

Oct. 21, 1952

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2,614,901

RECORDING HEAD FOR FACSIMILE REPRODUCTION AND THE LIKE

Filed Aug. 4, 1949

2 SHEETS—SHEET 1

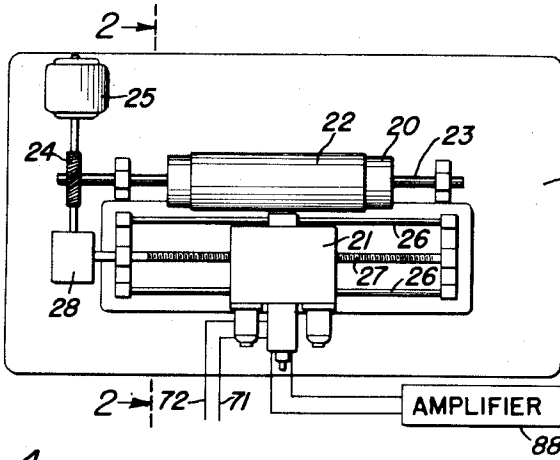


FIG. 1.

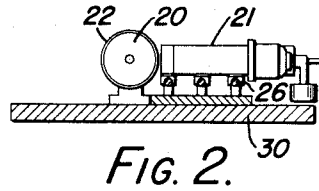


FIG. 2.

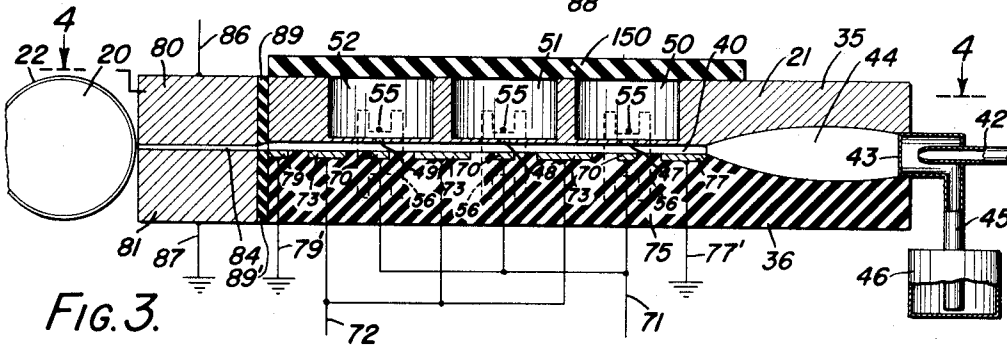


FIG. 3.

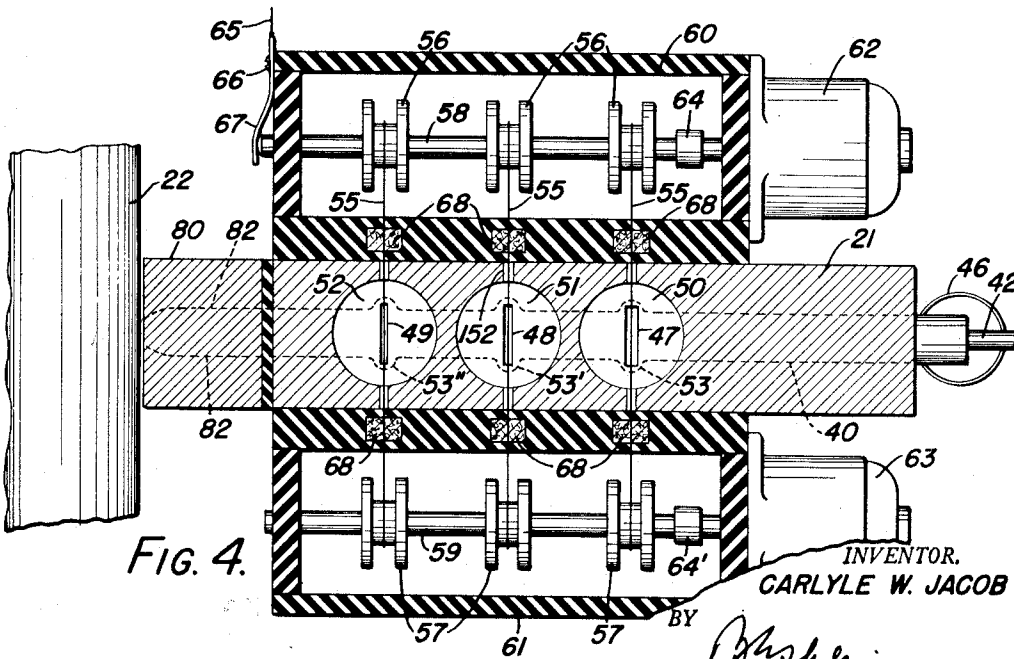


FIG. 4.

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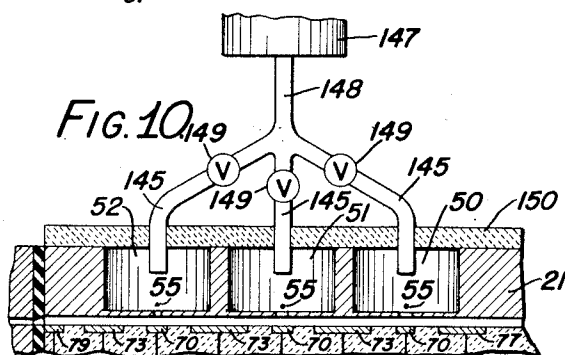
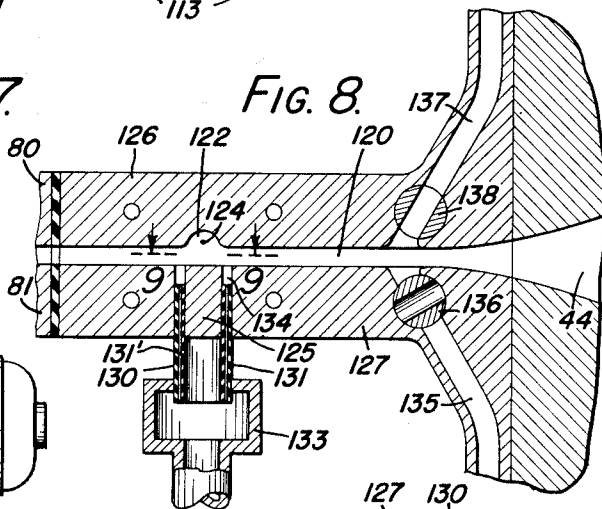
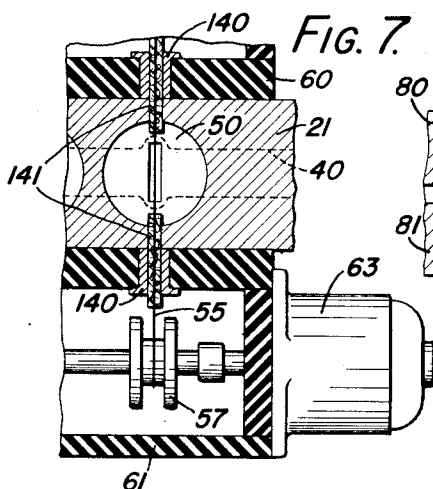
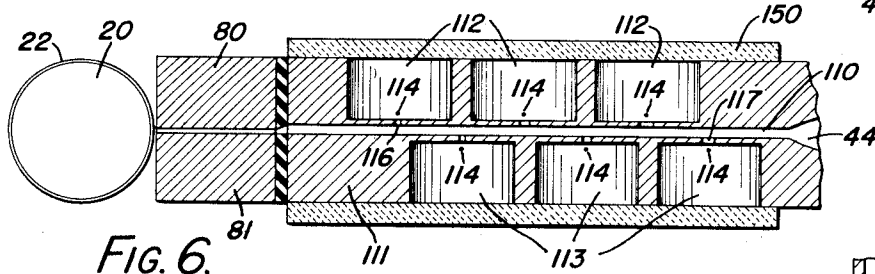
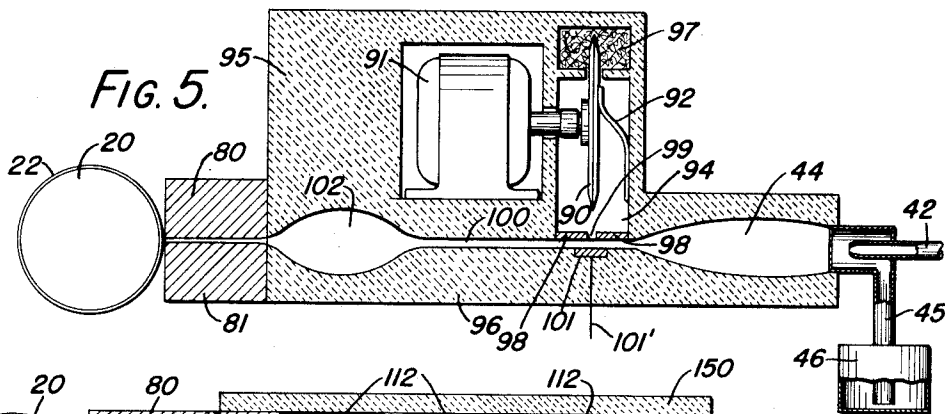
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2 SHEETS—SHEET 2



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2,614,901

RECORDING HEAD FOR FACSIMILE
REPRODUCTION AND THE LIKE

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Application August 4, 1949, Serial No. 108,553

26 Claims. (Cl. 346-75)

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The present invention relates to recording apparatus suitable for use in reproducing pictures or in making facsimiles of pictures, writings, maps, sketches, drawings, etc. More particularly the invention relates to apparatus in which a record is made upon a record-receiving medium through electronic control of one or more electrically charged streams or jets of air or gas containing ink or other marking particles by means of signals generated by scanning an original subject-matter sheet. In a still more specific aspect, the invention relates to an improvement on the electronic signal recording apparatus of my prior U. S. patent applications, Serial No. 2,624, filed January 16, 1948, and Serial No. 17,773, filed March 29, 1948, which have resulted, respectively, in Patent No. 2,577,894, dated December 11, 1951, and Patent No. 2,573,143, dated October 30, 1951.

In the system and apparatus of my prior applications above mentioned, a marking liquid, such as ink, is atomized and directed through a duct in a recording head or gun, the marking particles are charged with positive or negative ions by passing them through a corona discharge; and the stream of ionized particles are then passed through a duct in a precipitating unit in which an electrical field is created, the intensity of which is controlled in accordance with received signals generated by scanning the subject-matter sheet. The electrical field created in the precipitating unit will cause the charge particles to be precipitated on one side of the passageway through this unit. The percentage of particles deflected from the stream will depend on the magnitude of the signal. The greater the signal, the greater the number precipitated. A recording medium travels past the mouth of the precipitating duct. Since the number of droplets, that are deflected from the stream, is a function of the applied signals, the amount of ink deposited on the recording medium can be controlled from the applied signals. When the signal is at a maximum, all of the ink particles are precipitated from the stream, and consequently no mark will be produced on the recording medium.

In the recording heads or guns of my prior applications above mentioned, corona rods or electrodes are used as the charging means; and only one charge is applied to the marking stream as it passes through the charging duct.

It has been found that when the gun is in operation stray mist particles sometimes accumulate on the corona rods or electrodes, causing an erratic corona discharge.

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It has been found very difficult also, to smoothly charge the particles of the mist stream to a maximum by one application of ions from one corona rod or electrode. The ions in flowing from the corona rod or electrode across the stream of mist produce a certain degree of eddying and turbulence in the mist. If the ion current is too heavy or the slot in the corona chamber is too wide, the eddying will be so severe as to give the marking particles a large random momentum and cause them to impinge on the walls of the charging duct. This not only removes particles from the stream but removes them unevenly. The concentration of particles in the mist will vary from volume to volume and cause the recording of the recording medium to appear mottled.

A primary purpose of the present invention is to provide recording apparatus to the character described which will be more efficient in operation.

Another object of the invention is to provide recording apparatus of the character described which can be kept continuously efficient.

Another object of the invention is to provide recording apparatus of the character described which will require less attention and remain in working order almost indefinitely.

A further object of the invention is to provide in a recording head or gun of the character described a corona electrode whose efficiency can be kept always at the desired level.

Another object of the invention is to provide a recording head or gun of the character described in which the mist stream may be charged in such a way as it travels through the recording head, as to avoid eddying and turbulence in the mist and prevent impinging of marking particles on the walls of the charging duct.

A still further object of the invention is to provide a recording head or gun of the character described in which the mist stream may be charged a plurality of times as it passes through the charging duct, thereby to obtain the maximum charge and increase the sensitivity of the charged particles to the applied signals.

Still another object of the invention is to provide an apparatus of the character described in which provision is made for cleaning the charging electrodes and the ducts through which the streams of marking particles pass so as to prevent the marking particles from interfering with the efficiency of operation of the apparatus.

Other objects of the invention will be apparent

hereinafter from the specification and from the recital of the appended claims.

In the drawings:

Fig. 1 is a somewhat diagrammatic view showing in plan recording apparatus built according to one embodiment of this invention;

Fig. 2 is a section on the line 2—2 of Fig. 1;

Fig. 3 is a vertical sectional view on an enlarged scale showing a single jet recording head built according to one embodiment of this invention in registry with the recording cylinder or drum;

Fig. 4 is a sectional view on the line 4—4 of Fig. 3 looking in the direction of the arrows;

Fig. 5 is a sectional view, similar to Fig. 3, but showing a different embodiment of recording head or gun;

Fig. 6 is a fragmentary vertical sectional view, similar to the views of Figs. 3 and 5, but showing a still further embodiment of the invention;

Fig. 7 is a fragmentary view in plan, similar to Fig. 4, but showing different means for cleaning the corona wire;

Fig. 8 is a vertical sectional view similar to the views of Figs. 3, 5, and 6 showing an embodiment of the invention in which means is provided in the recording head or gun for supplying cleaning fluid to clean off the marking particles;

Fig. 9 is a fragmentary sectional view on the line 9—9 of Fig. 8, looking in the direction of the arrows; and

Fig. 10 is a fragmentary vertical sectional view showing still another way in which cleaning fluid may be applied to the corona chambers to clean away marking particles that may possibly have gotten therein.

Referring now to the drawings by numerals of reference, Figs. 1 and 2 show the recording apparatus generally. This apparatus comprises a rotatable recording cylinder or drum 20 and a recording head 21. The recording cylinder or drum 20 has wrapped therearound a record-receiving or recording sheet 22. The recording cylinder or drum is suitably supported on a shaft 23 which is driven through suitable gearing 24 from a motor 25.

In the embodiment shown, the recording head 21 is mounted to move axially of the recording drum 20 as the latter rotates so that each elemental area of the recording receiving sheet 22 is scanned or explored by the recording head. The recording head is guided in its movement relative to the drum by guide-rods 26 and is moved by a lead screw 27 which may be driven from the motor 25 at the desired rate through gearing in the gear box 28. The above described elements of the recorder are suitably supported and attached to the base.

The recorder may be controlled by electrical signals derived in the same manner as are the recorders of my earlier applications, for instance, from a photocell scanner in which the picture to be reproduced is mounted on a synchronously driven drum as well known in the facsimile art.

The present invention relates to features of the recording head. Several different types of recording heads are disclosed in the drawings. All of these recording heads consist primarily of means whereby ink or other marking substances, such as etching acids, are sprayed or directed onto the record-receiving medium in accordance with and under the control of the applied signals.

The recording head shown in Figs. 3 and 4, comprises a body whose upper portion 35 is formed of a suitable metal and whose lower portion 36 is made of a suitable insulating material

such as a porous ceramic or plastic. The confronting surfaces of the parts 35 and 36 form and bound a charging duct 40 which extends longitudinally of the head. The marking medium is injected into the right hand end of this duct through action of an air jet or tube 42 which is supplied with air from a suitable source of supply at substantially constant pressure. The air from the nozzle 42 is directed through an opening 43 into a droplet chamber 44 formed in the head 21 between parts 35 and 36; and in passing through the opening 43 sucks the ink or other marking medium up through the tube 45 from an ink supply reservoir 46.

The so-called droplet chamber 44 is relatively large and the ink sprayed therein is in the form of a fine mist. Since the droplet chamber is relatively large, the atomized particles will lose most of their high blast momentum and flow slowly through the chamber 44 as a fine suspension of mist. The left hand sides of the droplet chamber 44 converge gradually to the entrance to the duct 40 so that the marking liquid in the form of a mist acquires considerable velocity as it approaches the duct 40. On the way to the mouth of duct 40, the fast moving stream of mist is charged by ions discharged from a corona electrode. All this is similar to the construction of my prior applications above mentioned.

In the recording heads of these prior applications, however, there is but one corona electrode; and the mist particles receive but one charge in passing through the charging duct. One feature of the improved apparatus of the present invention is the provision of a plurality of corona electrodes so that repeated and successive ionic charges are applied to the stream of the marking medium and to the marking particles therein carried.

By passing the mist stream by several corona electrodes successively it has been found that the undesirable eddying and turbulence created by the charging effect of one electrode can largely, if not entirely, be obviated. The ion current of each electrode can be kept at a relatively low harmless value. Hence, in passing from one corona discharge region to the next the mild eddying, that may be present, dies down somewhat so that the mist in approaching an ionic field created by a corona electrode is relatively free from eddying and turbulence.

In the embodiment of the invention illustrated in Figs. 3 and 4 there are three corona electrodes 55 employed. Each corona electrode is in its own individual corona box or chamber segregated from the next corona electrode by a partition so that it will be impossible for mist to flow into one chamber and out the next. The several corona chambers are designated 50, 51, and 52, respectively.

As already stated, it has been found that when a recording gun is in operation, stray mist particles sometimes accumulate on the corona rod or electrode causing an erratic corona discharge. I have overcome this by using corona wires which can be shifted to expose different parts of them for use so that the part of the wire, which is active at any time, may be kept clean. In the embodiment shown, there are three corona wires 55 each of which has its opposite ends attached to pulleys 56 and 57, respectively, which are secured to shafts 58 and 59, respectively. These shafts are journaled in housings 60 and 61, respectively, that are secured to opposite sides of the recording head 21.

The current is supplied to the corona wires 55 from a suitable source through the wire 65 which is secured to a clip 67 that has contact with one end of the shaft 58. This clip is secured to housing 60 by a screw 66. Pulleys 56 and 57 and shafts 58 and 59 are made of electrically-conductive metal while the housings 60 and 61 may be made of a suitable insulating material such as plastic or ceramic. The shafts 58 and 59 are driven by separate motors 62 and 63.

The corona chambers 50, 51 and 52 have openings or mouths 47, 48 and 49, respectively, through which the ions are discharged into the mist stream. By pulling the corona wires 55 at a slow rate through the corona chambers, the portions of the wires opposite the openings 47, 48 and 49 may be continuously changed. Thus, clean, fresh portions of the wires may be continuously exposed so that the corona discharge will always be smooth.

The motors 62 and 63 are intended to operate alternately. Each is geared down to rotate at a very slow speed. The motor 62 is connected through an insulating connector 64 to the shaft 58. It drives the three pulleys 56 to cause these pulleys to wind up the corona wires 55 from the three pulleys 57. After the wires are completely transferred from one set of pulleys to the other, the motor 62 is stopped, and the motor 63 on the other shaft is set into operation to rewind the wires on the pulleys 57 on that shaft. During this operation the power to the motor 62 is shut off.

As the corona wires are wound from one set of pulleys to the other, they are preferably passed through packing chambers 68 formed in the housings 60 and 61 at opposite sides of the casting 35. These chambers 68 are filled with packings soaked in a solvent. These packings serve both to clean the wires and to seal the charging chambers against air leakage.

At the opposite side of the duct 40 opposite each of the openings 47, 48 and 49 of the corona chambers 50, 51, 52 is an attracting electrode 70. These attracting electrodes are mounted in the insulated lower portion 36 of the charging chamber. The voltage of the corona wire may be approximately 6,000 volts and its diameter about .005 inch. The attracting electrodes may have a negative voltage of say minus 4,000 volts. When the mist passing through the charging duct 40 passes under the corona wires, the particles of the mist are charged by ions flowing from the wires to the opposite attracting electrodes.

The ion-attracting electrodes at minus 4,000 volts not only pull down the ions but unfortunately to a small degree displace the charged ink particles downwardly. This is ordinarily not serious unless there are very many charging sections. Then the effect becomes cumulative and a rather large number of particles will actually be precipitated on the bottom side of the charging duct 40. To prevent this I have provided repelling electrodes 73 between successive attracting electrodes. These repelling electrodes may have a positive voltage of say plus 2,000 volts. The voltage and longitudinal dimension of each repelling electrode 73 should be such that the upward thrust of each repelling electrode just balances out the downward thrust of each attracting electrode. These repelling electrodes may be silvered or inlaid areas on blocks of plastic or porous ceramic, or may be metal plates mounted directly in the insulation portion 36 of the charging chamber.

For more completely balancing out the ionic thrusts, grounded conducting plates 77 and 79 may be mounted in the lower portion 36 of the charging chamber at the entrance and exit ends, respectively, of duct 40. These plates are grounded by wires 77' and 79', respectively. These plates serve to pick up stray currents from the repelling electrodes.

One advantage of using several charging sections is that each of these may be made, as already indicated, a mild charging section. The plurality of mild charging sections have a distinct advantage over a single strong charging section. The loss of marking particles by direct precipitation in the charging unit is much less when several charging sections are employed. Another advantage of multiple charging sections is that if one corona wire is not functioning properly and not discharging its full quota of ions, the other corona wires will to a considerable degree average out the charging deficiency and the record sheet 22 will still be acceptable.

As pointed out, in my application Serial No. 17,773 above mentioned, the ionic charging of the particles must take place in a strong electric field if heavy charging is to occur. Therefore, in a multiple charging unit where the final charge is acquired in the final stage, only this final charge need have a very high charging field. To achieve this, the voltages on the ion-attracting electrodes in the first two stages can be somewhat smaller than on the third, or the widths of the slot openings 47 and 48 of the corona chambers 50 and 51 in the first two stages can be made somewhat larger than the width of the opening 49 of the corona chamber 52 in the third stage to allow a larger number of the low velocity ions to flow into the mist stream. The turbulence will not be any greater with these wider slots because the reduced attracting electrode voltage does not impart to the ions as great an energy as in the final stage.

Thus, in a multiple charging unit the attracting electrode voltage should progressively increase with increasing number of sections and the ionic current should preferably decrease, with increasing number of sections. This ionic current can be controlled either by altering the width of the slot openings, or the spacing of the corona wires above the slots or the mist stream, or by altering the voltage so that successive corona wires receive successively increasing voltages.

From the charging duct 40, the mist passes through a duct 84 between the precipitation plates or blocks 80 and 81 of the precipitating unit. These blocks may be made as described in my applications above mentioned. They may be made from a porous conducting material, such as powdered metal. They are separated vertically by insulating sheets (not shown); and they are separated from the charging chamber by other insulating sheets 89, 89'. They may be provided with holes, as described in application Serial No. 2,624 so that ink particles deposited on their opposed surfaces may be drawn off by suction. The insulating sheets, which separate the blocks 80 and 81 vertically, as shown in dotted lines at 92 in Fig. 4 may be shaped to converge toward each other at the left hand end of the precipitating unit to form a narrow discharge port or orifice at the mouth of duct 84 through which the air or other gas with or without ink particles issues in the form of a fine stream.

The lower plate 81 may be kept at or near ground potential while the upper plate 80 has

voltage signals applied thereto. These voltage signals may be applied and controlled as described in my prior applications above mentioned. When the signal is the same as the potential on the lower plate, the marking droplets in the passageway 84 between blocks 80 and 81 pass therethrough in full strength with little loss in numbers by contact with the confining walls. Accordingly the ink droplets issuing from the precipitating orifice will strike the record receiving sheet 22 to produce a mark thereupon. If a potential signal is applied to the upper plate 80, which is different from the potential on the lower plate 81, an electric field will be created between the upper and lower plates, and the ink or other marking particles will be drawn downward and deposited on block 81.

The percentage of particles, which are deflected or drawn downward sufficiently to reach the lower plate 81 and be precipitated thereon, is determined by the magnitude of the signal. With the number of droplets precipitated on the lower plate a function of the strength of the signals applied to the upper plate, the amount of ink or other marking material deposited on the record receiving sheet 22 can be controlled. The signals as already stated, may be generated by scanning the subject matter object and may be carried by wires 85 and 87 (Figs. 1 and 3). Before being applied to the upper plate 80, the signal current may first pass through an amplifier 83 which serves to amplify the signals received from the signal transmitting or signal generating source.

Instead of using for the corona a length of wire wound about two pulleys, obviously, if a relatively short length wire is used and the two ends are welded together, the wire can be run continuously in one direction. This has the disadvantage, however, of requiring a weld that may cause an erratic corona discharge when the welded portion is in the corona chamber.

Another alternative construction is shown in Fig. 5. Here, instead of using a wire, a small metallic conducting wheel 90 having a narrow edge is used as the corona electrode. This wheel is mounted to be driven at very low speed by a motor 91. The corona wheel 90 should be suitably insulated from the motor mechanism so that it may be supplied with the corona voltage through a contact member such as contact member 92. The wheel is adapted to rotate in a chamber 94 formed in the upper portion 95 of the recording head 96. Above the chamber 94 and communicating therewith may be a second chamber 97 which is filled with a suitable packing, such as glass-wool soaked in solvent. As the wheel rotates then it will be kept clean. The advantage of the wheel over the wire is that the wheel being completely rigid and with a continuously smooth corona edge can be run continuously. Also, the wheel assembly occupies less space than the wire assembly.

Otherwise, the recording head 96 might be similar in structure to the head 21.

Preferably, however, both the upper and lower portions of the charging chamber of the recording head are made of an insulating material. This may be a porous ceramic or a porous plastic, or any other suitable insulating material. Porosity is employed here, as in the previously described embodiment of the invention and as in my earlier application mentioned, to permit drawing off by suction any marking liquid deposited on the walls of the charging duct. Holes (not shown) may be provided in the upper and lower portions

of the charging chamber for conducting away the deposited liquid if desired as disclosed in my earlier applications mentioned.

Another feature of the recording head of Fig. 5 is the provision of a mixing chamber ahead of the precipitating duct to provide a more homogeneous mist for delivery to the precipitating unit.

The marking liquid may be atomized in the same way as in the recording head of Figs. 3 and 4; and the atomized mist is delivered into a dispersing chamber 44, as in Figs. 3 and 4, and from there into the charging duct 100. The charging duct 100 carries the mist stream past the opening 99 in the corona chamber 94. The opening 99 is bounded by two metallic plates 98 and opposite it is an attracting electrode 101 which is negatively charged. The duct 100 is enlarged adjacent the precipitating plates 80, 81 to provide a mixing chamber 102. If the charging of the particles is not smooth; if, for instance, one small volume of mist differs slightly in its properties from the neighboring volume, then the mixing or diffusing chamber 102 will aid in making up these various volumes to produce a homogeneous mist. This is because in the chamber 102 the speed of movement of the mist is slowed down and one unit of volume catches up and mixes with the preceding and succeeding units of volume.

Obviously, a plurality of corona wheels 90 may be used along charging duct 100, just as a plurality of corona wires 55 may be used along charging duct 40, and for the same reason. Only one charging wheel has been shown in Fig. 5 for convenience in illustration.

Another embodiment of the invention is illustrated in Fig. 6. Here, a different system is employed for preventing deposit of the marking particles on the walls of the charging duct. Here, instead of using repelling electrodes, corona chambers are provided both above and below the duct 110 in the recording head 111. The upper corona chambers are denoted at 112 and the lower chambers 113. The openings 116 from the upper corona chambers are staggered with reference to the openings 117 from the lower corona chambers, so that the mist is first charged from a lower chamber with a charge in one direction and then charged from the upper chamber with a charge in the opposite direction and these differently directed charges alternate. This will prevent precipitation of the ink particles on the walls of the charging duct 110. Here, the corona electrodes are shown as wires 114 moving between spools as in the first described embodiment of my invention, shown in Fig. 4.

In the embodiment shown in Fig. 6, both the corona chamber openings 116 and the corona chamber openings 117 decrease in width from the entering to the leaving end of the charging duct for the purpose explained with reference to the openings 47, 48 and 49 in the embodiment of recording head shown in Figs. 3 and 4.

Another embodiment of the invention is disclosed in Fig. 8. The corona wire can be placed very close to the slot or opening, which connects the corona chamber with the charging duct, or can be placed even inside the opening if the corona wire voltage is brought down approximately to the voltage of the slot. Then practically all the ions from the corona discharge will flow to the opposite attracting electrode. To maintain the corona discharge, in such case, the voltage of the attracting electrode should be lowered from a negative voltage of say minus

4,000 volts to a negative voltage of say minus 8,000 volts.

With the corona wire placed inside of the slot, the corona chamber can be reduced in size or even eliminated, as is disclosed in the embodiment of the invention shown in Fig. 8. Here the corona wire 124 is stretched inside the recess 122 in the charging duct 120. Preferably the wire 124 is above the direct line of flow of the mist so as not to become unduly contaminated with the mist particles.

In the recording head of Fig. 8 both the upper part 126 and the lower part 127 of the charging section are made of porous conducting metal. The portion 125 of the lower part 127 which is opposite recess 122 is insulated from the rest of the lower part 127 of the charging section and either grounded or given a negative charge. This portion 127 constitutes an attracting electrode.

There are several advantages to the corona system of Fig. 8. With the corona wires so close to the mist stream, the charging field across the mist stream between the wire and the ion attracting electrode is very high. Moreover, the ionic current through the mist stream can be made very high without causing excessive electric wind disturbance. The electric wind disturbance is roughly proportional to the distance between the ion-producing and the ion-receiving electrodes. With the corona wire in a recess, such as 122, this distance can be kept small. Another advantage is that with a small corona chamber there is less tendency for the air or mist to enter or leave the corona chamber because of the very rapid equalization of pressure inside and outside the small corona chamber or recess.

To permit the use of mists of an electrically conducting nature, such as alcohol sprays, the insulating members must be protected from the alcohol. Figs. 8 and 9 show one way in which this may be accomplished. The ion-receiving electrode 125 is here insulated from the lower part 127 of the recording head by an insulating guard 130 which completely surrounds the electrode 125. Here the insulating guard has a porous interior. It may be made of two parts 131 and 131' which are grooved on their confronting faces to provide grooves 132 down the center of the insulation. A non-conducting fluid, such as kerosene, may then slowly be forced constantly from a high pressure tank 133 up through the insulator. Upon emerging from the top the kerosene spreads out and is absorbed by the porous conductors 127 on either side of the electrode 125. The constant flow of the kerosene or other solvent over the top surface of the insulation maintains said top surface free of film of conducting alcohol or other electrically conducting marking fluid. Thus the apparatus will effectively function with conducting marking fluids.

Preferably the top of the insulation is set below the duct 120 providing a recess 134 above the top of the insulation. This is to keep the insulation out of the direct path of the flowing marking mist.

Obviously, this type of self cleaning insulator may be used both around the corona electrodes and around the precipitating electrodes.

To clean the sides of the charging ducts, such as duct 120, and to remove therefrom any marking particles that may be deposited thereon, cleaning sprays of non-conducting fluids, like oil or conducting solvents like alcohol can be introduced periodically into the system. It is es-

pecially desirable to clean the charging duct periodically if the marking fluid used is a suspension of fine marking particles in a vehicle rather than a true solution. After a few hours of operation these fine particles will begin to clog the porous walls of the duct 120 and destroy their capillary function. For the purpose of supplying the solvent, a duct 135 may be provided in the recording head leading from a suitable source of solvent supply to the duct 120. This duct 135 is normally closed by a manually operable valve 136. Since suitable solvents are usually of a conducting nature, like alcohol, it is necessary after the solvent has been turned off to supply non-conducting oil to spray and wash away the conducting alcohol from the head. The non-conducting oil spray may be supplied through a duct 137 and be controlled by a manually operable valve 138.

The system may be shut down periodically and the solvent valve opened to supply the solvent which will dissolve the marking particles and wash them away. After the solvent valve is turned off, then the valve 138 is opened to permit the non-conducting oil to flow over the sides of the duct 120 and wash away the conducting alcohol from the system.

Obviously, the apparatus for cleaning shown in Fig. 8 can be used in any of the disclosed embodiments of the invention.

In the embodiment of the invention shown in Fig. 4 the corona wires 55 are drawn through chambers 68 filled with packings soaked with solvent. Another way of keeping the corona wires clean is shown in Fig. 7. Here a tube or tubes 140 are mounted in walls of the one or both of the spool housings 60 and 61; and tubular swabs 141 are mounted in these tubes around the corona wires. The swabs may be pushed in and out of the corona chambers along the corona wires manually or automatically, to clean the corona wires. Clean corona wires are essential to avoid uneven corona discharge.

An alternate arrangement for keeping the corona wires clean is shown in Fig. 10. Here a tank or reservoir 147 filled with a solvent is connected by main duct 148 and branch ducts 145 with the several corona chambers 50, 51 and 52. Flow of the solvent to the corona chambers is controlled by the valves 143. To clean the wires, the valves 149 are opened periodically so that solvent may be squirted or sprayed from the reservoir on the wires.

As shown in Figs. 3, 6 and 10, the corona chambers may be covered with a cover plate 150 made of an insulating material such as plastic or ceramic. This will confine the corona discharge to the recording head. To insure the maximum efficiency of the corona discharge the corona chamber 50, 51, 52 (Fig. 1), 94 (Fig. 5), 112 and 113 (Fig. 6), and 122 (Fig. 8) may be coated inside with insulation, or a second shielding electrode may be placed above each corona electrode, which is of the same potential as the corona electrode, and which will prevent the ions from the corona electrode from dissipating themselves on the upper walls of the corona chamber and cause these ions to be directed at the mist stream.

In all of the embodiments of the invention it is preferred to widen the charging duct or channel laterally opposite each of the corona chamber openings. The lateral recesses so formed are denoted at 53, 53' and 53'' in Fig. 4 and 123 in Fig. 9. The recess permits full charging of the mist particles flowing very closely to the channel wall.

Without the recess these particles would not be fully charged because of the weakening of the charging electric field in the immediate vicinity of the side wall of the channel or duct due to the side wall. With the side wall recessed the disturbing influence of the wall is removed. The mist stream flows essentially in a straight line past the recess with but only partial flow into the recess. The small portion of the stream that does penetrate into the recess is moving at reduced speed and so is extra heavily charged.

The long recesses 152 (Fig. 4) at the junction between the corona wire and the supporting insulation are intended to provide partial protection against spray mist particles falling on said junctions. As the reels or spools 56 and 57 revolve; and the corona wires are drawn away from said junctions, it is desirable that the clean wires do not drag away with them the ink deposits from said junctions. If necessary, clean air may be slowly introduced into the recesses, as in the case of my application Serial No. 2,624 to keep out any mist vapors. This clean air has another purpose also, namely, to maintain a slight positive pressure in each corona chamber that tends to keep stray mist particles from entering the corona chamber through the slot openings 47, 48 and 49.

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.

Having thus described my invention, what I claim is:

1. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a corona electrode, whose discharge portion has linear extent, mounted in said head in operative position, at one side of said duct, to charge the particles in said stream, means for moving said electrode in the head to bring different areas of its discharge portion successively into charging position, a precipitating unit having a passageway therethrough communicating with said duct and into which the charged particles pass, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

2. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a corona wire movably mounted in said head, means for moving the wire linearly to bring different parts of it into operative relation to the duct to charge the particles in the stream, a precipitating unit having a passageway therethrough into which the charged particles pass and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

3. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream

containing the entrained marking particles may be passed, a pair of spools journaled in said head, a corona wire mounted to be wound from one spool onto the other, means for rotating the spools so that different parts of the wire are brought successively into operative relation with said duct to charge the particles in said stream, a precipitating unit having a passageway therethrough into which the charged particles may pass, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

4. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a corona electrode whose discharge portion has linear extent mounted in said head in operative position at one side of said duct to charge the particles in said stream, said corona electrode comprising an endless corona wire, means for moving said wire so that different parts of it are brought successively into operative relation with said duct to charge the particles in said stream, a precipitating unit having a passageway therethrough communicating with said duct into which the charged particles may pass, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

5. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a corona electrode whose discharge portion has linear extent, mounted in said head in operative relation to said duct to charge the particles in said stream, means for moving the electrode in the head to bring different areas of its discharge portion successively into charging position, means for cleaning said electrode, a precipitating unit having a passageway therethrough into which the charged particles pass from the duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

6. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a corona electrode, whose discharge portion has linear extent, mounted in said head in operative relation to said duct to charge the particles in said stream, means for moving the electrode in the head to bring different areas of its discharge portion successively into charging position, a packing chamber having cleaning means therein through which the corona electrode travels in its movement, a precipitating unit having a passageway therethrough into which the charged particles pass from the duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

7. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a corona electrode whose discharge portion has linear extent mounted in said head in operative position at one side of said duct to charge the particles in said stream, said corona electrode comprising a charging corona wheel rotatably mounted in said head, means for rotating the wheel to bring different parts of its

periphery into operative relation to said duct to charge the particles in the stream, a precipitating unit having a passageway therethrough communicating with said duct into which the charged particles may pass from the duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

8. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a corona electrode whose discharge portion has linear extent mounted in said head in operative position at one side of said duct to charge the particles in said stream, said corona electrode comprising a charging corona wheel rotatably mounted in said head, means for rotating said wheel to bring different parts of its periphery into operative relation to said duct to charge the particles in the stream, a cleaning chamber through which said wheel passes in its rotation, a precipitating unit having a passageway therethrough communicating with said duct into which the charged particles may pass from the duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

9. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a corona electrode mounted in said head in operative relation to said duct, said duct being widened laterally opposite said corona electrode, a precipitating unit having a passageway therethrough into which the charged particles may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

10. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a plurality of corona electrodes mounted in operative relation to and spaced along said stream to impart successive ionic charges thereto, a precipitating unit having a passageway therethrough into which the stream may pass from said duct and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

11. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a plurality of corona electrodes mounted in operative relation to and spaced along said stream to create successive ionic charging atmospheres through which the stream passes and the field-strength of which is greater in the latter stages than in the first stage, a precipitating unit having a passageway therethrough into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

12. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a plurality of corona electrodes mounted in operative relation to and spaced along said stream to create successive charging atmospheres through which said stream passes and the field-strength of

which increases progressively, a precipitating unit having a passageway therethrough into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

13. A recording head of the character described having a duct extending therethrough through which a mist stream containing marking particles entrained in a gas may be passed, a plurality of corona electrodes mounted in the head at one side of said duct in operative relation thereto and spaced from one another in the direction of flow of said stream, ion-attracting electrodes mounted in the head at the opposite side of said duct and insulated from one another, and means for balancing the thrusts of the attracting electrodes to prevent precipitation of droplets of mist on the walls of the duct, a precipitating unit having a passageway therethrough into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

14. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a plurality of corona electrodes mounted in said head in operative relation to and spaced along said stream to charge the particles in said stream, said electrodes being each of linear extent and being so disposed relative to said stream that their charging thrusts balance, means for moving each of said electrodes in the head to bring different areas of its discharge portion successively into charging position, a precipitating unit having a passageway therethrough communicating with said duct and into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

15. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a plurality of corona electrodes mounted in the head at one side of said duct in operative relation thereto and spaced from one another in the direction of flow of said stream, a plurality of corona electrodes mounted in the head at the opposite side of the said duct in operative relation thereto and alternating with the first-named electrodes along the direction of flow of said stream, each of said electrodes having a discharge portion of linear extent, means for moving each electrode in the head to bring different areas of its discharge portion successively into charging position, a precipitating unit having a passageway therethrough communicating with said duct and into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

16. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a plurality of corona electrodes mounted in the head at one side of said duct in operative relation thereto and spaced from one another in the direction of flow of said stream, an ion-attracting electrode mounted in one wall of said duct oppo-

site each of the corona electrodes, and repelling electrodes mounted in said one wall of the duct between successive ion-attracting electrodes, the voltage and longitudinal dimension of each repelling electrode being such as to offset the thrust on the stream of the attracting electrodes, a precipitating unit having a passageway therethrough into which the stream may pass from said duct, and means for creating an electrical field in said passageway the intensity of which is controlled in accordance with received signals.

17. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a plurality of corona chambers provided in said head at one side of said duct and spaced from one another in the direction of flow of said stream, a charging corona electrode mounted in each of said chambers, a slot-opening in the head leading from each of said chambers into the duct to permit discharge of ions from the corona electrodes into the stream, an ion-attracting electrode mounted in one wall of the duct opposite each of said openings, some of said slot-openings being narrower than others, the ion-attracting electrodes which are opposite the wider slots having lower voltages than those opposite the narrower slots, a precipitating unit having a passageway therethrough into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

18. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a plurality of corona chambers provided in said head at one side of said duct and spaced from one another in the direction of flow of said stream, a corona electrode mounted in each of said chambers, a slot-opening in the head leading from each of said chambers into the duct to permit discharge of ions from the corona electrodes into the stream, the slot-openings of successive chambers being progressively narrower in width in the direction of flow of the stream, an ion-attracting electrode mounted in one wall of the duct opposite each of said openings, said ion-attracting electrodes having progressively higher voltages in the direction of stream-flow, a precipitating unit having a passageway therethrough into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

19. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a plurality of separate corona chambers provided in said head at one side of said duct and spaced from one another in the direction of flow of said stream, an opening in the head leading from each of said chambers into the duct to permit discharge of ions from the corona electrodes into the stream, an ion-attracting electrode mounted in one wall of the duct opposite each of said openings, the several ion-attracting electrodes being insulated from one another, said duct being widened out laterally opposite each of said openings, a precipitating unit having a passageway therethrough into which the stream may pass from said duct, and means for creating an elec-

trical field in said passageway, the intensity of which is controlled in accordance with received signals.

20. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a corona chamber provided in said head at one side of said duct, a charging corona electrode whose discharge portion has linear extent mounted in said chamber, a slot-opening in said head leading from the corona chamber into the duct to permit discharge of ions from the corona electrode into the stream, means for moving the electrode in said head to bring different areas of its discharge portion successively into charging position, an ion-attracting electrode mounted in one wall of the duct opposite said slot-opening, means for supplying a solvent for the marking particles to said corona chamber to clean said charging electrode, a precipitating unit having a passageway therethrough into which the stream of charged particles may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

21. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a charging corona electrode mounted in said head at one side of said duct in operative relation thereto, to charge the particles in said stream, said charging electrode having a discharge portion of linear extent, means for moving said electrode in said head to bring different areas of its discharge portion successively into charging position, an ion-attracting electrode mounted in the head opposite said corona electrode, an insulator surrounding said attracting electrode, said insulator being porous, and the wall of the duct in which the attracting electrode and the insulator are mounted being porous also, means for forcing a cleaning fluid up through the pores of the insulator into the duct, the precipitating unit having a passageway therethrough communicating with said duct and into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

22. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a charging electrode whose discharge portion has linear extent mounted in said head at one side of said duct in operative relation to the duct to charge the particles in said stream, means for moving said electrode in said head to bring different areas of its discharge portion successively into charging position, an insulator for insulating the corona electrode from the head, an ion-attracting electrode mounted in the head opposite said corona electrode, an insulator for insulating the attracting electrode from the head, a precipitating unit having a passageway therethrough communicating with said duct and into which the stream may pass from said duct, an insulator for insulating the precipitating unit from the rest of said head, means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals, one, at least, of said insulators being porous, and means for

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forcing a cleaning liquid through the pores of said insulator.

23. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a charging corona electrode, whose discharge portion has linear extent, mounted in said head at one side of said duct in operative relation thereto to charge the particles in said stream, means for moving said electrode in said head to bring different areas of its discharge portion successively into charging position, an ion-attracting electrode mounted in the head opposite said corona electrode, means for supplying a cleaning solvent to said duct to remove marking particles deposited on the walls of the duct, a precipitating unit having a passageway therethrough communicating with said duct and into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

24. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, said duct being recessed, a charging corona electrode positioned in said recess above the direct line of flow of the stream, an ion-attracting electrode mounted in the wall of the duct opposite the corona electrode, a precipitating unit having a passageway therethrough into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

25. A recording head of the character described comprising means for entraining marking particles in a gas, a duct through which a stream containing the entrained marking particles may be passed, a charging corona electrode, whose discharge portion has linear extent, mounted in said head at one side of said duct in operative relation thereto to charge the

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particles in said stream, means for moving said electrode in the head to bring different areas of its discharge portion successively into charging position, ion-attracting means in the opposite side of said duct, said duct being enlarged beyond the electrode charging area to provide a mixing chamber for the charged particles, a precipitating unit having a passageway therethrough communicating with said duct and into which the charged particles may pass from said mixing chamber, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

26. A recording head of the character described having a duct extending therethrough through which a stream containing marking particles entrained in a gas may be passed, a plurality of charging corona electrodes mounted in operative relation to said duct, an ion-attracting electrode mounted at the opposite side of the duct to each of the charging electrodes, said charging electrodes being adapted to produce ionic currents progressively decreasing in the direction of stream-flow, said attracting electrodes having attracting electrode voltages progressively increasing in the direction of stream-flow, a precipitating unit having a passageway therethrough into which the stream may pass from said duct, and means for creating an electrical field in said passageway, the intensity of which is controlled in accordance with received signals.

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