particles move in paths which are substantially parallel in a plane perpendicular to the electrodes 14 and 18. Hence, the marking on the record receiving blank 21 can be very abruptly terminated. Such operation gives improved and superior results and enables the signals to be recorded on the record-receiving blank 21 with extremely sharp and well defined areas.

In connection with Fig. 1, the principles of the invention have been described wherein there is but a single duct 13, and in such an arrangement the record-receiving blank 21 moves relative to the discharge orifice longitudinally of the axis 23 of the drum as well as rotatably with respect thereto. It will be obvious, however, that the above improvements or features of the invention, as well as those hereinafter described, are equally applicable to a so-called multiple jet recording head such as that disclosed in Figs. 7 to 11, inclusive, of the above-mentioned patent where a plurality of streams of a mixture are employed in a recording head and the marking particles selectively precipitated therefrom.

Another feature of the invention or modifica-

tion of the arrangement of Fig. 1 is shown in Fig. 3 wherein the upper surface of a duct 26 is formed by two electrically separated electrodes, a signal electrode 27 and a grounded electrode 28, with the end of the grounded electrode forming a part of the discharge orifice of the duct 26. The lower surface of the duct 26 is formed by three sections or electrodes; first, a grounded section 29 of somewhat greater length than the upper signal electrode 27, then a signal electrode 31, and another grounded electrode 32. In this arrangement signals are applied to the electrodes 27 and 31, with those applied to electrode 31 first passing through a suitable time delay unit 33 where the signals are somewhat delayed. The delay unit 33 is adapted to delay the signals a predetermined interval substantially equal to, or in proportion to, the speed of travel of a marking particle along the duct 26 from the electrode 27 to electrode 31.

With the arrangement of Fig. 3 a marking particle that has been deflected in a downward direction and not precipitated by the application of a signal on the electrode 27 is given a slight upward thrust by the lower signal electrode 31 at the time it reaches this electrode. This slight upward thrust on the marking particle counteracts the momentum it may have in a downward direction, resulting from the signal applied to the electrode 27, and straightens out the path of the particle. Thus as the marking particle passes over the second signal electrode 31, it will have practically no upward or downward momentum and will therefore emerge from the orifice or discharge opening of the duct 26 with no momentum tending to move the same out of the focal area of the discharge orifice. Thus the paths of the marking particles will be substantially parallel or collimated in planes perpendicular to the electrodes 28 and 32 and will impinge upon the record-receiving blank 21 within the focal area of the duct 26.

With the arrangement of Fig. 3, the lower signal electrode 31 is so arranged and located that it has practically no precipitating effect on the particles passing thereover and in no manner destroys or affects the precipitating characteristic of the duct. In this connection its sole function is to counteract the downward movement of the marking particle which may have been initiated into a downward precipitating movement but which is not completed at the time the particle passes over the second signal electrode 31. The application of a maximum signal to the upper signal electrode 27 completely precipitates all the marking particles before they pass out of operative relation with the grounded electrode 29, and no marking particles for this condition will reach the portion of the duct 26 over the lower signal electrode 31.

In Fig. 3 the grounded electrode 29 is somewhat longer than the signal electrode 27 so that marking particles which are to be precipitated and which are initiated in a downward or precipitating movement will reach the grounded electrode 29 and be precipitated before they can be acted upon by the second signal electrode 31. Thus the duct has a first variable strength field zone under electrode 27, a second zone of constant or zero field strength over the left hand end of electrode 29 extending beyond the electrode 27, a third variable strength field zero over the electrode 31 and followed by a fourth zone of constant or zero field strength over electrode 32.

For best results with apparatus of the nature

described herein the drum 22 with the recording blank 21 thereon must be relatively close to the discharge orifice of the precipitating duct. This proximity of the recording sheet has, however, some tendency to retard the free flow of the air from the discharge orifice. In other words, the nearness of the recording sheet to the duct prevents the air from escaping as easily and smoothly as it should. Fig. 4 illustrates the manner in which this condition can be remedied or relieved. There the electrodes forming the upper surface of the duct are somewhat shorter than the electrode of the lower surface or the electrode on which the marking particles are precipitated. In other respects the illustration of Fig. 4 is substantially the same as Fig. 1, with an upper signal electrode 36, a lower grounded electrode 37, and an upper grounded electrode 38 to the left of the signal electrode 36 and insulatively separated therefrom. However, in the construction shown in Fig. 4, the lower grounded electrode 37 is longer in the direction of the duct than both upper electrodes 36 and 38 together. With this arrangement the mixture from the droplet chamber 11 passes through the duct 39 where the desired number of marking particles are precipitated principally in the zone under electrode 36 and the resultant stream directed toward the recording blank 21 through the zero or constant field zone under electrode 38. Since the upper surface of the duct 39 is somewhat shorter than the grounded lower electrode 37, the air of the mixture is permitted to escape upward in the direction of the arrows 41 in the zone including the extension of electrode 37 much more readily and smoothly than would be the case if the electrodes 36 and 38 extended the full length of the lower electrode 37. The high forward momentum of the marking particles that may be left in the stream passing along the duct 39 is such that they continue their movement in a substantially straight line and thus do not tend to escape with the air in the direction of the arrows 41 but strike the drum in the small focal area of the duct 39.

In the embodiment of the invention illustrated in Fig. 5 the stream of the mixture from the droplet chamber 11 first encounters a section or zone of the duct 42 where both the lower electrode 43 and an upper electrode 44 are at ground potential with the shorter of the electrodes, such as the upper one 44, converging to decrease the cross-sectional area of the duct. This converging of the duct 42 tends to impart downward momentum to the particles of the mixture so that they flow along the duct nearer the bottom electrode 43. With the particles thus concentrated near the upper surface of the lower grounded electrode 43, there is less movement required to precipitate the same in the zone of the duct under electrode 46, since they have less distance to move transversely of the duct or stream to reach the lower precipitating electrode when a signal is applied to the signal electrode 46. The signal electrode 46 need not extend the full length of the duct 42 that is, to the end of the lower electrode 43, but may terminate short of the end of lower electrode 43 so as to permit the escape of the air from the duct in much the same manner as illustrated in the arrangement of Fig. 4.

Fig. 5 also shows a feature of the invention where a baffle is placed between the discharge or orifice end of the duct 42 and the recording blank 21. The baffle, indicated generally by reference

numeral 47, may consist of a pair of plates one above the other, separated by a passageway between the lower edge of the upper plate and the upper edge of the lower plate in line with and substantially equal to or less than the cross-section of the discharge duct 42 at the point of the baffle plates 47. Instead of the arrangement shown, a single baffle plate with the orifice therein in line with the duct may be employed, or a single baffle, such as the lower one only, may be employed. The purpose of the baffle plate or plates 47 is to catch and retain any of the marking particles which, due to a signal or other cause, have a downward momentum, after leaving the duct, sufficient to move them out of the focal area of the duct prior to impingement upon the recording blank 21. Thus, with such a baffle there is no chance of the marking particles impinging upon the recording blank outside the focal area of the duct since the paths of such particles are substantially collimated with respect to each other in a plane perpendicular to the electrodes 46 and 48. Preferably, the baffles 47 are of porous material to absorb the marking particles that might strike the same, and a connection to a slight vacuum or to a reduced pressure sink may be made between the baffle and the electrodes 46 and 43 to prevent the accumulation of marking particles on the edges of the orifice which might otherwise subsequently be blown against the recording blank 21.

Another feature of the invention is illustrated in Figs. 6 and 7 wherein the mixture from the droplet chamber 11 passes along a duct 50 between upper electrodes 48 and 48*a*, and a lower grounded electrode 49 on which the particles are selectively precipitated in accordance with and under the control of the received signals. The electrode 48 is the signal electrode and the electrode 48*a* is grounded. In this arrangement the spacers such as 51, Fig. 7, separating the two electrodes are shaped to decrease the cross-sectional area of the duct 50 whereby the particles issuing from the orifice of the duct are in a highly concentrated condition. A feature of this arrangement is the manner in which the cross-sectional area of the duct 50 is decreased due to the configuration of the spacers 51. The first convergence of the duct is effected by mild inward curvature in the spacers in the area indicated by the reference numeral 52, and from this point on to the discharge orifice 53 of the duct the sides converge in substantially straight lines, as for example, along the surfaces indicated by reference numeral 54. The walls of the duct converging in this manner cause the unprecipitated particles contained in the mixture moving along the duct to move in converging straight lines. Upon emerging from the orifice 53 of the duct the particles contained in the stream continue their straight line motion because of their high momentum and impinge upon the recording blank 21 in a fine focal spot which may be only a small fraction, say one-tenth, of the width of the orifice. The recording blank should, of course, be placed substantially at the focal spot.

With this arrangement, other things being equal, a high concentration of marking particles in the focal area on the blank 21 can be effected and the speed of the drum can be greatly increased and still the recording sheet 21 thereon be adequately marked. Another advantage of the arrangement of Figs. 6 and 7 is that the discharge orifice 53 may be wider than is otherwise possible to thereby reduce the danger of clogging or partially clogging the same. Furthermore, this arrangement permits a high concentration of particles on an elemental area of the recording sheet 21 without the exit velocity of the mist through the orifice 53 being so excessively high as to cause turbulence or other destructive and undesirable conditions. By slightly hollowing out and shaping the electrodes 48*a* and 49, as shown, mild focusing in the vertical plane is also possible. This hollowing out, although desirable, is not necessary for successful operation of the unit.

It will be understood that both the grounded and signal electrodes of all the arrangements described above are preferably made of porous material or have capillary pores or passageways therein to permit absorption and passage of the marking particles therethrough, and that any one or all of these electrodes, as well as other surfaces with which the mixture may come in contact, absorb the marking particles rapidly and prevent undue accumulation thereof on the surfaces. To increase the absorption properties of the various electrodes and other elements or surfaces which the mixture contacts after leaving the droplet chamber, they may have voids, passageways, or ducts, such as 56, therein which are connected to a reduced pressure sink whereby the absorbed marking particles are withdrawn from the elements.

When it is desired to deposit large quantities of marking material on the recording surface, and to control this deposit in a simple "on and off" manner without regard for tonal shadings, it may be advantageous to use a solid pencil of ink or other liquid marking medium rather than droplets entrained in an air stream. The pencil of the liquid marking medium is obtained by passing the ink or other liquid marking material under pressure through a small nozzle. Preferably the nozzle is made of an electrical conducting material and is kept at a relatively high voltage so as to charge the marking liquid passing through the nozzle. The marking liquid may, however, be charged in other ways, also, as, for instance, by a corona discharge either before or after the stream leaves the nozzle. The ink or other marking liquid may be either of a conducting or non-conducting nature as desired.

In the arrangement shown in Fig. 8, 60 denotes a nozzle having a fine orifice 61 through which a liquid stream of ink or other liquid marking material is discharged under pressure in a solid stream. The nozzle may be of any suitable construction. The orifice opening is very fine and much smaller than the duct in the nozzle itself so that the stream of marking liquid issues from the nozzle as a pencil or beam.

The pencil of ink or other marking liquid is charged electrically either before or after leaving the nozzle. Preferably the nozzle 60 is made of a conducting metal and is connected to a source of relatively high voltage so as to charge the marking liquid as the liquid passes through the nozzle.

The charged pencil 62 of ink or other marking liquid, after leaving the nozzle 60 passes between signal electrodes comprising an upper signal block or electrode 65 and a lower precipitating block or electrode 66 which is spaced from electrode 65 by spacing elements as in the previously described embodiments of the invention, and which forms with electrode 65 a duct 63. The signal electrode has the control signal applied

thereto. The precipitating block or electrode 66 is grounded.

Separated from the signal electrodes in the direction of flow of the marking liquid are upper and lower impingement blocks 67 and 68; and separated from the impingement blocks and further on in the direction of stream flow are upper and lower splash blocks 69 and 70. Block 67 is spaced from block 68 and block 69 is spaced from block 70 so that the impingement and splash blocks provide ducts through which the pencil or beam of marking liquid passes. Blocks 67, 68, 69 and 70 are all grounded; and all are porous.

The signal electrodes are relatively short longitudinally, that is, in the direction of flow. They influence the pencil or beam of marking liquid, therefore, really only after it has left them. When a proper signal voltage is applied to the upper signal electrode 65, then, the pencil or beam of marking liquid will be deflected downwardly and will hit the lower impingement block 68 and be stopped.

This block 68 is porous with a fine capillary structure so that the ink or other marking liquid, which impinges on the surface of the block, is instantaneously drawn off. Only the surface of the block 68 need be of capillary nature being covered by many fine capillary passageways or indentations that lead to the sides of the block. In this case the remainder of the block is relatively solid. Here the marking liquid that impinges on the surface is rapidly drawn toward the side of the block by means of the capillary structure, away from the point of impingement. It is preferable, however, that the capillary structure extend downward into the interior of the block to more rapidly aid in removing the marking liquid from the surface. In this case, the capillary structure is linked up with the surface capillary structure so that the ink or other marking liquid, which impinges on the surface is instantaneously drawn off. Here the block may be connected to a vacuum line or other low pressure sink, to aid in removal of the marking liquid from the surface.

The porous nature of the block 68 should completely stop the pencil or beam without any splashing, but the splash blocks 69 and 70 are provided should there be any splashing. They also are porous, like block 68, and will absorb any splash. The splash blocks are spaced slightly further away from one another, that is, further away from the undeflected marking pencil or beam, than the impingement blocks 67 and 68 so as not to catch the full volume of marking liquid from the beam when deflected.

Fig. 9 shows how the various blocks, signal electrode, impingement, and splash, can be connected together to form a single duct 75. Here 76 denotes the nozzle, and 77 the nozzle orifice. It will be noted that the walls bounding orifice 77, as do the walls of orifice 61 (Fig. 8), converge to form a liquid pencil or beam that is narrower than duct 75 so that the stream of liquid as it emerges from the nozzle will not hit the sides of the duct.

In the embodiment shown in Fig. 9, the upper signal electrode or block 80 is separated from the walls of nozzle 76 by insulation 81 and it is separated by insulation 82 from a combined impingement and splash block 83. The control signals are applied to block 80. Block 83 is grounded.

The lower side of duct 75 is bounded by a combined electrode, impingement and splash block 85 that is grounded and that is separated by insulation 86 from nozzle 76. The surfaces of all of the blocks 80, 83 and 85 are porous, like block 68, the blocks again being preferably completely capillary in structure; and again the blocks are preferably connected with means for drawing away the deposited marking liquid. Block 85 is recessed adjacent the mouth of the duct 75, as denoted at 87, to provide a wider duct opening. This is for the same purpose as the provision of a wider space between upper and lower splash blocks 69 and 70 of the embodiment of my invention illustrated in Fig. 8, the wider spacing of blocks 83 and 85 adjacent the mouth of duct 75 being so as not to catch the full volume of the ink from the beam when deflected. As before the blocks may have spacing plates between them filling in the sides of the duct, so that splash may be absorbed on both sides as well as at top and bottom.

Although only the apparatus of Figs. 8 and 9 has been described as for directing a solid pencil or beam of marking liquid onto the paper or other recording material, it is obvious that a pencil of ink or other marking liquid would also work in the embodiments of the invention illustrated in Figs. 1 to 7 inclusive.

It will further be understood that while various features and arrangements of the invention are depicted and illustrated in separate or different figures of the drawings in order to more clearly illustrate the same, substantially all these features or any one or more of them could be incorporated into a single unit to provide a precipitating or discharge duct or head having all the combined features and advantages thereof.

It will be understood, moreover, that while the invention has been described in connection with several different embodiments thereof, it is capable of further modification, and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice in the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth and as fall within the scope of the invention or the limits of the appended claims.

What is claimed is:

1. In a device of the type described for recording electric signals, means for supporting a record-receiving medium, a source of an electrically-charged marking medium, a duct or passageway narrow in at least one dimension for conducting a stream of said marking medium from said source to a point adjacent said record-receiving medium, means for establishing in a first portion or zone of said duct electric fields in accordance with received signals, means including said fields to precipitate the marking stream proportionally, and means for establishing in a second portion or zone of said duct a substantially constant electric field.

2. In a device of the type described for recording signals, means for supporting a record receiving medium, means for supply a stream of electrically charged marking particles suspended in a gas under pressure, a duct or passageway narrow in at least one dimension for conducting said stream from said supplying means to a point adjacent said medium, means for establishing in a zone of said duct electric fields in accordance with received signals to correspondingly precipi-

tate the marking particles from said stream, means for establishing in a second zone of said duct a substantially constant electric field, and means for establishing in a third zone of said duct electric fields in accordance with received signals but in opposite directions to those of said first zone.

3. In a device of the type described for recording signals, means for supporting a record receiving medium, means for supplying a stream of electrically charged marking particles suspended in a gas under pressure, a duct or passageway narrow in at least one dimension for conducting said stream from said supplying means to a point adjacent said medium, means for establishing in a zone of said duct electric fields in accordance with received signals to correspondingly precipitate the marking particles from said stream, means for establishing in a second zone of said duct a substantially constant electric field, means for establishing in a third zone of said duct electric fields in accordance with received signals but in opposite directions to those of said first zone, a signal delay circuit, and means including said circuit to delay the establishment of said fields in said third zone a time interval proportional to the travel time of a particle from said first zone to said third zone.

4. In an electric signal recorder, means for supplying a stream of electrically charged marking particles suspended in a gas under pressure, means for supporting a record receiving blank, a duct for conducting said stream from said supply means to a discharge orifice adjacent said blank, said orifice directing said stream to a focal area on said blank, means for establishing electric fields in said duct in accordance with received signals whereby various numbers of said particles per unit volume of said stream are moved transversely thereof and precipitated therefrom, and means for preventing nonprecipitated particles of said stream from striking said blank outside the focal area of said orifice.

5. In an electric signal record, means for supplying a stream of electrically charged marking particles suspended in a gas under pressure, means for supporting a record receiving blank, a duct for conducting said stream from said supply means to a discharge orifice adjacent said blank, said orifice directing said stream to a focal area on said blank, means for establishing in a first zone of said duct electric fields in accordance with received signals to precipitate a corresponding portion of the particles from said stream by moving the particles transversely of said stream, means for establishing in a second zone of said duct electric fields in accordance with received signals and in opposite direction to the fields of said first zone and means including said second zone for at least partially neutralizing the transverse movement of the unprecipitated particles of said stream to prevent non-precipitated particles of said stream from striking said blank outside the focal area of said orifice.

6. In a signal recorder, means for supplying a stream of electrically charged marking particles suspended in a gas under pressure, means for supporting a record receiving blank, a duct for conducting said stream from said supply means to a discharge orifice adjacent said blank, said orifice directing said stream to a focal area on said blank, means for establishing in a first zone of said duct electric fields in accordance with received signals, means for establishing in a second zone of said duct a substantially constant electric field, means for establishing in a third zone of said duct electric fields in accordance with received signals but in opposite direction to those in said first zone, and means for establishing in a fourth zone of said duct a substantially constant electric field.

7. In a signal recorder, means for supplying a stream of electrically charged marking particles suspended in a gas under pressure, means for supporting a record receiving blank, a duct for conducting said stream from said supply means to a discharge orifice adjacent said blank, said orifice directing said stream to a focal area on said blank, means for establishing electric fields through said duct in accordance with received signals whereby various numbers of said particles per unit volume of said stream are moved transversely thereof and precipitated therefrom, a surface between said orifice and said blank, and means including said surface for preventing any transversely moving particles of said stream after discharge from said orifice from striking said blank outside the focal area of said orifice.

8. In an electric signal recorder, a supply of a mixture of electrically charged ink or marking particles suspended in a gas under pressure, means for supporting a record receiving blank, a duct for a stream of said mixture having a plurality of zones along the length thereof, means for establishing a variable electric field in a first zone of said duct in proportion to electric signals, means including said field for moving the particles transversely of said stream and precipitating varying numbers from unit volumes thereof, a second zone of said duct which said stream next encounters substantially free of varying electric fields with at least one surface parallel to the direction of flow of said stream, and means including said surface to catch and retain transversely moving particles of said stream, said stream then impinging on said blank where the unprecipitated particles mark the same.

9. In an electric signal recorder, means for supplying a stream of electrically charged ink or marking particles suspended in a gas under pressure, means for supporting a record receiving blank, a duct for conducting said stream from said supply means to said discharge orifice adjacent to said blank, means for establishing in said duct a variable electric field in proportion to electric signals to move the particles transversely of said stream and precipitating varying numbers thereof onto one of the surfaces of said duct, at least said last-mentioned surface extending in the direction of movement of said stream beyond one or more of the other surfaces thereof to permit escape of the gas from said stream, and means for preventing nonprecipitated particles of said stream from striking said blank outside the focal area of said orifice.

10. In a signal recording device of the type described, means for supplying a stream of electrically charged marking particles suspended in a gas under pressure, means for supporting a signal receiving blank, a substantially rectangular cross-sectional duct relatively narrow in at least one dimension for conducting said stream from said supply means to a discharge orifice adjacent said blank, said duct being of decreasing cross-sectional area in the direction of flow of said stream whereby said particles converge during passage along said duct, and means responsive to electric signals for selectively and

varyingly precipitating the particles from said stream during passage along said duct.

11. In a signal recording device of the type described, means for supplying a stream of electrically charged marking particles suspended in a gas under pressure, means for supporting a signal receiving blank, a substantially rectangular cross-sectional duct narrow in at least one dimension for conducting said stream from said supply means to a discharge orifice adjacent said blank, said duct being of decreasing cross-sectional area in the direction of flow of said stream whereby the particles in said stream converge during passage along said duct to concentrate substantially at a focal point on said recording blank, signal controlled means for establishing electric fields between surfaces of said duct and means controlled by said fields to varyingly and selectively precipitate the particles from said stream during passage of said stream through said duct.

12. In a signal recording device of the type described, means for supplying a stream of electrically charged marking particles suspended in a gas under pressure, means for supporting a signal receiving blank, a substantially rectangular cross-sectional duct narrow and substantially constant in at least one dimension for conducting said stream from said supply means to a discharge orifice adjacent said blank, a baffle between said orifice and said blank having an opening substantially equal in area to the cross-sectional area of the stream issuing from said orifice, means including signal controlled electric fields between two surfaces of said duct for transversely moving the particles of said stream and precipitating varying numbers thereof from said stream and means including said baffle for catching the particles having sufficient transverse momentum after leaving said orifice to move out of the focal area of said orifice.

13. In a signal recording device of the type described, means for supplying a stream of electrically-charged marking particles suspended in a gas under pressure, means for supporting a signal receiving blank, a substantially rectangular cross-sectional duct narrow in at least one dimension for conducting said stream from said supply means to a discharge orifice adjacent said blank, a baffle between said orifice and said blank having an opening substantially equal in area to the cross-sectional area of the stream issuing from said orifice, means including signal-controlled electric fields between two surfaces of said duct for transversely moving the particles of said stream and precipitating varying numbers thereof from said stream, means including said baffle for catching the particles having sufficient transverse momentum after leaving said orifice to move out of the focal area of said orifice, a reduced pressure sink, and means including said reduced pressure sink for removing the particles deposited on said baffle.

14. In a signal recording device of the type described, means for supplying a stream of electrically-charged marking particles suspended in a gas under pressure, means for supporting a signal-receiving blank, a substantially rectangular cross-sectional duct narrow in at least one dimension for conducting said stream from said supply means to a discharge orifice adjacent said blank, said duct having at least one pair of opposite focusing walls with at least the latter part thereof substantially straight and converging at a substantially constant rate to the discharge orifice of said duct, means including signal controlled electric fields between two surfaces of said duct for transversely moving the particles of said stream and precipitating varying numbers thereof from said stream, and means including the straight converging walls of said duct for directing the non-precipitated particles of said mixture to a considerably smaller area on said blank than the area of said discharge orifice.

15. In a signal recording device of the type described, means for supplying a stream of electrically-charged marking particles suspended in a gas under pressure, means for supporting a signal-receiving blank, a substantially rectangular cross-sectional duct narrow in at least one dimension for conducting said stream from said supply means to a discharge orifice adjacent said blank, said duct having at least one pair of focusing walls which decrease the cross-sectional area of said duct in the direction of movement of said mixture, means including signal-controlled electric fields between two surfaces of said duct for transversely moving the particles of said stream and precipitating varying numbers thereof from said stream, and means including said focusing walls for focusing the unprecipitated particles of said stream to an area on said blank considerably smaller than the area of said orifice.

16. In a signal recording device of the type described, means for supplying a stream of electrically-charged marking particles suspended in a gas under pressure, means for supporting a signal receiving blank, a substantially rectangular cross-sectional duct relatively narrow in at least one dimension for conducting said stream from said supply means to a discharge orifice adjacent said blank, means operative in at least a portion of said duct to selectively precipitate marking particles from said stream according to received signals, and at least the portion of said duct near the exit orifice being of decreasing cross-sectional area in the direction of flow of said stream whereby non-precipitated particles are caused to converge during passage along said last-mentioned portion of said duct to concentrate them at a focal point on the recording blank.

17. In a signal recording device of the type described, means for supplying a stream of electrically charged marking particles suspended in a gas under pressure, means for supporting a signal receiving blank, a duct relatively narrow in at least one dimension for conducting said stream from said supply means to a discharge orifice adjacent said blank, means operative in at least a portion of said duct to selectively precipitate marking particles from said stream according to received signals, and at least the portion of said duct near the exit orifice being of decreasing cross-sectional area in the direction of flow of said stream whereby non-precipitated particles are caused to converge during passage along said last-mentioned portion of said duct to concentrate them at a focal point on the recording blank.

18. In a signal recording device of the type described, means for supporting a signal-receiving blank, a duct having a discharge orifice at one end thereof adjacent said blank, means for supplying to said duct through the other end thereof a stream of electrically-charged marking particles suspended in a gas, means for selectively removing in accordance with received signals varying numbers of marking particles from

said stream prior to discharge from said orifice, and means including said duct to control the paths of the marking particles remaining in the emergent stream so that they are directed at a small focal spot on the receiving blank of less area than the cross-sectional area of said discharge orifice.

19. In a signal recording device of the type described, means for supporting a signal-receiving blank, a duct having a discharge orifice at one end thereof adjacent said blank, means for supplying to said duct through the other end thereof a stream of electrically-charged marking particles suspended in a gas, means for selectively removing in accordance with received signals varying numbers of marking particles from said stream prior to discharge from said orifice, said duct having opposite side walls which converge to said discharge orifice to direct the marking particles remaining in the emergent stream toward a small focal spot on said receiving blank.

20. In a signal recording device of the type described, means for supporting a signal-receiving blank, a duct having a discharge orifice at one end thereof adjacent said blank, means for supplying to said duct through the other end thereof a stream of electrically-charged marking particles suspended in a gas, means for selectively removing in accordance with received signals varying numbers of marking particles from said stream prior to discharge from said orifice, and means for collimating in at least one plane the paths of movement of the marking particles remaining in the emergent stream and causing said particles to continue in said substantially collimated paths to said receiving blank.

21. In an electric signal recorder, means for supplying a stream of an electrically-charged marking medium under pressure, means for supporting a record-receiving medium, a duct through which said stream flows to a discharge orifice, said orifice restricting said stream to a focal area on said record-receiving medium, means for establishing transverse electrical fields in said duct in accordance with received signals whereby to control the flow of said stream to the record-receiving medium, a surface between said orifice and said record-receiving medium, and means including said surface for preventing any transversely moving portions of the marking medium from striking the record-receiving medium outside the focal area of said orifice.

22. In an electric signal recorder, means for supplying a stream of an electrically-charged marking medium under pressure, means for supporting a record-receiving blank, a duct for said marking medium having a plurality of zones along its length, means for establishing a variable electric field in a first zone of said duct in proportion to electric signals to precipitate said marking medium, said duct having a second zone which is substantially free of varying signals and which has at least one surface extending generally in the direction of flow of said stream, and means including said surface to catch and retain the precipitated marking medium.

23. In an electric signal recorder, means for supplying a stream of an electrically-charged marking medium under pressure, means for supporting a signal-receiving blank, a duct through which said stream flows from said supply means to a discharge orifice, a baffle between said orifice and said blank having an opening through which said stream flows, means including signal-controlled electric fields between two surfaces of said duct for deflecting said stream, and means including said baffle for catching the deflected marking medium.

24. In an electric signal recorder, means for supplying a stream of an electrically-charged marking medium under pressure, means for supporting a signal-receiving blank, a duct through which said stream flows from said supply means to a discharge orifice, a baffle between said orifice and said blank having an opening therein through which the stream may pass, means including signal-controlled electric fields between two surfaces of said duct for varyingly and selectively deflecting said stream, means including said baffle for catching the deflected marking medium, and a splash catcher between said baffle and said blank for catching the deflected marking medium not caught by said baffle, said splash catcher having an opening different in at least one dimension from the corresponding dimension of the opening in said baffle.

25. In an electric signal recorder, means for supplying a stream of an electrically-charged marking fluid under pressure, means for supporting a signal-receiving blank, means disposed between said supply means and said blank for subjecting said stream to transverse signal-controlled electric fields to varyingly deflect said stream, means disposed between the last-named means and said blank for catching the deflected marking fluid, and means disposed between said catching means and the blank for catching the splash of the deflected marking fluid.

26. In an electric signal recorder, means for supplying a stream of an electrically-charged marking fluid under pressure, means for supporting a signal-receiving blank, means disposed between said supply means and said blank for subjecting said stream to varying transverse, signal-controlled electric fields to deflect said stream, means disposed between the last-named means and said blank for catching the deflected marking fluid, and means disposed between said catching means and the blank for catching the splash of the deflecting marking fluid, both the first and second catching means being electrically neutral and being porous.

27. In an electric signal recorder, means for supplying a stream of an electrically-charged marking fluid under pressure, means for supporting a signal-receiving blank, a relatively short duct disposed between said supply means and said blank through which said stream flows, means including said duct for subjecting said stream to varying transverse, signal-controlled electric fields to deflect said stream, a porous impingement block disposed between said duct and said blank for catching deflected marking fluid, and a porous splash block disposed between said impingement block and said blank for catching the splash of the deflected marking fluid.

28. In an electric signal recorder, means for supplying a stream of an electrically-charged marking fluid under pressure, means for supporting a signal-receiving blank, a relatively short duct disposed between said supply means and said blank through which said stream flows, means including said duct for subjecting said stream to varying transverse, signal-controlled electric fields to deflect said stream, a porous impingement block disposed betweeen said duct and said blank and spaced from both for catching the deflected marking fluid, and a porous splash block disposed between said impingement block and said blank and spaced from both for

catching the splash of the deflected marking fluid.

29. In an electric signal recorder, means for supplying a stream of an electrically-charged marking fluid under pressure, means for supporting a signal-receiving blank, a duct disposed between said supply means and said blank through which said stream flows to an orifice adjacent said blank, said duct having a plurality of zones along its length, means for establishing a variable electric field in a first zone of said duct in response to electric signals, said duct having a second zone in which the walls of the duct are porous and are adapted to catch marking fluid deflected by the electric field in the first zone, and said duct having a third zone in which the walls of the duct are also porous and are adapted to catch the splash of deflected marking fluid from the first zone.

30. In an electric signal recorder, means for supplying a stream of an electrically-charged marking fluid under pressure, means for supporting a signal-receiving blank, a duct disposed between said supply means and said blank through which said stream flows to an orifice adjacent said blank, said duct having a plurality of zones along its length, means for establishing a variable electric field in a first zone of said duct in response to electric signals, said duct having a second zone in which the walls of the duct are porous and are adapted to catch marking fluid deflected by the electric field in the first zone, and said duct having a third zone in which the walls of the duct are also porous and are adapted to catch the splash of deflected marking fluid from the first zone, the bounding wall of said duct in its second and third zones being at uniform electric potential.

31. In an electric signal recorder, means for supplying a stream of an electrically-charged marking fluid under pressure, means for supporting a record-receiving blank, a duct disposed between said supply means and said blank through which said stream flows to an orifice adjacent said blank, said duct having a plurality of zones along its length, means for establishing a variable electric field in a first zone of said duct in response to electric signals, said duct having a second zone in which the walls of the duct are porous and are adapted to catch marking fluid deflected by the electric field in the first zone, and said duct having a third zone in which the walls of the duct are also porous and are adapted to catch the splash of deflected marking fluid from the second zone, said duct being differently spaced in at least one direction in said third zone from the undeflected stream of marking fluid than in its second zone.

32. In an electric signal recorder, means for supplying a stream of an electrically-charged marking fluid under pressure, means for supporting a record-receiving blank, means disposed between said supply means and said blank and constituting a first zone through which said stream is passed and in which a variable transverse electric field is established in accordance with received electric signals to varyingly deflect said stream, means disposed between said first zone means and said blank and constituting a second zone for catching and carrying off deflected marking fluid, and means disposed between said second zone means and said blank for catching and carrying off the splash of the deflected marking means.

33. In an electric signal recorder, means for supplying a stream of an electrically-charged marking fluid under pressure, means for supporting a record-receiving blank, means disposed between said supply means and said blank and constituting a zone through which said stream passes, means for establishing a variable transverse electric field in said zone in accordance with received electric signals to varyingly deflect said stream, a porous member of capillary structure disposed between said zone means and said blank for catching and carrying off deflected marking fluid, and means for conducting off the deflected fluid caught on said porous member.

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Number	Name	Date
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