

June 18, 1968

J. A. ENGSTROM ET AL

3,389,398

HIGH SPEED PRINTING APPARATUS

Filed Oct. 17, 1963

3 Sheets-Sheet 1

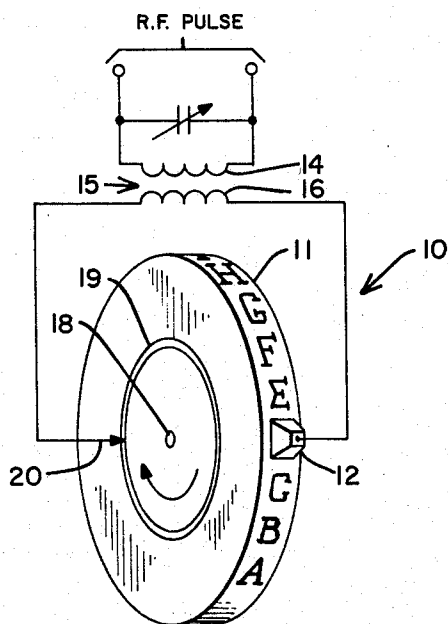


Fig. 1

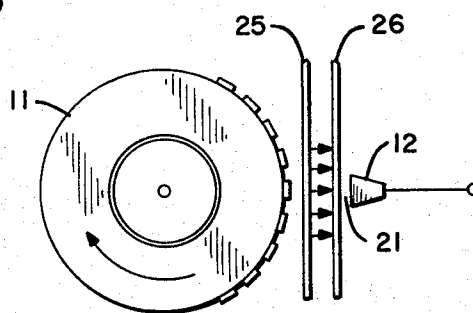


Fig. 2

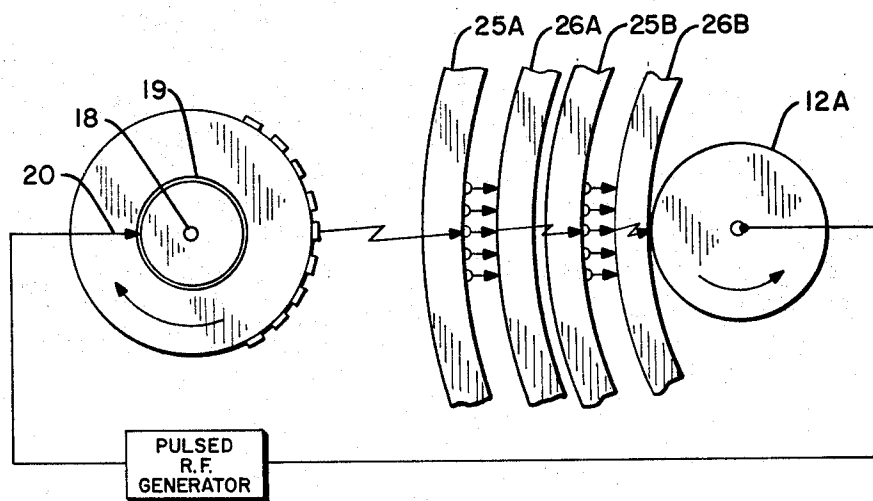


Fig. 3

INVENTORS
JOHN A. ENGSTROM
ERWIN G. WEBER

BY *Erwin M. Haugen*
ATTORNEY

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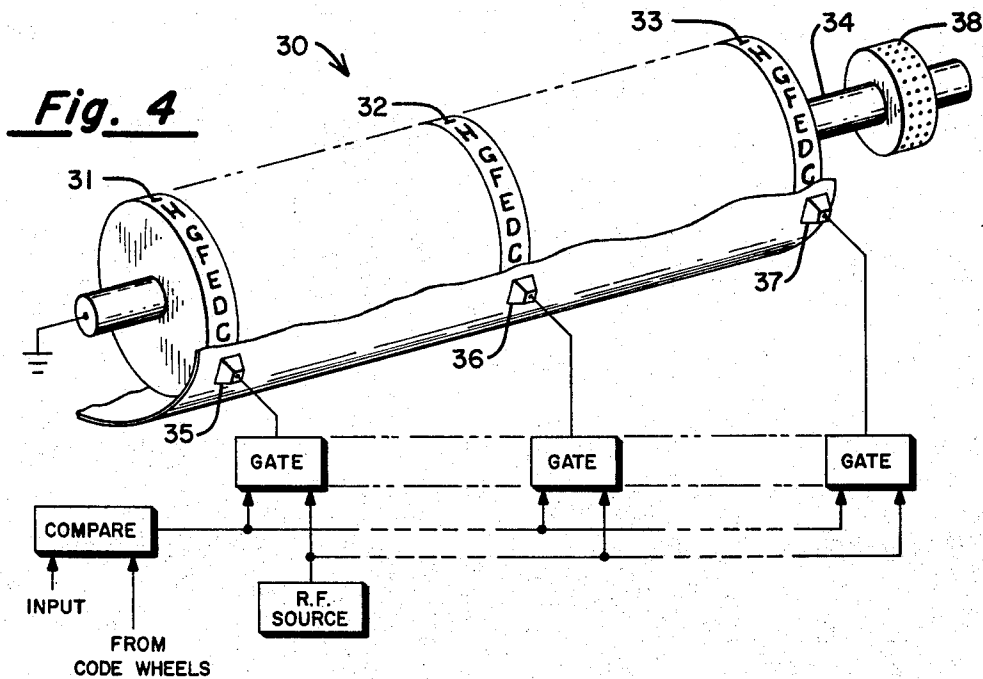
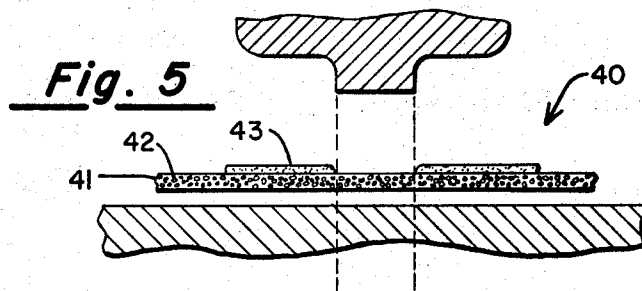
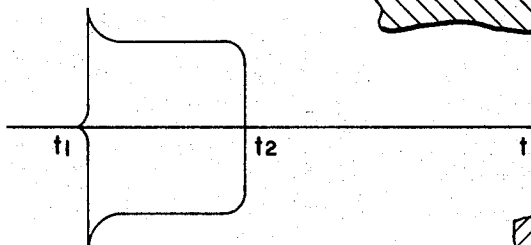
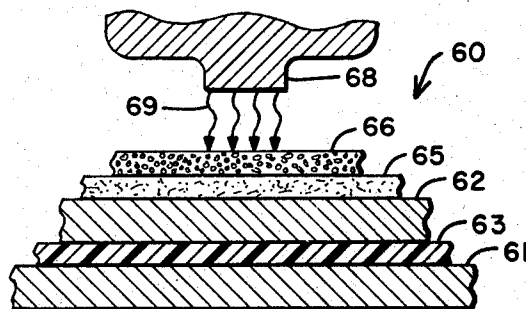
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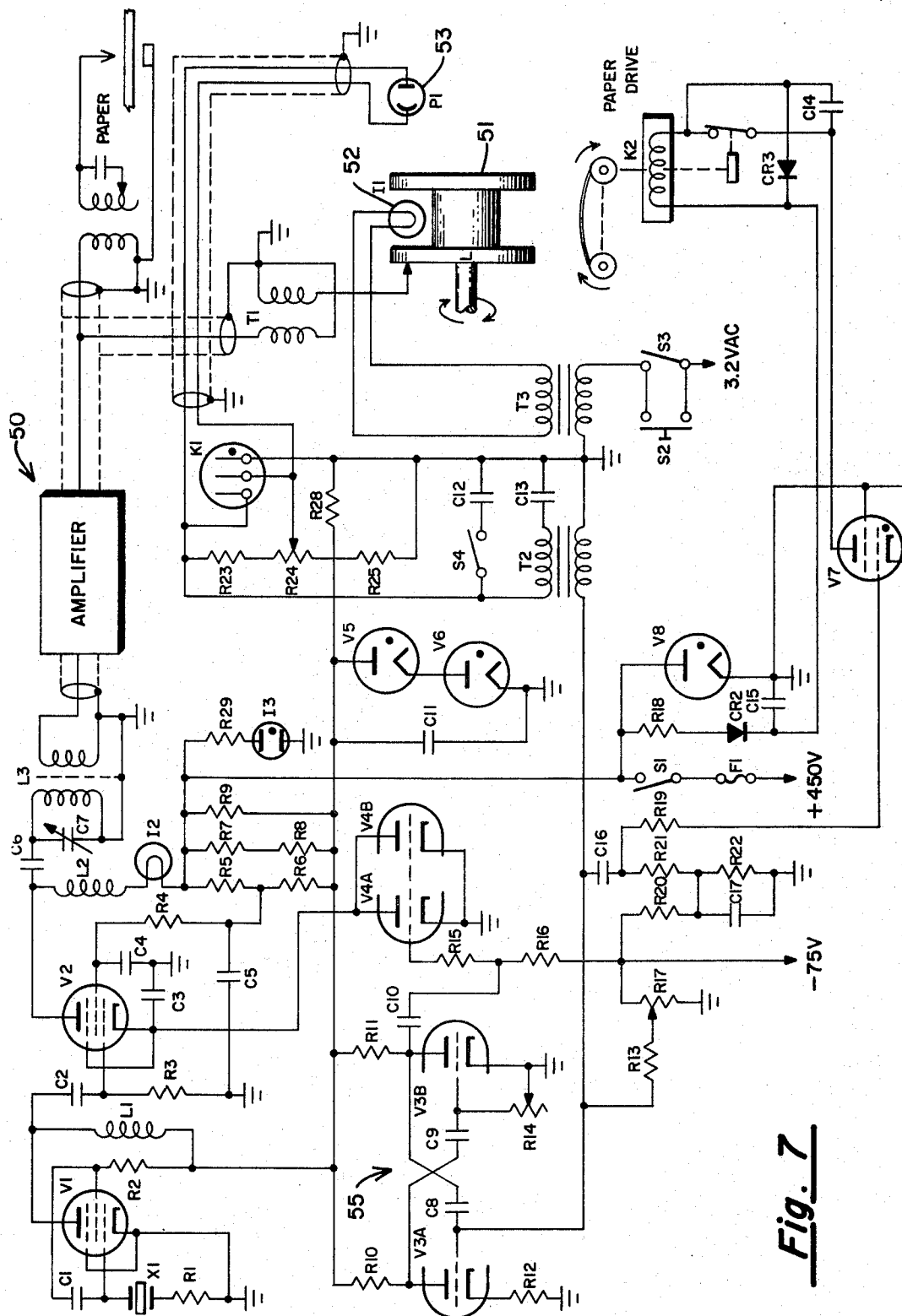
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J. A. ENGSTROM ET AL

HIGH SPEED PRINTING APPARATUS

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3,389,398

HIGH SPEED PRINTING APPARATUS

John A. Engstrom, Minneapolis, Minn., and Erwin G. Weber, Bad Homburg vor der Hohe, Germany, assignors to Sperry Rand Corporation, New York, N.Y., a corporation of Delaware

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6 Claims. (Cl. 346—74)

ABSTRACT OF THE DISCLOSURE

An R.F. plasma printing apparatus which is designed to print indicia on a suitable recording means such as paper. The apparatus utilizes a specific brush transitional discharge which exists between the spark and arc stages but which is terminated prior to the arc stage.

The present invention relates generally to an apparatus and technique for inscribing information on a medium such as paper or the like, and more specifically to an extremely high speed device of this type which utilizes an electrical discharge phenomena for forming an image, character or symbol on a record member. The electrical discharge phenomena employs a specific form of pulse which is particularly adapted to establish a brush type electrical discharge between the energized character element and the record member, the discharge being extinguished prior to its being transformed into an arc.

At the present time, many types of high-speed data processing systems are available. It is frequently desired to record the processed information as two dimensional characters on a permanent or semi-permanent medium, the most convenient form of documentation being the printing of the information on a record member or medium such as paper or the like. Data processing systems have become highly complex and reliable devices which are capable of handling data at extremely high rates of speed, and one significant barrier to operating at higher rates of speed is the rate at which the processed data may be read out of the equipment and processed as a permanent or semi-permanent record. Accordingly, any enhancement in the speeds possible in the preparation of these records from the output would obviously enhance the operation of the entire system. In other words, unless the speed of the preparation of a permanent or semi-permanent record is enhanced, it is impossible for the user to achieve the full advantage of any increased speed of the entire data processing system. While it is sometimes possible to store the output of the computer system until such time as the printer is available for recording, substantially smaller storage and more reliable systems may be utilized if the rate of printing out the information is increased.

One currently known technique for preparing permanent records relates to the preparation of latent images which must be subsequently developed or processed in order to render the image visible. This technique suffers from the disadvantages of requiring additional operations and their accompanying stages, and further from the aspect of the delays encountered in rendering the image visible. Immediate print-out is available in connection with the present invention.

The use of an electrical discharge for preparing a permanent or semi-permanent image on a recording medium has been employed for various purposes in the past. Electrostatic techniques utilizing DC power supplies with suitable triggering sources have also been utilized. In addition, corona and arc techniques have also been employed. The electrostatic systems utilizing DC are not entirely satisfactory inasmuch as relatively high DC fields are necessary to suitably perform the operation. The use of

2

an arc to perform the work necessary to prepare or inscribe an image is considered somewhat unsuited to the task inasmuch as large area arcs are difficult to control without the danger of encountering local hot spots or the like throughout the character, image or the like. The corona discharge is essentially unsuited for high speed operations inasmuch as insufficient power is available to form a useful image, character or the like, the corona discharge having no practical high speed printing capability. In accordance with the present invention, a multi-channel, filamentary discharge which is characteristic of a brush or transition type discharge is used for forming the printed image. The brush discharge state is a transitional type discharge which exists at an interval of time between the corona discharge state and the arc discharge state.

The brush discharge comprises a plurality of closely spaced individual sparked channels which transcend the electrode gap under the influence of a high potential field existing thereacross. It is the use of this transitional zone which is responsible for the dissipation of sufficient energy to perform the printing operation in accordance with the present invention. The existence of any spark as a transitory, discontinuous electrical equilibration process across an electrode gap will depend not only upon the medium carrying the spark, the gas, but also on the circuitry which supplies the energy to the gap. Inasmuch as the gas available in the gap is normally atmospheric air, the circuitry supplying the energy to the gap will become pertinent. Accordingly, at the preferred frequency range of from about 4 mc. to about 10.5 mc., energy application is possible for only between about 50 micro-seconds and 60 micro-seconds. This arrangement has been found proper for establishing the brush type of transitional discharge.

The energy dissipated in the discharge process is manifested in the surrounding gas as a shock wave with a bright luminous phenomena and also with sound energy in the form of audible cracks, hisses, etc. The greater the quantity of heat available in the spark gap, the higher the light emission of the channel and the faster the channel travels across the gap by pre-ionization of its path through its own emitted ultra-violet photons and resulting photo-electrons. The time necessary for the preparation of channels for a break-down across the gap is defined as the formative time lag, this being the total time necessary to develop or initiate a spark. The formative time lag reduces sharply with an increase in the gap-over-voltage; the over-voltage being the excess over that certain minimum voltage which is required to establish a spark across the gap. The existence of space charges and high-frequency potentials each have a profound influence upon the formation and types of sparks available. In very high frequencies, certain sluggish ions become immovable and the electrons travel many more times across the gap. In this situation, the ionization probability is increased. It has been found, however, that spark charges are not active in the early stages in the build-up of the spark, and the formative time lag is due largely to the time required for currents to grow to space-charged-producing magnitudes. At each sparking event, there is also a statistical time lag, however, this statistical time lag is insignificant when frequencies and voltages are very high and when pre-ionizing devices such as radio-active elements or the like are employed.

It has been determined that moderately high frequencies such as is in the range of from between about 4 mc. and 10.5 mc. are ideal for producing a high energy discharge which is particularly suited for printing operations. At these frequencies it has been learned that the discharge is predominantly electronic in nature, however, sufficient heat is dissipated in order to give the printing arrangement disposed across the gap a directional character in-

3

cluding the transmission of the shock wave or the like. The fast rise time experienced at these frequencies appears to cause the simultaneous breakdown of a plurality of channels across the gap. The polarity reversal at these frequencies is believed to be sufficient to sweep out space charges and the discharge is interrupted at substantially the point in time at which the discharge is in the spark-to-arc transition stage. In other words, this discharge is interrupted prior to the time at which the electrodes become heated, and thereby become subject to sublimation, and also subject to commencing a slowly extinguishable, inertia-laden arc. However, the energy dissipated is sufficient and adequate to provide a powerful shock wave across the gap which is sufficient to accomplish the printing operation. In addition to the RF energy being employed across the gap, it is possible to combine this with a direct current pulse and extend the frequency range beyond that set forth hereinabove, particularly with regard to higher frequencies.

The particular recording media employed may comprise an ordinary permanent or semi-permanent recording paper having conventional carbon impregnated tissue paper such as a carbon-copy paper interposed between the individual layers thereof. The carbon-coated paper serves as a medium from which the mark is transferred onto the blank recording paper, the selective transfer of carbon from the carbon copy paper being obtainable under the influence of a momentary RF discharge from an appropriately selected alphanumeric character electrode. The impact of the carbon onto the record paper provides sufficient adherence to render the copy permanent or semi-permanent in nature.

Therefore, it is an object of the present invention to provide an improved information recording system which utilizes an electrical discharge to transcend (between or through) a gap area with a recording medium being interposed therein, the discharge being a non-burning RF discharge which remains alive for a certain predetermined interval of time, the discharge being permitted to progress beyond the corona stage, but being extinguished as it reaches the brush transition region prior to its forming an arc between the electrodes.

It is a further object of the present invention to provide an improved recording system which utilizes a relatively high energy electrical discharge between a pair of spaced electrodes, a recording medium being interposed between the electrodes, the discharge being characterized in that it dissipates an unusually high quantity of energy, and is non-burning in nature.

It is yet a further object of the present invention to provide an improved information recording system which employs an electrical discharge across a gap area existing between a pair of electrodes, the discharge being in a controlled frequency range, and existing for a certain controlled interval of time, the electrode means including a plurality of raised, alphanumeric characters, selecting means being adapted to energize certain preselected electrodes at certain predetermined points of time.

Other and further objects of the present invention will become apparent from a study of the following specification, appended claims, and accompanying drawings wherein:

FIG. 1 is a perspective view of a single stage printer fabricated in accordance with the present invention, and illustrating in addition thereto a simplified schematic diagram of associated electrical circuitry;

FIG. 2 is a side elevational view, partially in section, and showing, in exploded form, the device illustrated in FIG. 1, and in addition thereto, showing a medium for preparing and accepting printed material thereon;

FIG. 3 is a side elevational view of a slightly modified form of the present invention, and illustrating in combination with the printing device, a plurality of sheets of a recording medium for the simultaneous preparation of a plurality of copies;

4

FIG. 4 is a perspective view of a printing apparatus made in accordance with the present invention and illustrating a ganged print wheel assembly combination with a mating group of ganged cooperating electrodes, and further illustrating circuitry which may be utilized for use in connection with the printer of the present invention;

FIG. 5 is a partial sectional view of a character from a print wheel together with a cooperating electrode, and illustrating a printing medium disposed therebetween;

FIG. 6 is a plot of the pulse form which is preferably utilized in accordance with the present invention;

FIG. 7 is a schematic diagram of a preferred circuit for generating the pulses for use in connection with the practicing of the present invention; and,

FIG. 8 is a front view, partially in section, of a somewhat modified front electrode arrangement and used in connection with the present invention.

In accordance with the preferred modification of the present invention, particular attention is directed to FIG. 1 wherein the printing system generally designated 10 is illustrated, the system including a printing or type wheel 11 having a plurality of raised character indicia thereon, the wheel being provided with a second or mating electrode 12, the electrode 12 being disposed in closely spaced relationship to the individual faces of the individual type characters. A circuit is established to provide a potential difference between the face of the wheel and the second electrode as shown schematically in FIG. 1. Energy from the RF source is connected to the primary winding 14 of the transformer 15, the secondary 16 forming a circuit through the type wheel and the second electrode. In other words, the secondary of the transformer is adapted to set up a high intensity field across the gap which exists between the face of the electrode 12 and the surface of the individual characters on the type wheel 11. The wheel 11 is adapted to rotate about the axis 18, suitable sliding contact existing between the circuitry and the contact band 19 as indicated at 20.

In operation, an ordinary sulfate or bond paper together with a conventional carbon impregnated or coated carbon-copy paper is placed in the gap area indicated in FIGURE 2 at 21 between the surface of the individual characters on the wheel and the surface of the second electrode. In practice, this distance is between about 4 mils and 10 mils, and preferably of the order of 8 mils. Upon rotation of the wheel, together with simultaneous vertical movement of the recording medium and associated carbon impregnated paper, appropriately timed pulses are applied to the primary transformer in order to establish a suitable field between the type face and the cooperating counter electrode when the desired indicia is opposite the electrode. It is preferred that the peripheral velocity of the type wheel 11 be substantially in excess of the rate of speed of movement of the recording paper and carbon paper in order that the vertical disposition of the individual letters will be substantially uniform across a document. Stated another way, the wheel must rotate sufficiently rapidly so that the inter-line spacing is substantially uniform, one to another, regardless of the circumferential location of the specific letter which may be actuated in the individual cycle. Another way of obviating this feature of the operation of the apparatus would be to intermittently move, control or pulse the movement of the carbon paper and recording medium paper as it traverses the gap between the type wheel and the second electrode.

The nature of the pulse form applied to the electrodes is shown at FIGURE 6, the shape shown there having been found to provide a desirable printing characteristic. The intensity of the potential differential of a field existing between the type face and the counter electrode is preferably between about 1500 volts and 2000 volts peak-to-peak for a gap distance of about 8 mils. The frequency of the pulse is between about 4 mc. and 10.5 mc., the duration being between about 50 and 60 microseconds. For a pulse of this description, the electrode wheel is 5 inches in diameter, is preferably rotating at a speed about

600 r.p.m., with the paper moving at a speed compatible for one line per revolution of printing.

Turning now specifically to FIGURE 2 of the drawings, it will be seen that the discharge between the face of the character on the wheel and the second electrode dissipates sufficient energy along its path in order to be able to dislodge carbon particles from the carbon impregnated paper 25 and cause them to impinge upon the surface of the recording media or paper 26. In this regard, the pattern formed on the recording paper is distinct, possesses fine line definition, and is substantially as permanent as the paper per se.

Turning now to FIGURE 3, it will be observed that the system shown therein is generally similar to the system as illustrated in FIGURES 1 and 2, the exception being the inclusion of a plurality of sheets of recording paper and carbon impregnated paper for the preparation of multiple copies. For purposes of clarity, the numbering system used in connection with FIGURES 1 and 2 has been preserved as much as possible. Where indicated, an alphabetical suffix may be employed. In addition to the multiple sheets of recording media, a rotating second electrode is employed in lieu of a separate drive means for controlling the movement of the paper between the printer electrode and the counter electrode. The energy for establishing the discharge between the electrodes is provided by the pulsed RF generator, where indicated.

Turning now to FIGURE 4, the printer generally designated 30 includes a plurality of ganged or parallelly operated character printers. The individual characters include a plurality or complete line of axially disposed alphanumeric characters along with their associated electrodes, only a portion of which are shown in the interest of clarity. The characters are preferably arranged uniformly along the surface of the cylinder and are provided with a suitable identification code or signal grouping system which runs in synchronism with the alphanumeric characters, and preferably is coaxial therewith. In this regard, each of the individual character wheel areas 31, 32, and 33 are disposed in axially spaced relationship along the shaft 34, along with and in cooperatively disposed relationship with each of the individual counter electrodes 35, 36, and 37 respectively. The identification code or signal grouping is shown in the code wheel as at 38. Thus, suitable circuitry as is well known in the art may be employed in the compare block to compare the signals received from the input line signal and the code wheel. When the comparison is obtained, each appropriate gate or gates is enabled and an energy pulse from the RF source is permitted to pass through the gate and timely perform the writing function. The gate and the comparator are preferably electronic devices such as those which are commercially available, no particular or unusual structure being required. Apparatus of this type are well-known in the art. The recording paper and carbon impregnated paper are arranged to pass through the discharge zone at a substantially constant rate, the paper being carried along by suitable driven reels or the like. The reels and drive schemes therefor are conventional, well known in the art, and are commercially available. Since the angular rate of rotation of the printing wheel is fast relative to the rate of movement of the record paper, the printer may be arranged to print an entire line with each revolution, or may be alternatively arranged to print a portion of the characters only at each revolution. Upon completion of the required number of revolutions for accomplishing the printing operation, the paper continuing to move, the printing cycle is interrupted until the paper has traveled a sufficient distance to accommodate the next succeeding line of print. If desired, an intermittent drive means may be employed for the record paper, the paper remaining stationary while the printing wheel is engaged in the printing cycle.

For convenience, the printing pulse is preferably applied to the counter electrode only, the wheel being main-

tained at ground potential. In this regard, the electrical discharge will occur across the gap where and when desired, the gap distance being maintained at a minimum for the selected character on the wheel at point of printing. Printer wheels of this type are commercially available, and well known in the art. It will be appreciated that one may energize specific character areas on a rotating wheel if desired, and satisfactorily accomplish the printing operating in that manner. However, due to certain design considerations, insulation barrier problems and the like, the approach most readily suited to practice is to periodically and appropriately energize each of the specific counter-electrodes, as indicated. Attention is now directed to FIGURE 5 wherein a sensitive paper is illustrated. The paper, generally designated 40, is particularly adapted for use in connection with the present invention, and comprises a base substance 41 which is impregnated with a material 42 which contrasts in color with the outer opaque coating material 43. For example, convenient contrasting impregnating material 42 may be finely divided carbon, and a conventional contrasting opaque material 43 may conveniently be powdered zinc oxide or the like. The white zinc oxide coating is selectively removed by the RF discharge, revealing as a print, a black alphanumeric image of the character electrode. This method is particularly suitable for varied high-speed printing, and for producing simultaneous, multiple copies. It is possible to obtain as many as four copies simultaneously without requiring any unusual treatment.

The zinc oxide is applied as a continuous unbroken layer to the surface of a highly porous carbon-transfer paper. The zinc oxide powder may be mixed with a nitrocellulose binder, acetone being used as a solvent, the mixture being applied to the surface of the carbon-transfer paper with brush, roller, or other suitable coating technique. It will be appreciated that no unusual post-processing, developing, heat treating, fixing, or powder adhering technique is necessary. The zinc oxide coated paper permits a further advantage in that only one sheet is necessary for each copy desired, rather than the two which are required if an intermediate carbon-transfer paper is being utilized for providing the contrast.

Attention is now directed to FIGURE 7 of the drawings which illustrate schematically a signal generating system which is specifically adaptable to energize in the printing system in accordance with the aspects of the present invention. This exciter network is comprised of a 4-mc. crystal-controlled oscillator, amplifier, and control circuit. The latter is a single-shot multivibrator that regulates the pulse duration of the keyer tube from 50 microseconds to 6 milliseconds, as desired. The oscillator portion of the circuitry is disposed along the upper left-hand portion of the schematic illustration of FIGURE 7, the amplifier portion being disposed to the right thereof. The control circuit utilized may be any conventional scheme compatible with the system, such as a conventional comparator or the like. One system that may be utilized to provide pulses of RF power is shown at the right-hand portion of FIGURE 7. The revolving wheel is shown at 51 which is adapted to interrupt the path of light between the lamp 52 and the photocell 53. The energy on the photocell controls the pulse duration by controlling the energization of the multi-vibrator portion of the circuitry as shown generally at 55. The speed of rotation of the wheel, together with the aperture dimensions in wheel 51 control the length of time that the multi-vibrator is actuated, and thus the duration of the RF pulse across the printing gap. It will be realized that other techniques may be employed to trigger the mechanism to provide the pulse desired, and the specific technique is merely one possible scheme which has been found to be suitable for use in connection with the system.

Reference is made to Table 1 below which indicates a list of suitable component parts for the exciter network and printer.

Table 1.—Parts list for exciter and printer

C1	.005.
C2	100 μ fd.
C3	.005.
C4	.005.
C5	8 mfd. 250 volt.
C6	.005.
C7	Variable 12–20 μ fd.
C8	.002.
C9	.002.
C10	.01.
C11	.03.
C12	1.
C13	.25.
C14	8 mfd. 250 volt.
C15	500 mfd. 200 volt.
C16	330 μ fd.
C17	.02.
C18	.01.
C19	.01.
R1	56K.
R2	22K.
R3	22K.
R4	100.
R5	6.8K.
R6	6.8K.
R7	6.8K.
R8	8.2K.
R9	5K.
R10	22K.
R11	68K.
R12	3.3K.
R13	470K.
R14	1 Meg. pulse width.
R15	68K.
R16	1 meg.
R17	50K threshold E.
R18	11.8K.
R19	100K.
R20	220K.
R21	27K.
R22	33K.
R23	15 meg.
R24	5 meg trigger E.
R25	15 meg.
R26	1 meg.
R27	5 meg. trigger rate.
R28	500K threshold E.
R29	270K.
V1	6AG7 oscillator.
V2	6146 amplifier.
V3	5963 multivibrator.
V4	6AS7 keyser tube.
V5	0B2.
V6	0A2.
V7	2D21.
V8	0B2.
I1	Lamp 1615.
I2	Lamp 47 plate current.
I3	Lamp neon.
P1	922 photo tube.
L1	100 μ h.
L2	2.5 μ h.
L3	Variometer RF gain.
T1	H.V. RF transformer.
T2	Pulse transformer.
T3	6.3 to 110 v. filament trans.
S1	H.V. switch.
S2	Momentary trigger.
S3	Continuous trigger.
S4	Repetition rate change.

X1	4 mc. crystal.
CR1	1N127.
CR2	1N1489.
CR3	1N1489.
5 K1	Neon relay.
K2	Rotary solenoid.
F1	0.5 amp fuse.
C8=.002 pulse width is variable from 50 to 800 μ sec.	
C8=.015 pulse width is variable from 100 μ sec. to 6 msec.	
10	The RF at Point X may be connected to stationary printers, transformers, etc.

Attention is directed to FIGURE 8 of the drawings which indicates an unusually advantageous electrode arrangement for use in connection with the present invention. In this regard, the electrode configuration generally designated 60 includes a counter electrode or a ground plane 61 and a floating electrode 62 which is separated from the ground plane 61 by thin layer insulating bodies such as polymerized methyl methacrylate or the like 63. The printing medium includes the conventional record paper 65 together with the superposed carbon-transfer paper 66. The electrode in the form of an alphanumeric character is indicated at 68, the surface of the electrode being separated from the surface of the paper by the gap area as at 69. This particular configuration has been found to yield brush transitional discharges which assist in the overall printing operation. The system provides a lower effective gap capacitance since the floating electrode is capacitively coupled to the counter electrode surface and thereby acts as a series capacitance arrangement.

In order to increase the speed of the operation, and thereby provide for shorter RF pulse durations, a ground strap may be provided along the surface of the carbon transfer paper if desired.

It has been found that when the pulse durations approach one millisecond in length, both the paper and the character electrode must move simultaneously in order to achieve legible printing. For pulse durations shorter than about 1 millisecond, only one of the two must be moving. Thus, the shorter pulse duration provides greater latitude in design considerations for the overall system.

It has been found that distortion in the characters is minimized by the use of the zinc oxide coating paper. The insulating properties of the zinc oxide appear to assist in maintaining a uniform character print. Speeds of up to 1725 r.p.m. yield legible prints with pulse frequencies of 4.5 up to 10.5 mc. For the higher speed of rotation of the character drum, it has been found that the higher frequency provides more legible print.

In order to increase legibility of the print, it may be desirable to provide a pair of alphanumeric electrodes one of which is a mirror image of the character being printed. Attention is directed to FIGURE 3 of the drawings which indicates this possible configuration, drum 12A having the mirror-images of the characters appearing on the character electrode mechanism, and revolving in synchronism therewith. In this regard the printing medium would be moved between the mating electrodes, as indicated.

What is claimed is:

1. In an information recording system comprising, in combination, recording media and printing means including a plurality of individual characters for imprinting selected ones of said characters onto said media, said printing means comprising a plurality of two-dimensional alphanumeric characters each having an electrically conductive work surface and being arranged in a matrix array, an electrically conductive reference plane having a work surface and being arranged in spaced relationship from said characters and defining a gap therebetween, energizing means coupled to the work surfaces of said characters and said reference plane for selectively applying a discharge consisting essentially of an RF brush discharge across said gap in the form of printing signal for

actuating a predetermined character of said matrix, said energizing means being adapted and arranged to apply said printing signal to said characters wherein the printing signal has a frequency range from about 4 mc. to 10.5 mc., a potential which is at least equal to the breakdown potential for said gap and is permitted to continue between the corona stage and the arc stage but is extinguished before the arc stage is developed.

2. In an information recording system comprising, in combination, recording media and printing means including a plurality of individual characters for imprinting selected ones of said characters onto said media, said recording media including a record sheet and a carbon impregnated sheet disposed adjacent thereto, said printing means comprising a plurality of two-dimensional alphanumeric characters each having an electrically conductive work surface and being arranged in a matrix array, an electrically conductive reference plane having a work surface and being arranged in spaced relationship from said characters and defining a gap therebetween, and means for moving said printing means along a path adjacent said gap, energizing means coupled to said characters for establishing a discharge consisting essentially of an RF brush discharge in the form of a printing signal between a predetermined character of said matrix and said reference plane, said energizing means being adapted and arranged to apply said printing signal to said characters wherein the printing signal has a frequency range from about 4 mc. to 10.5 mc., is permitted to continue between the corona stage and the arc stage but is extinguished before the arc stage is developed, and has a potential difference which is at least equal to the breakdown potential for said gap, the energy of said printing signal being sufficient to dislodge said carbon particles and cause them to impinge upon said record sheet.

3. In an information recording system comprising, in combination, recording media and printing means, including a plurality of individual characters for imprinting selected of said characters onto said media, said recording media including a record sheet and a contrasting color media disposed adjacent said record sheet, said printing means comprising a plurality of two-dimensional alphanumeric characters each having an electrically conductive work surface and being arranged in a matrix array, an electrically conductive reference plane having a work surface and being arranged in spaced relationship from said characters and defining a gap therebetween, and means for

moving said printing means along a path adjacent said gap, energizing means coupled to said characters for establishing a discharge consisting essentially of an RF brush discharge in the form of a printing signal between a predetermined character of said matrix and said reference plane, said energizing means being adapted and arranged to apply said printing signal to said characters wherein the printing signal has a frequency range from about 4 mc. to 10.5 mc., is permitted to continue between the corona stage and the arc stage but is extinguished before the arc stage is developed, and has a potential difference which is at least equal to the breakdown potential for said gap, the energy of said printing signal being sufficient to expose said contrasting color media on said sheets.

4. The information recording system as described in claim 3 being particularly characterized in that said gap is about 8 mils and said potential is in the range of about 1700 volts.

5. The information recording system as described in claim 3 being particularly characterized in that said frequency is about 4 mc.

6. The information recording system as described in claim 3 being further characterized in that said potential is applied for a period of between about 50 and 60 microseconds.

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BERNARD KONICK, *Primary Examiner*.

TERRELL W. FEARS, *Examiner*.

L. J. SCHROEDER, *Assistant Examiner*.