Oct. 11, 1938. E. W. ALLEN, JR 2,133,181

HIGH SPEED FACSIMILE RECORDING DEVICE

Filed June 18, 1935 2 Sheets-Sheet 1

Fig I

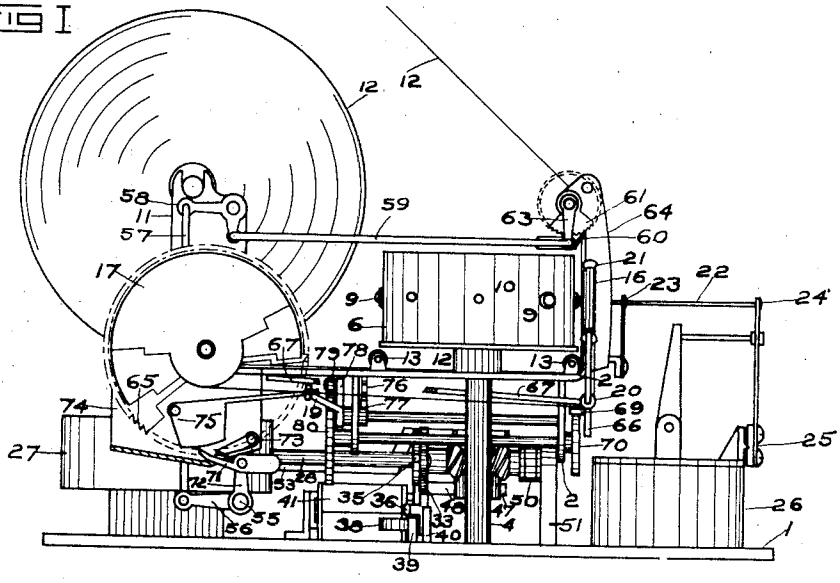


Fig V

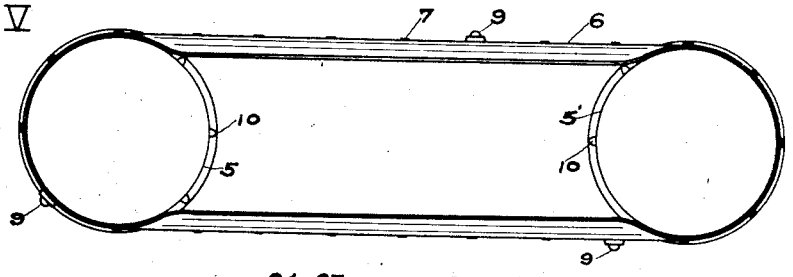


Fig IX

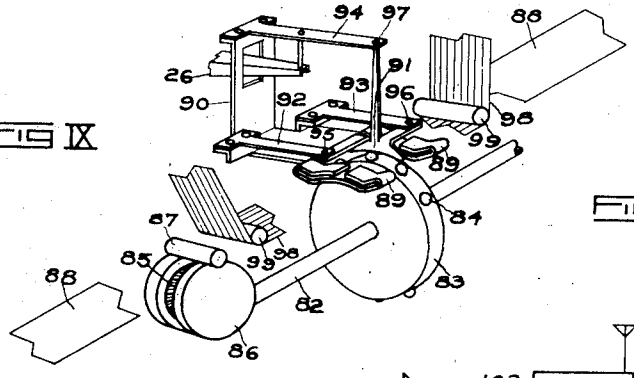


Fig VI

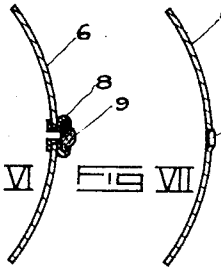
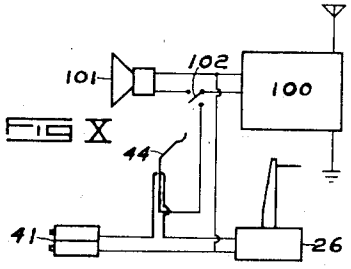


Fig VII

Fig X



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FIG II

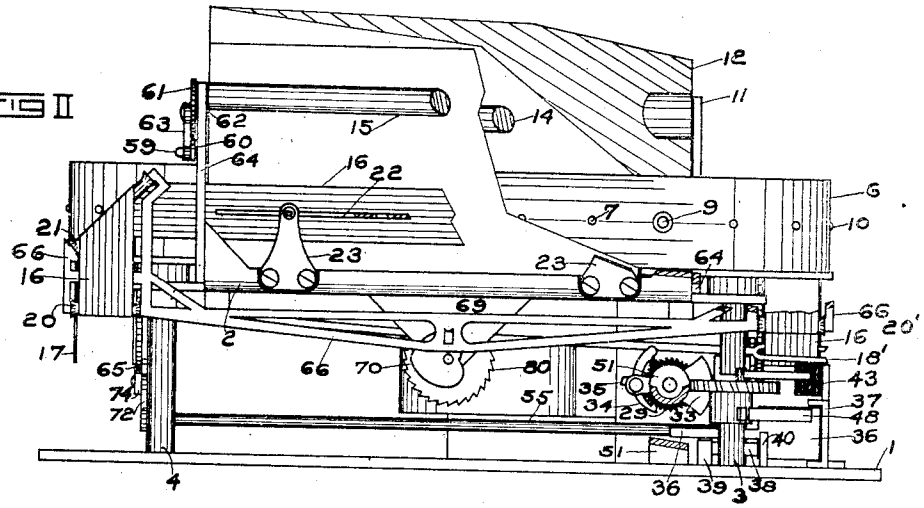
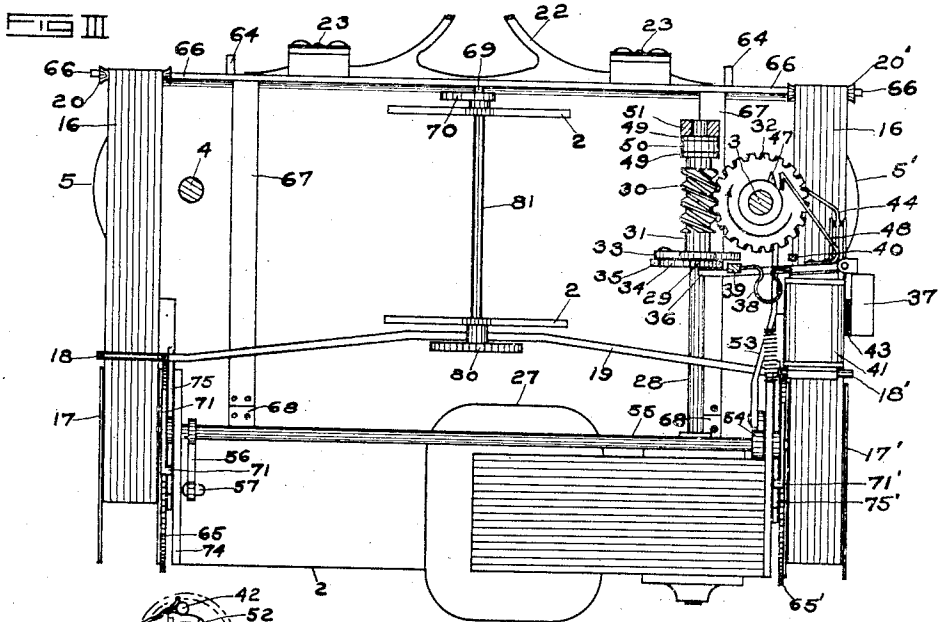


FIG III



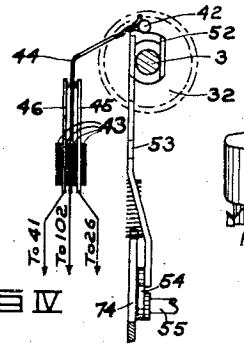


FIG IV

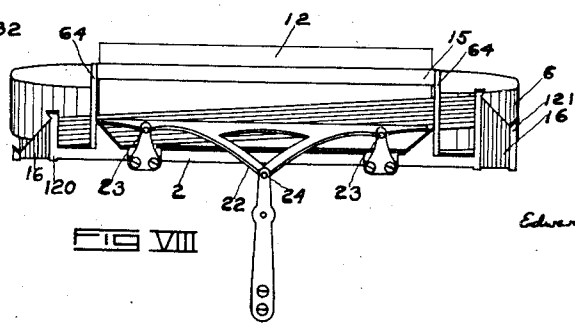


FIG VIII

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2,133,181

UNITED STATES PATENT OFFICE

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HIGH SPEED FACSIMILE RECORDING DEVICE

Edward W. Allen, Jr., Washington, D. C.

Application June 18, 1935, Serial No. 27,250

18 Claims. (Cl. 178—11)

This invention relates to improvements in facsimile recorders, and more particularly to recorders in which a signal responsive platen cooperates with a scanning member to produce a picture upon a recording sheet in accordance with received signals.

Recorders of this general type have been known heretofore and reference may be had to U. S. Patent No. 1,848,862 to Young and British Patent No. 380,217 to Triggs as examples thereof. In each of these recorders it will be noted that although the scanning direction is longitudinal of the platen, the actual movement of the scanning member is transverse to the platen. This action transverse to the platen sets both the platen and the recording sheet into rapid vibration and makes the recorder extremely noisy. This characteristic is especially objectionable when the recorder is offered for use in the home in conjunction with conventional radio receivers. A further characteristic, which is especially noticeable with a recorder having a long platen such as that shown by Young, resides in the fact that the mechanical impedance of the platen varies with the point of intersection of the platen with the scanning ridge. This is due to the fact that the platen and its supports have not heretofore been so designed as to prevent the platen from rotating about its point of contact with the scanning element. Owing to the electromagnetic coupling between the platen drive and the signal reeciving circuits, this change in the mechanical impedance results in a change in the electrical impedance which the winding of the platen drive magnet presents to the receiving circuit. This variation in mechanical impedance also makes more difficult the design of the platen supports to prevent the platen "bounce", which is characteristic of this type of recorder.

This invention further contemplates the use of a tape or ribbon, similar to those used in typewriters, bearing a marking medium which marks the recording sheet under the combined action of the platen and the scanning member. Examples of recorders which have heretofore employed such ribbons are found in U. S. Patents No. 709,158 to Kleinschmidt and No. 1,886,189 to Hough. In the patent to Hough, in which a ribbon is used in conjunction with a recording sheet greatly exceeding the ribbon in width, the facsimile stylus travels longitudinally of the ribbon, and only an elemental width of the ribbon is utilized. This results in an uneconomical use of the ribbon, a feature which this invention is designed to correct.

For assuring synchronism between the recorder and the transmitting scanner, the invention contemplates the use of a positive drive start-stop synchronizing arrangement which is an improvement upon that disclosed by U. S. Patent No. 1,985,654 to Finch.

Accordingly, it is an object of this invention to produce a facsimile recorder of the moving platen type, in which the scanning member travels longitudinally of the platen, thereby resulting in quieter operation.

Another object of this invention is to produce an extremely light but rigid scanning member against which the platen may reciprocate.

Another object is to produce a mounting for the platen which will allow the platen to reciprocate against the scanning member but will prevent rotation of the platen in its plane of reciprocation.

A further object of the invention is to produce a marking ribbon feed which will provide a more economical use of the ribbon than formerly attained by recorders of this type.

A further object of this invention is to produce an improved synchronizing arrangement of the start-stop type.

A further object is to produce a recorder embodying the above improvements which will be compact and otherwise suitable for home use.

Further objects and advantages of the invention will be apparent to those skilled in the art from a detailed description in connection with the accompanying drawings, of which:

Figure I is a profile view of a page recorder embodying the improvements of the invention.

Figure II is a broken front view of the same recorder.

Figure III is a sectional view looking upward from a point just above the base.

Figure IV is a top view of the ribbon and paper feed cam and the signal switch.

Figure V is a view of the scanning member and driving drums.

Figure VI is a sectional view of the scanning member at one of the scanning points.

Figure VII is a sectional view of the scanning member at one of the driving perforations.

Figure VIII is a perspective view of the platen mounting and of a modified ribbon feed.

Figure IX is a perspective view of a tape recorder embodying the improvements of the invention.

Figure X is a diagram of the circuit connections employed by the recorders and the manner of connecting them to a radio set.

Page recorder.—Referring to the drawings in

detail, and more particularly to Figures I to VII, a base 1 carries spaced therefrom a frame member 2. Rotatably mounted in bearings in the base 1 and the member 2 are a pair of vertically disposed shafts 3, 4 carrying fixed thereto a pair of flanged drums 5, 5'. An endless concavo-convex metallic belt 6 passes over the drums 5, 5' and assumes a cylindrical section in the space between its points of contact with the drums. Metallic tapes of this type are well known per se, one such being disclosed in U. S. Patent No. 1,402,589 to Farrand. The section assumed by this tape is shown in Figures VI and VII, and over eight or nine inch centers, forms an extremely rigid structure. The radius of gyration of such a section may be several times the thickness of the belt, whereas that of a flat belt is but a small fraction of the thickness $\left(\frac{1}{\sqrt{12}}\right)$. Since the rigidity of the belt is proportional to the square of the radius of gyration, the increase in rigidity obtained from this section is enormous. By a proper selection of the width and thickness of the belt, the normal curvature of the belt as it passes over the pulleys can be made slightly less than the curvature of the pulleys. Under these conditions the belt will hug the pulleys and give extremely smooth operation. Owing to the resilience of the belt, the driving effort is extremely small. The belt is perforated at intervals 7 equal to one eighth of the circumference of the drum 5, and is equal in length to three times the circumference of the drum. Three of the perforations, spaced at equal intervals around the belt, are larger than the rest and carry fittings 8 supporting scanning elements or styli 9. These scanning styli may be of agate, glass, steel, or any substance having wear resisting qualities. They may be steel balls with the fittings 8 fashioned to fit. The fittings 8 need not be clamped rigidly to the belt 6 but may be clamped with a slightly resilient washer adjacent the rear side of the belt to allow for flexure as the belt passes to and from the drums. Each of the drums has seven pins 10 which cooperate with the perforations 7 intermediate the scanning styli 9, and, corresponding with the position of the scanning styli, has a recess which receives the turned over portion of the fittings 8. The perforations are punched with a slight flare to enable the pins 10 to engage them smoothly and also to give the sections including the perforations the same section modulus as the intermediate sections and thus prevent buckling of the belt as it passes onto and off of the drums.

Two uprights 11 supported from the frame 2 are forked at the top to support a roll of recording paper 12. Paper from the roll passes beneath the idler rollers 13, in front of the scanning member 6, and between the feed roller 14 and the idler roller 15. An inked tape or ribbon 16 extends from a spool 17, through the fork 18 of the lever 19, over guide rollers 20, 21, across the front of the recording paper 12, to a similar set of guide rollers 20', 21', through the fork 18', and to a spool 17' upon the opposite side of the recorder. A platen 22 is disposed adjacent the forward side of the ribbon and lies in the same plane as the scanning styli 9. This platen is supported at three points, at least two of which lie in different planes spaced in the direction of reciprocation of the platen. The supports 23 and 24 are flexible in the direction normal to the plane of the recording paper but are extremely rigid in any direction parallel to this plane. This construction provides a support for the platen which will allow the platen to reciprocate in a plane normal to the recording sheet but which prevents rotation in this plane or shifting out of this plane. The static position of the platen may be adjusted by the adjustament 25, such an adjustment being necessary where optional positive or negative images are desired to be recorded from a conventional modulated tone frequency signal. The signal responsive magnet 26 which drives the platen may be of any conventional type such as used in radio loudspeakers, one very satisfactory type being disclosed in U. S. Patent No. 1,973,277 to Barfield.

Motor drive and synchronizing arrangement.—The drive for the scanning belt comprises a motor 27 having a shaft 28 to which is fixed a ratchet wheel 29. A double spiral worm 30, formed integrally with the sleeve 31, is freely rotatable upon shaft 28 and meshes with the 20 tooth worm gear 32 fixed to shaft 3. A counterweighted crank arm 33 on sleeve 31 carries a pivoted pawl 34 which engages the teeth of ratchet wheel 29 fixed to shaft 28. Pawl 34 has an outwardly extending projection or stop 35 which may be engaged by the latch 36. Latch 36 is pivoted to the frame member 37. A U shaped spring 38 is disposed between a grooved step in the latch and a grooved post 39 fixed to the base 1. This spring is under compression and gives the latch 36 a toggle action with two stable positions, one when the latch lies against the post 40 and the other when the latch lies against the pole faces of the synchronizing magnet 41. The latch may have nonmagnetic inserts opposite the pole faces to prevent freezing thereto. When the latch lies against the post 40, its tip will lie in the path of rotation of the projection 35 of pawl 34 and will release the pawl from the ratchet wheel 29, restraining the scanning mechanism and allowing the motor 27 to run independently thereof. When the latch lies against the pole pieces of the magnet 41, the tip thereof is not within this path of rotation and the motor drives the scanning mechanism unrestrained.

Slightly less than one revolution of the drums is required to move a scanning point completely across the paper, or that portion of the paper upon which platen 22 acts. As a point 9 leaves this area, a pin 42 (Fig. IV) carried by the worm gear 32 engages the cam surface of switch lever 44, causing lever 44 to open the front contact 45 and to close the back contact 46, the contact assembly being rigidly supported from the frame member 37 by the insulating members 43. This disconnects the platen drive magnet 26 from the signal source 100 and connects the synchronizing magnet 41 thereto. (Fig. X.) At the same time, cam 47 upon the hub of the worm gear 32 engages the cam surface upon the free end of the flat spring 48, which is attached to the latch 36, and tends to throw the latch against the post 40. (Fig. III.) If at this time a synchronizing signal is being received, the attraction of the magnet 41 for the latch will prevent its movement into the path of the projection 35 and the scanning mechanism will not be restrained. If no synchronizing signal is being received, the latch will be thrown into the path of the projection, releasing and restraining the scanning mechanism. In order to absorb the shock incident to restraining the scanning mechanism, sleeve 31 is provided with a thrust bearing composed of two metallic washers 49 between which is a washer 50 composed of glyptal, viscoloid, loaded rubber or the like. This thrust bearing lies against the support 51 within

which bears the forward end of shaft 28. The length of the cam 47 is such that the cam surface of spring 48 will override it just as the latch 36 restrains the projection 35. Owing to the toggle action of the spring 38, the latch will remain in this position until a synchonizing signal is received, but since the spring 48 is not now being flexed, the latch will be very quickly withdrawn upon the receipt of such signal.

Two advantages of the above construction are immediately apparent. First, the latch is not required to absorb the shock incident to restraining the scanner as has heretofore been the case. This allows an extremely light and fast latch movement which tends to increase the accuracy of synchonism. Second, by mounting the ratchet upon the high speed motor shaft, the accuracy of synchronism is increased substantially in direct proportion to the gear ratio between the motor and the scanning mechanism, since the limitation upon the number of positions which the scanner may assume with respect to the motor resides in the number of teeth in the ratchet.

The accuracy of synchronism may be further increased by sending from the transmitter a synchronizing signal of sloping wavefront. The initial amplitude of the signal will be sufficient to maintain the latch against the pole pieces of the magnet 41, but the greater final amplitude will be required to withdraw the latch from the path of the stop in the event that the scanner has been restrained. This expedient will compensate for the difference in time between the initial contact of the cam 47 and spring 48 and the arresting of the stop 35 by the latch 36. Transmitters for generating synchronizing signals having the required slope are known in the art, for example see U. S. Patent No. 1,998,812 to Hogan, but insofar as I am aware, these signals have not been used in conjunction with apparatus capable of giving the result herein disclosed.

Where the transmitter and the receiver are driven from the same or interlocked power systems, motor 27 may be a synchronous motor and may drive the scanner without the interposition of the above disclosed or other synchronizing arrangements.

Paper feed.—As the scanning points 9 pass from the recording paper, pin 42 (Fig. IV) on worm gear 32 engages the cam 52 and causes the connecting rod 53 to oscillate the crank 54 and the shaft 55. This motion is imparted through crank 56, rod 57, bellcrank 58, and rod 59 to the pawl 60 (Fig. I). Pawl 60 rotates the ratchet wheel 61 one tooth for each such movement, and the rotation is imparted to the paper feed roller 14 by means of shaft 62 to which both are fixed. Crank 63 is pivoted upon the shaft 62 and maintains the pawl 60 in engagement with the ratchet wheel 61. Shaft 62 is freely rotatable in a pair of upright supports 64 attached to the frame 2. Also freely rotatable in these supports is a shaft carrying the idler roller 15. The paper feed roller and the idler roller are so disposed that the paper issuing therefrom assumes a position convenient for reading without withdrawing it from the recorder. If desired, for convenience in dividing the recording sheet into short sections for easy handling, a serrated tearing edge, such as used in many paper dispensing devices, may be disposed above the idler roller 15, supported from the uprights 64.

Ribbon feed.—Mounted for free rotation upon opposite sides of the frame 2 are a pair of ratchet wheels 65, 65' (Figs. I–III). Conventional typewriter ribbon spools 17, 17' are rigidly fastened to the ratchet wheels by means well known in the typewriter art. As heretofore stated, the ribbon 16 passes through the fork 18, over the guide rollers 20, 21, 21', 20', through fork 18', to the spool 17'. Guide rollers 20, 21, 21', 20' are carried by a frame 66, having two rearwardly disposed arms 67 which are flexibly connected to the bottom of the frame 2 by a pair of flat springs 68. The frame 66 is supported at its forward end by a rearwardly extending pin 69 which rides upon the cardioid cam 70.

As the shaft 55 is oscillated once for each scanning line, a pawl 71, actuated from shaft 55 by a crank 72, ratchets the wheel 65 one tooth. A pawl 73, pivoted to the vertical frame member 74, prevents rotation in the opposite direction. This ratcheting action continues, moving the ribbon across the recording sheet, until the ribbon is wholly unwound from the spool 17'. The ribbon being fastened to spool 17', succeeding movements of the ratchet will tension the ribbon. Since at this time the spool 17 is full and the spool 17' is empty, this tension will cause the end 18 of the forked arm 19 to be forced downward, and the end 18' to be forced upward. This action allows the weight 75, pivoted to the frame 74, to fall and displace pawls 71 and 73 from the ratchet 65. At the same time, the end 18', rising, carries therewith the weighted member 75', allowing the pawls 71' and 73' to engage the ratchet 65'. Successive oscillations of shaft 55 will now cause the ribbon 16 to be fed in the opposite direction.

Forked arm 19 is given two stable positions by a toggle spring 76, similar to the toggle spring 38, which bears between the frame 2 and an upstanding projection of the bushing 77. Forked arm 19 has also an upstanding crank 78 which carries a pawl 79. Pawl 79 cooperates with a ratchet wheel 80 which is fixed to the shaft 81, as is the cardioid cam 70. As the forked arm is oscillated to reverse the ribbon feed, ratchet wheel will be rotated one tooth for each oscillation in a clockwise direction. The frame 66, supported upon cardioid cam 70, will assume different positions and present different longitudinal sections of the ribbon 16 to the platen 22 during successive traversals of the ribbon. By a proper design of the cam 70, substantially all of the ribbon lying intermediate the short end sections may be presented in turn to the platen.

Alternative ribbon feed.—Figure VIII shows a modified ribbon feed which has all of the advantages of the feed above disclosed, with the added advantage of a great reduction in the number of parts and a resulting simplification in construction. In this modification, the ribbon 16, instead of being fed in a direction substantially parallel to the platen 22, is fed diagonally thereacross at such an angle that the platen subtends all portions of the ribbon intermediate the ends thereof at each traversal of the latter. The ribbon guides 120, 121 are carried rigidly by the frame 2. This construction results in the elimination of elements 66 to 70 and 78 to 81. Also, since the sole function of the fork 19 is to reverse the ribbon feed, any conventional self reversing ribbon feed, such as that used in typewriters, may be substituted for that shown herein in detail.

Tape recorder.—A tape recorder employing scanning styli that move longitudinally of the platen and employing also the improved platen mounting is shown in Figure IX. A shaft 82, driven either synchronously or by means of a

start-stop synchronizing arrangement such as above disclosed, carries a wheel 83 having scanning styli 84, equal in number to the number of scanning lines allotted to the symbols to be recorded. The distance between successive scanning styli in the series is equal to the height of the symbol, and the space between the end styli is such as to give the proper spacing between symbols. Driven from shaft 82 by the worm gear 85 are a pair of tape feed rollers 86, with which the idler roller 87 cooperates to grip the tape 88. Upon each side of the wheel 83 is a tape guide 89 of such dimensions that the tape 88 fits snugly therein, but may still be drawn therethrough by the feed rollers 86. The tape guides are so designed that they impart a corrugated section to the tape as it passes over the scanning wheel 83, the central corrugation having a cylindrical section of radius equal to the radius of rotation of the styli 84 and a width equal to the distance between scanning styli. The tape guides are supported from a frame 90, from which the platen 91 is supported by three spring strips 92, 93, and 94. The connection of the strips 92 and 93 to two oppositely disposed arms 95 and 96, and the connection of the strip 94 to the vertically disposed arm 97 forms a support for the platen 91 which allows free reciprocation within the plane of rotation of the scanning styli 84, but prevents rotation within a movement outside of this plane. The platen is driven through the strip 94, which may have a stiffening ridge if necessary, by a signal responsive drive magnet 26 similar to that of the page recorder. The marking ribbon 98 passes under the guide rollers 99, over the guides 89, and beneath the platen 91. The ribbon may be stepped intermittently or moved uniformly, in timed relation to the movement of the wheel 83. If a carbon paper ribbon is used, economical use may be made thereof by moving it in timed relation to the tape feed rollers 86 but at a slower speed. If an inked typewriter ribbon is used, the movement is preferably made intermittent, proper provision being made for reversal as disclosed in connection with the page recorder. Suitable ribbon feeds for a tape recorder are also disclosed by Kleinschmidt and Triggs, referred to above. If start-stop synchronism is employed with the tape recorder, the wheel 83 is synchronized once each revolution, viz., when the space between the ends of the series of scanning styli lies beneath the platen 91.

This recorder may also be adapted for double image recording as disclosed by Triggs by disposing the scanning styli at equal intervals completely around the wheel 83, making the platen 91 equal in length to twice the distance between scanning styli, and dimensioning the tape guides 89 so that an equal width of the tape is presented between the platen and the scanning styli. This expedient of recording a double image makes exact synchronism of the transmitter and the receiver unnecessary.

Circuit connections.—In Figure X is shown the circuit employed by the recorder and the manner in which the recorder is connected to the radio receiving set, where such is used as the receiving medium. For facsimile operation, the switch 102 is thrown to connect the switch 44 into the output circuit of the radio receiver 100. The operation of switch 44, alternately connecting the platen drive magnet 26 and the synchronizing magnet 41 into the circuit, has already been described. This operation is conventional and is shown by the patent to Hough, heretofore mentioned. The impedance of both the platen drive magnet and the synchronizing magnet should match the impedance of the output circuit of the receiver. The receiving circuit may be adapted for the reception of a modulated tone frequency by inserting between the switch 102 and the switch 44 a transformer and rectifier arrangement similar to that shown by Triggs.

Other modifications of the devices herein disclosed will be apparent to those skilled in the art without departing from my invention, the scope of which I desire to be limited only by the appended claims.

I claim:

1. In a facsimile recording stylus, the combination of a scanning device, a platen having a printing edge of appreciable length in the direction of scanning and with progressive elemental lengths of which the stylus is adapted to cooperate in sequence, means for moving the platen in a plane into and out of engagement with the stylus, and means comprising a belt for moving the stylus in a direction parallel to the printing edge of the platen and for supporting the stylus rigidly against the movement of the platen.

2. A facsimile recording device comprising a movable platen, a plurality of styli, means comprising a belt for moving the styli in translation across the platen and for supporting the styli rigidly against the movement of the platen, a sheet disposed between the platen and the styli, and means for moving the platen in response to facsimile signals whereby a record may be made upon the sheet.

3. A facsimile recording device as in claim 2, in which the belt is a metallic belt having a concavo-convex cross-section in the region adjacent the platen.

4. A facsimile recording device comprising a movable platen, a plurality of styli, means comprising a belt for moving the styli in translation along the platen and for supporting the styli rigidly against the movement of the platen, a sheet and a marking ribbon disposed between the platen and the styli, and means for moving the platen in response to facsimile signals whereby a record may be made upon the sheet by the marking ribbon.

5. In a facsimile recording device, the combination of a scanner, a platen having a printing edge of appreciable length in the direction of scanning and with progressive elemental lengths of which the scanner is adapted to cooperate in sequence, means for moving the platen in a plane into and out of engagement with the scanner, and means for supporting the platen so as to permit reciprocation and prevent rotation thereof in the plane of motion.

6. In a facsimile recording device, the combination of a scanner, a platen having a printing edge of appreciable length in the direction of scanning and with progressive elemental lengths of which the scanner is adapted to cooperate in sequence, means for reciprocating the platen in a plane into and out of engagement with the scanner, and supporting means for the platen comprising a plurality of members having flexibility in the direction of reciprocation and rigidity in all directions normal thereto, at least two of the members lying in different planes spaced apart in the direction of reciprocation.

7. In a facsimile recording device, the combination of a scanner, a platen having a printing edge of appreciable length in the direction of scanning and with progressive elemental lengths of which

the scanner is adapted to cooperate in sequence, means for reciprocating the platen into and out of engagement with the scanner, and supporting means for the platen comprising a plurality of flat spring members, at least two of which are rigidly supported in different planes.

8. In a facsimile device, scanning mechanism comprising a metallic tape and means for supporting and moving the tape, said tape forming between its points of contact with the supporting means a structural member whose minimum radius of gyration exceeds the thickness of the tape.

9. In a facsimile device, a scanning mechanism comprising a metallic belt and a plurality of pulleys for supporting and moving the belt, and a signal responsive platen adjacent the belt, the belt presenting a stiffness to the platen greatly in excess of the stiffness presented to the pulleys.

10. A scanning member for a facsimile device comprising an endless metallic belt which forms a plurality of parti-cylindrical sections, the axes of generation of the sections lying in two mutually perpendicular planes.

11. A scanning member for a facsimile device comprising an endless metallic belt which forms a plurality of parti-cylindrical sections, the axes of generation of certain of the sections lying in a common plane and the axes of generation of the remaining sections being perpendicular to this plane.

12. A scanning member for a facsimile device comprising an endless metallic belt bearing a plurality of raised scanning styli, said belt forming a plurality of parti-cylindrical sections, the axes of generation of the sections lying in two mutually perpendicular planes.

13. In a recording device, the combination of a recording sheet, a ribbon bearing a marking medium adjacent the sheet, a platen in cooperative relation to the ribbon to cause the marking medium to be transferred to the sheet, means for traversing the ribbon across the platen, and means for moving the ribbon after a predetermined number of traversals in a direction transverse thereto.

14. In a facsimile scanner, a start-stop synchronizing device comprising a driven member having a stop, a latch for the stop having two stable positions, one of the positions lying in the path of the stop, means controlled by the driven member for moving the latch to one of the positions upon the approach of the stop, and means responsive to synchronizing signals for moving the latch to the other position.

15. In a facsimile scanning device, a start-stop synchronizing device comprising a driving ratchet, a driven member, a pawl carried by the driven member in cooperative relation to the ratchet, a stop on the pawl, a latch having two stable positions, one of which lies in the path of travel of the stop, means controlled by the driven member for moving the latch to the position whereby it will engage the stop and release the pawl from the ratchet, and means responsive to synchronizing signals for moving the latch to the other position whereby the pawl may reengage the ratchet.

16. A start-stop synchronizing device for a facsimile scanner comprising a driving shaft, a worm in coaxial alignment with the shaft, a stop on the worm, a latch for the stop, a gear meshing with the worm, a synchronizing magnet for moving the latch out of the path of the stop, means controlled by the gear for moving the latch into the path of the stop, and a thrust bearing for absorbing the shock sustained by the worm when the latch engages the stop.

17. In a facsimile recorder having a scanning period and an underlap period during each cycle of operation, a stop for restraining the operation of the recorder, a latch for the stop, means for maintaining the latch out of the path of the stop during the scanning period, means for moving the latch into the path of the stop during the underlap period, and means responsive to synchronizing signals for preventing the movement of the latch.

18. The method of synchronizing a start-stop facsimile recorder with a transmitter which comprises transmitting for each cycle of operation of the transmitter a synchronizing impulse having time separated components of different amplitudes, utilizing all of the components to maintain the recorder in operation in the event that it is in synchronism with the transmitter, and using only the final components to initiate operation of the recorder in the event that it is at rest.

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