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ELECTROSTATIC INCREMENTAL DRIVE
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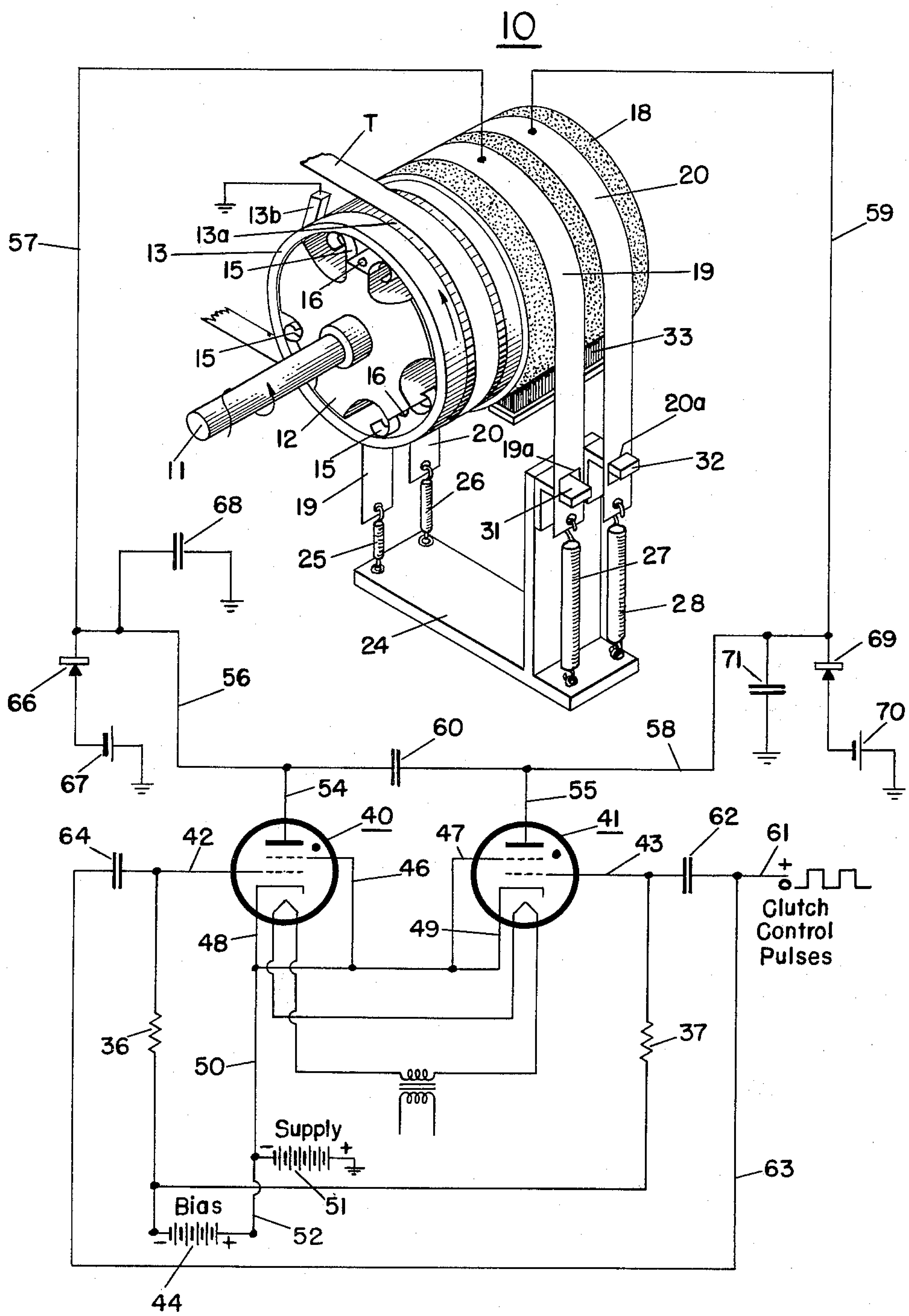

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ELECTROSTATIC INCREMENTAL DRIVE

Ralph E. Page, La Grangeville, N.Y., assignor to International Business Machines Corporation, New York, N.Y., a corporation of New York

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This invention relates to an electrostatic incremental drive unit and has for an object the provision of an electrostatic incremental drive suited for magnetic tape.

The present invention is particularly applicable to incremental or low-speed compatible tape drives for recording binary bits of information at random time intervals. In applications of this type, the magnetic tape frequently is required to be advanced in small increments of about .005 inch at rates up to 500 steps per second. While precision mechanical ratchets or escapements may perform this function, the extremely high frequency rate of operation required is not conducive to long life. The present system does not have the above limitation and is an improvement on the apparatus described and claimed in my copending application Serial No. 784,297, filed December 31, 1958. The present form of the invention is a species disclosed and generically claimed but not specifically claimed in copending application Serial No. 784,297, filed December 31, 1958 by Clyde J. Fitch and assigned to the same assignee as the present application.

It is a further object of the invention to provide an electrostatic incremental drive unit suited for high frequency rate of operation and having a long life.

It is another object of the invention to provide an incremental drive for a drive member using the electrostatic principle as a brake instead of as a driver.

In accordance with the present invention, there is provided an electrostatic incremental drive unit suited for magnetic tape comprising a rotor adapted for continuous rotation and having ring means thereon. The ring means includes a drive member for the tape and friction means is disposed between the rotor and the ring means normally to drive the ring means with the rotor. The ring means is adapted to carry electrostatic resistance material in an encircling relation and a plurality of individual brake bands extend around and in engagement with the electrostatic resistance material. The individual brake bands are adapted for selective energization alternately to lock one of the brake bands to the electrostatic resistance material for rotation with the ring means. A mechanical stop means selectively engages the brake bands to permit predetermined limited rotation of the drive member after locking one of the brake bands to the electrostatic resistance material.

More specifically, in accordance with one form of the present invention, the drive member for the tape is integral with the ring means and the electrostatic resistance material is bonded thereto. The brake bands are provided with notches or openings through which stationary stop members are adapted to extend. The stop members are smaller than the openings to permit limited movement of the brake bands with the drive member before being prevented from further rotation by engagement with the stop members. The brake bands have connected to one end thereof means for returning them to their original positions after deenergization. In the form of the invention illustrated herein, the return means has been shown as tension springs which are adapted to be elongated when the brake bands are energized and locked to the drive member for rotation therewith prior to engagement with the stop member. After a brake band is deenergized, the tension spring is effective to return the associated brake band to its original position with respect to its associated stop member preparatory to a succeeding cycle of operation.

The present arrangement is particularly suited for fast operation in that the driving and restoration of the energized and deenergized brake bands occur almost simultaneously. This is an improvement over prior arrangements where additional time was required for the slot gap in the driving ring to fully restore to its original position before initiation of a succeeding cycle.

It is a further object of the invention to provide a control for the electrostatic incremental drive unit whereby the energization periods of the brake bands overlap to delay release of one brake band while effecting gripping of the other brake band. Such control circuit is a type of multivibrator including a pair of gaseous discharge tubes having their output circuits respectively connected to the brake bands. Input pulses are supplied to the tubes to effect alternate excitation of the output circuits and means is provided for effecting delay of release of one brake band while effecting gripping of the other brake band. The delay means includes an energy storage device which discharges alternately through the gaseous discharge tubes of the multivibrator.

For further objects and advantages and for a more detailed description of the invention, reference may be had to the following description taken in conjunction with the accompanying drawing which is a schematic diagram of the present invention showing parts thereof in perspective.

Referring to the drawing, there is shown an electrostatic incremental tape drive unit **10** having a drive shaft **11** which is adapted for continuous rotation in the direction of the arrow, as by a suitable motor and gear arrangement, not shown. The shaft **11** is adapted to rotate at relatively slow speed, for example in the order of 60 r.p.m. A rotor **12** is secured to the drive shaft **11** for rotation therewith. A cylinder or ring **13** is positioned on the rotor **12** and is adapted normally to rotate with the rotor **12** by means of friction drive shoes **15** which are carried by the rotor **12** and engage the inner surface of the ring **13**. The drive shoes **15** have been illustrated as curved spring members which are secured to the rotor **12** as by screws **16**.

The ring **13** is made from an electrically-conducting material such, for example, as steel and includes as a portion thereof a drive member *13a* which serves as a capstan having a rubber surfaced track area for engaging the tape T which passes therearound. The opposite end of the ring **13** has bonded to the outer surface thereof a rim or sleeve **18** of suitable electrostatic resistance material which serves as a brake face. The electrostatic resistance material is semi-conductive, i.e., having a resistivity within the general range of 10^6 to 10^7 ohms per cubic centimeter and may be composed of a mixture of natural or synthetic rubber, an inert filler such as asbestos, conductive particles such as carbon black and a phenolic resin.

The electrostatic resistance material **18** is adapted to be engaged by a pair of brake bands **19** and **20**. The brake bands **19** and **20** are electrically-conducting and preferably are made from a flexible material such as thin strips of spring steel. The brake bands **19** and **20** are in contact with the electrostatic material **18** over an arc of 180° and the electrostatic resistance material **18** may be a single rim, as shown, or it may be divided into two separate rims each of which is engaged by the respective brake bands **19** and **20** since the material **18** acts as a pair of brake faces. One end of each of the brake bands **19** and **20** is connected to a support **24** by springs **25** and **26** respectively. The opposite ends of the bands **19** and

20 are connected to the support 24 by springs 27 and 28 respectively. The springs 25 and 26 have a relatively light tension as compared to the heavy tension of springs 27 and 28. The ends of the bands 19 and 20 adjacent the heavy springs 27 and 28 are provided with apertures or slots 19*a* and 20*a* respectively. The slot 19*a* is adapted to have inserted therein a stop member 31 and the opening 20*a* in band 20 is adapted to receive a stop member 32. Both of the stop members 31 and 32 are carried by the support 24. A brush or wiper 33 of suitable material such as mohair, may be provided to wipe the surface of the electrostatic resistance material 18 as it rotates to keep it clean.

The ring 13 is adapted to be continuously rotated by the friction drive from rotor 12 when not restrained by either of the two brake bands 19 or 20. When voltage is applied to one of the bands 19 or 20, there is established a potential difference between the electrostatic resistance material 18 and the respective brake band creating adhesion between the band and the dielectric material 18 on the ring 13 which causes the brake band to move with the ring and overcome the pull of the heavy tension springs 27 or 28 until the stop 31 or 32 arrests this movement. This movement is predetermined by the relative size of the openings 19*a* and 20*a* in bands 19 and 20 and their respective stops 31 and 32. More specifically, the movement of the ring 13 is controlled by the difference in the width of the slot 19*a* along the length of band 19 and the corresponding dimension of the stop 31. Similarly, when band 20 is energized, the movement of the ring 13 is controlled by the difference in the width of the slot 20*a* along the length of band 20 and the corresponding dimension of the stop 32. As previously described, this movement preferably is equivalent to .005 inch of capstan peripheral distance.

In the drawing, the unit 10 has been illustrated with a voltage applied to band 19 and the ring 13, which includes the capstan 13*a*, is held stationary. A suitable switching circuit is provided for alternately applying voltage to the brake bands 19 and 20. To again start movement of the capstan, a start pulse is applied to the switching circuit and voltage is immediately applied to brake band 20. The brake band 19 preferably continues to be energized for a regulated time in order to obtain maximum adhesion between band 20 and the electrostatic resistance material 18 before complete release of brake band 19. Such regulated time may be, for example, in the order of 150 microseconds. When the voltage is no longer applied to band 19, the ring 13 and capstan 13*a* will turn and drive tape T until the band 20 has been moved into contact with stop 32 similar to the relationship between stop 31 and band 19 as shown in the drawing. At this time the stop 32 will be in engagement with the bottom edge of opening 20*a* in band 20. While the ring 13 is driving the brake band 20 in the direction of the arrow, the brake band 19 will be moved in the opposite direction by the heavy spring 27 until movement of the band 19 is arrested by the stop 31. At this time the upper edge of slot 19*a* will engage the upper surface of stop 31 and a cycle of the incremental drive unit will have been completed. This arrangement provides for rapid response of the unit as the drive and restoration of the bands 19 and 20 occur almost simultaneously.

Any suitable switching circuit may be employed for selectively energizing the brake bands 19 and 20 in accordance with the foregoing sequence of operation. One suitable switching or control circuit has been illustrated in the drawing and is of the electronic multivibrator type employing two thyratron tubes 40 and 41.

The thyratron tubes 40 and 41 of the multivibrator are each provided with control grids 42 and 43 which are connected to the negative terminal of a bias voltage source 44 by way of resistors 36 and 37 respectively. The shield grids 46 and 47 are returned to the cathodes 48 and 49 respectively of tubes 40 and 41. The cathodes 48 and 49 are connected by way of a conductor 50 to a negative terminal of a suitable power supply 51, the positive terminal of which is grounded. The positive terminal of the source of bias voltage 44 is connected to the cathodes 48 and 49 by way of conductor 52. The thyratron tubes 40 and 41 are provided with output circuits which include plates 54 and 55 respectively. Plate 54 of tube 40 is connected by way of conductors 56 and 57 to brake band 19 and plate 55 of tube 41 is connected by conductors 58 and 59 to brake band 20. The other side of the brake circuits is provided with a common connection to ground by way of a brush 13*b* which engages the conductive ring 13 on rotor 12. Thus when the output circuits from tubes 40 and 41 are excited, there is established a potential difference between the electrostatic resistance material 18 and the respective brake bands 19 and 20. Between plates 54 and 55 of the thyratron tubes 40 and 41 there is connected a capacitor or condenser 60, the value of which is a function of the turn off time of each of tubes 40 and 41.

When the power of the multivibrator is first turned on, the thyratron tube 40 conducts, thus energizing the brake band 19 and locking it to the electrostatic resistance material 18 to hold ring 13 in the position shown in the drawing. When a positive brake control pulse is applied to the multivibrator at 61, it passes by way of capacitor 62 to the control grid 43 of tube 41 and by way of conductor 63 and capacitor 64 to the control grid 42 of tube 40. Since the tube 40 is already on, the control pulse will not affect tube 40 but will turn tube 41 on. Just prior to the turning on of tube 41, the charge on the capacitor 60 between plates 54 and 55 of tubes 40 and 41 respectively was equal to the supply voltage minus the voltage drop through tube 40. As soon as the tube 41 is turned on, its plate voltage drops to a lower value, thus causing the capacitor 60 to discharge. When this occurs, the plate voltage of tube 40 drops below the value required to sustain ionization and the tube 40 turns off leaving only tube 41 on. Thus it will be seen that the time required for the tube which is on to turn off depends upon the deionization time of the tube and the value of the capacitor 60. When tube 41 is turned on, the brake band 20 becomes energized and the brake band 19 remains energized until the tube 40 becomes deionized. The foregoing operation is repeated when a second positive control pulse is applied to the multivibrator at 61 thereby turning tube 40 on and turning tube 41 off. Thus it will be seen that the capacitor 60 will discharge alternately through the tubes 40 and 41 and this circuit will effect delay of release of one of the brake bands while effecting gripping of the other brake band. Stated differently, this circuit allows the on brake to remain on for a controllable time after the off brake has been turned on.

As may be seen in the drawing, the output circuit from tube 40 includes a diode 66 and a source of potential 67, the positive side of which is connected to ground. It also includes a capacitor 68, one side of which is connected to ground. Similarly, the output circuit of tube 41 includes a diode 69 having a source of potential 70 one side of which is connected to ground and a capacitor 71 also having one side connected to ground. The diodes 66 and 69 and their sources of potential 67 and 70 act as a clamping means for preventing excessive negative excursions of the thyratron plate voltage when the respective tubes 40 and 41 are turned off. The capacitors 68 and 71 likewise act as clamping means and help to minimize excessive negative excursions of thyratron plate voltage.

While the foregoing circuit for the electrostatic drive unit is of the electronic type, it will of course be understood that a similar control can be provided by other suitable switching circuits. The delay of release of one brake band while effecting gripping of the other brake band can be obtained by employing switch contacts of the type which make-before-break. Thus when the contacts of the switch are being transferred from one position to the other, the off brake band will be turned on before the on brake band is turned off.

From the foregoing description it will be seen that the present arrangement enables the driving and restoration of the brake bands to occur almost simultaneously, thus permitting the tape to be stepped along rapidly advancing the tape in .005 inch increments. When a block of information is recorded on the tape it is desirable to advance the tape a substantial distance, for example about ¾ inch before recording the next block of information. This may be accomplished by turning off both of the thyratron tubes **40** and **41** and permitting the ring **13** to rotate with the rotor **12** through the required distance before one of the tubes is again turned on for a succeeding cycle of operation.

It should be understood the invention is not limited to the specific arrangements shown herein and that changes and modifications may be made within the scope of the appended claims.

What is claimed is:

1. An electrostatic incremental drive suited for magnetic tape comprising a rotor adapted for continuous rotation, ring means on said rotor, said ring means including a drive member for engaging the tape, friction means between said rotor and said ring means normally to drive said ring means with said rotor, electrostatic resistance material carried by and encircling said ring means, a plurality of individual brake bands extending around and in engagement with said electrostatic resistance material, means for alternately energizing said individual brake bands to lock one of the latter to said ring means, mechanical stop means supported in stationary position and spaced from said ring means, said mechanical stop means being effective on said brake bands in timed relation with the energization of said brake bands to permit predetermined limited rotation of said drive member of said magnetic ring means and the associated one of said brake bands locked thereto after energization of said associated brake band, and means connected to said brake bands to return them to their original positions after deenergization.

2. An electrostatic incremental drive unit suited for magnetic tape comprising a rotor adapted for continuous rotation, ring means on said rotor, said ring means including a drive member for the tape, friction means between said rotor and said ring means normally to drive said ring means with said rotor, electrostatic resistance material encircling said ring means and bonded thereto, a plurality of individual brake bands in engagement with said electrostatic resistance material, said brake bands being energized alternately to lock one of said brake bands to said electrostatic resistance material, and mechanical stop means supported in stationary position and spaced from said ring means, said mechanical stop means engaging said brake bands in predetermined sequence to permit predetermined limited rotation of said drive member after locking one of said brake bands to said electrostatic resistance material.

3. An electrostatic incremental drive unit according to claim 2 wherein each of said brake bands has a slot therein into which said mechanical stop means is adapted to extend.

4. An electrostatic incremental drive unit according to claim 3 wherein said slots are larger than said mechanical stop means and the difference in size between said slots and said mechanical stop means determines the degree of limited rotation of said drive member.

5. An electrostatic incremental drive unit according to claim 2 including means connected to said brake bands to return them to their original positions after deenergization.

6. An electrostatic incremental drive unit according to claim 5 wherein said return means for said brake bands comprises tension springs connected to one end of said brake bands to bias said brake bands in a direction opposite to the direction of rotation of said drive member.

7. An electrostatic incremental drive unit according to claim 6 wherein said brake bands have slots therein adjacent the ends which are connected to said tension springs, and said mechanical stop means extend into said slots to limit the movement of said brake bands when they are energized and locked to said drive member and also to limit movement of said brake bands in reverse direction by said springs when said brakebands are deenergized.

8. An electrostatic incremental drive system suited for magnetic tape comprising a rotor adapted for continuous rotation, ring means on said rotor, said ring means having integral therewith a drive member for the tape, friction means between said rotor and said ring means normally to drive said ring means with said rotor, electrostatic resistance material encircling said ring means and secured thereto, a pair of brake bands in engagement with said electrostatic resistance material, means for energizing said brake bands alternately to lock one of said bands to said electrostatic resistance material comprising a multivibrator including a pair of discharge tubes, output circuits for said tubes respectively connected to said brake bands, circuit means for supplying input pulses to said tubes to effect alternate excitation of said output circuits, means for effecting delay of release of one of said brake bands while effecting gripping of the other of said brake bands, said last-named means including an energy storage device which discharges laternately through said discharge tubes of said multivibrator, and mechanical stop means effective on said brake bands to permit predetermined limited rotation of said drive member after locking one of said brake bands to said electrostatic resistance material.

9. An electrostatic incremental drive system according to claim 8 wherein said discharge tubes are thyratrons, and said energy storage device comprises a condenser connected between the plates of said thyratron tubes.

10. An electrostatic incremental drive system according to claim 9 including diode means and a source of potential connected in circuit between the plate and the associated brake band to prevent excessive negative excursions of the anode voltage of each tube as it becomes inactive.

11. An electrostatic incremental drive unit suited for magnetic tape comprising a single cylinder of electrically-conducting material, a portion of said cylinder serving as a capstan for the tape, another portion of said cylinder having a sleeve of semi-conducting resistance material thereon, a pair of electrically-conducting brake bands extending around said sleeve for engagement therewith, means for intermittently and alternately energizing said brake bands to establish a potential difference between said resistance material and said brake bands for locking the energized one of said brake bands to said resistance material, rotating means having a friction drive engaging the interior of said cylinder to rotate said cylinder and the energized one of said brake bands therewith, and means to limit movement of said energized brake band and thus limit the rotation of said cylinder and said tape capstan portion thereof.

12. An electrostatic incremental drive unit according to claim 11 including means connected to said brake bands for returning them to their original positions after deenergization.

13. An electrostatic incremental drive unit according to claim 12 wherein said means to limit movement is characterized by said brake bands having slots therein cooperating with fixed stop members, and said means for returning said brake bands to their original positions comprise tension springs connected to said brake bands, the energized brake band moving against the pull of its spring and the deenergized brake band being restored to its original position by its spring.

14. In an electrostatic drive system suited for magnetic tape having a single cylinder of electrically-conducting material, a portion of which serves as a capstan for the tape and another portion of which has a sleeve of semi-conducting resistance material thereon, and a pair of electrically-conducting brake bands extending around the semi-conducting resistance material for engagement therewith, the method of advancing the tape in predetermined

increments comprising the steps of energizing one of the brake bands to lock the band to the resistance material by establishing a potential difference therebetween, rotating the cylinder and the brake band locked thereto through a predetermined angle of rotation to advance the tape a predetermined increment, interrupting the rotation of said cylinder, and effecting delay of release of the locked brake band from the resistance material while effecting gripping of the other brake band on the resistance material.

15. In an electrostatic drive system suited for magnetic tape having a single cylinder of electrically-conducting material, a portion of which serves as a capstan for the tape and another portion of which has a sleeve of semi-conducting resistance material thereon, and a pair of electrically-conducting brake bands extending around the semi-conducting resistance material for engagement therewith, the method of advancing the tape in predetermined increments comprising the steps of energizing one of the brake bands to lock the band to the resistance material by establishing a potential difference therebetween, rotating the cylinder and the brake band locked thereto through a predetermined angle of rotation to advance the tape a predetermined increment, interrupting the rotation of said cylinder, effecting delay of release of the locked brake band from the resistance material while effecting gripping of the other brake band on the resistance material, rotating the cylinder and the other brake band through a predetermined angle of rotation, and concurrently returning the released brake band to its original position preparatory to repeating the foregoing cycle.

References Cited in the file of this patent

UNITED STATES PATENTS

1,871,272	Jongedyk	Aug. 9, 1932
2,073,983	Anderson	Mar. 16, 1937
2,338,305	Simmon	Jan. 4, 1944
2,541,013	Clutz	Feb. 13, 1951
2,568,824	Rahbek	Sept. 25, 1951
2,630,512	Rahbek	Mar. 3, 1953
2,850,907	Foster	Sept. 9, 1958
2,850,908	Foster	Sept. 9, 1958

FOREIGN PATENTS

438,860	Germany	Dec. 28, 1926

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,995,284 August 8, 1961

Ralph E. Page

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 23, for "Serial No. 784,297" read -- Serial No. 784,299 --; column 6, line 4, for "brakebands" read -- brake bands --; column 6, line 23, for "laternately" read -- alternately --.

Signed and sealed this 6th day of February 1962.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents