United States Patent

Smith et al.

[15] **3,677,554**

[45] **July 18, 1972**

[54] DUPLICATING APPARATUS FOR CASSETTES

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[21] Appl. No.: **55,419**

[52] **U.S. Cl.** .....**274/3**, 179/100.2 E, 179/100.2 Z, 226/91, 242/197, 274/4 C

[51] **Int. Cl.** **G11b 5/86**

[58] **Field of Search**.....179/100.2 E, 100.2 Z; 226/91, 226/92, 183; 242/55, 19 A, 197–200; 274/4 B, 4 C, 4 E, 4 F, 11 B, 11 C, 3

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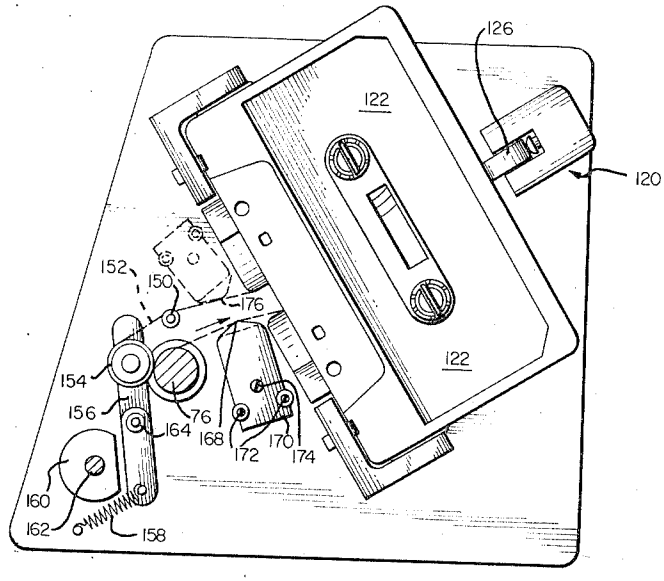
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[57] **ABSTRACT**

Apparatus for fast, high quality duplication for magnetic tape in cassettes, having mounts for the cassettes with openings for a loop of tape to extend out from each cassette and to be positively driven. The loop is positioned around a short idler and the idler is then biased against a drive mandrel common to all stations in the apparatus. At each station a transducer is located past the drive mandrel shortly ahead of the location at which the looped tape re-enters the opening of the mount.

21 Claims, 11 Drawing Figures



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4 Sheets-Sheet 1

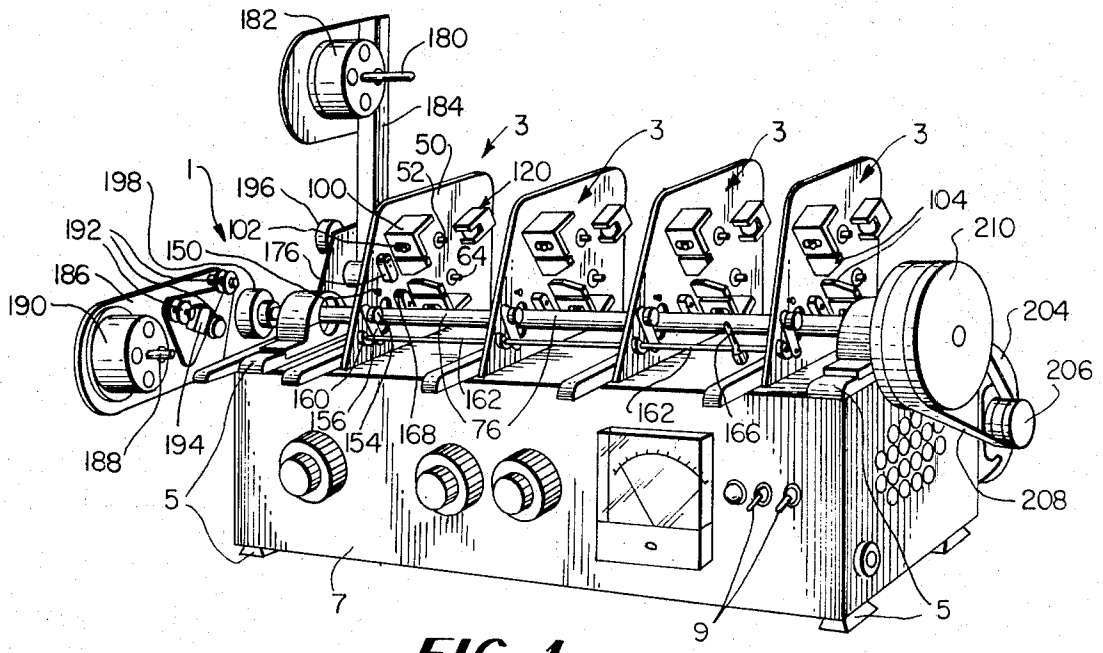


FIG. 1

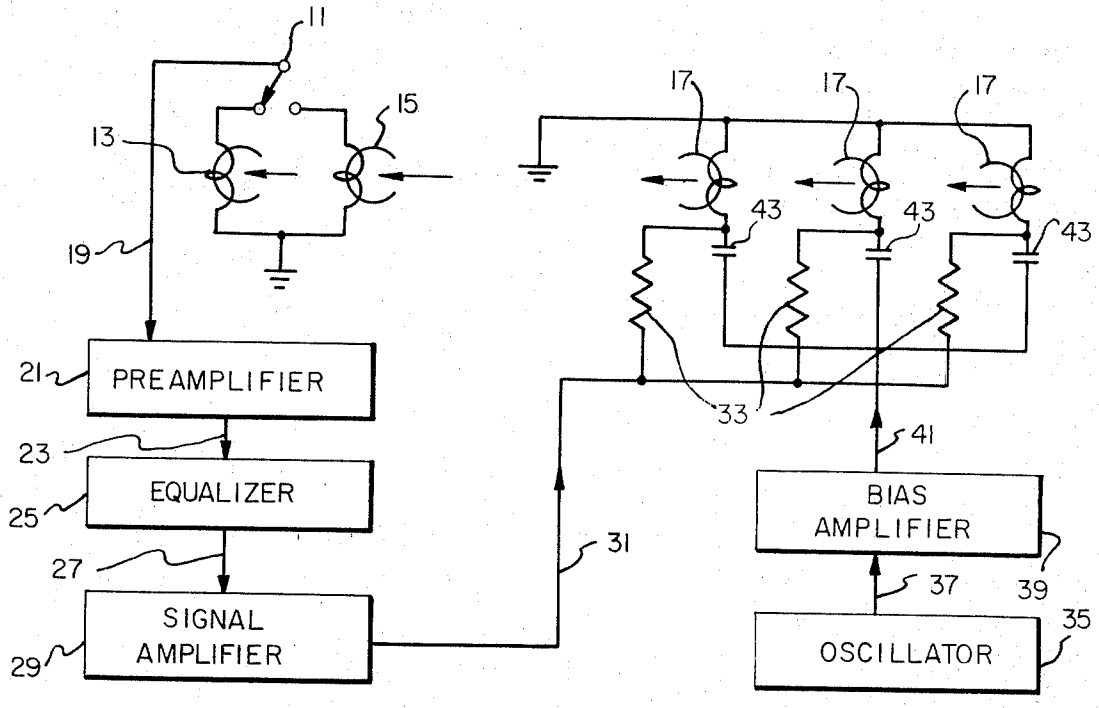


FIG. 2

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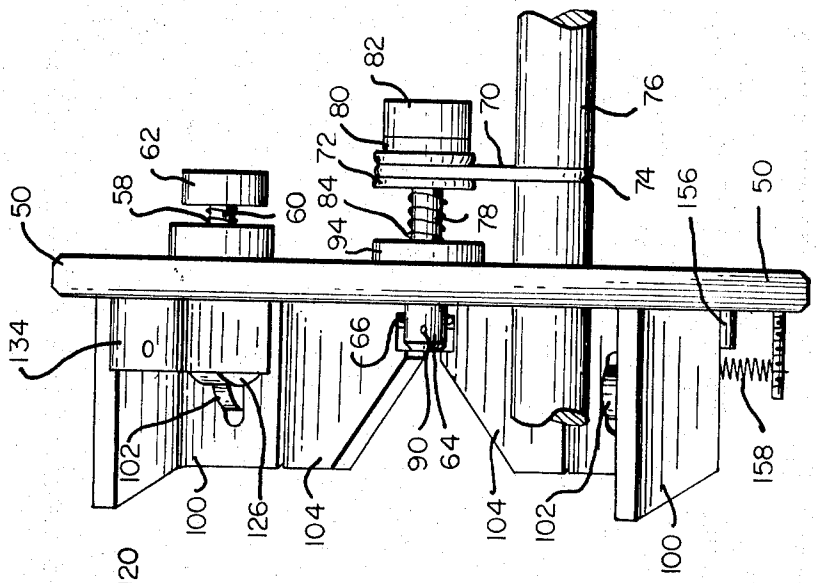


FIG. 4

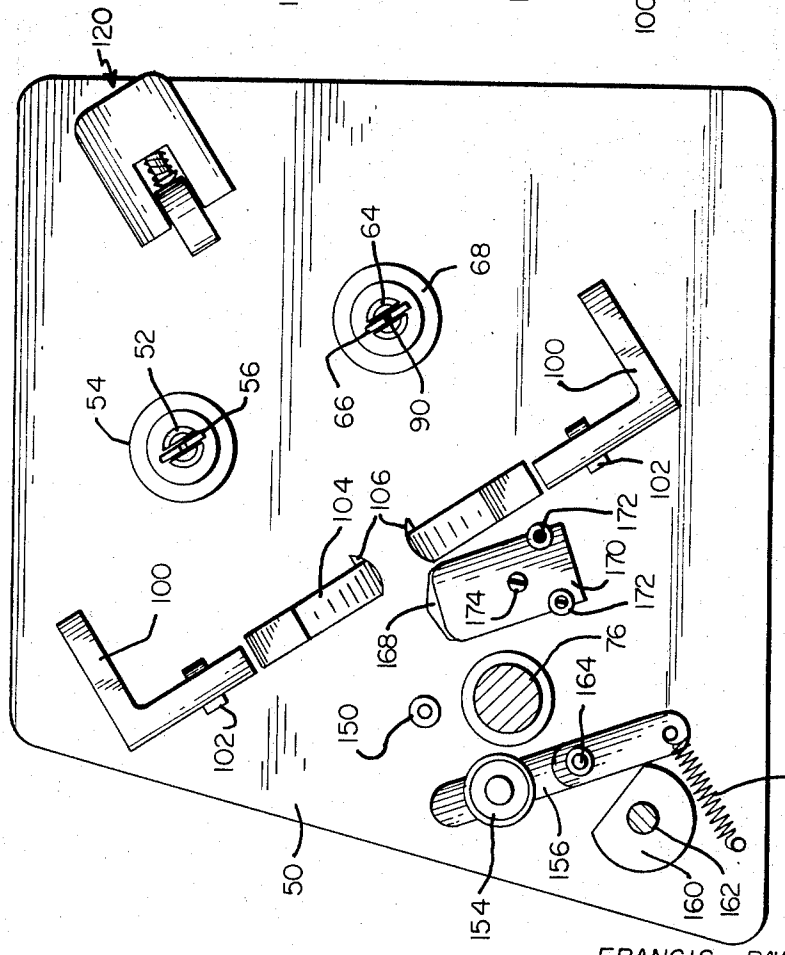


FIG. 3

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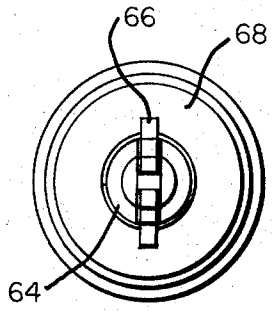


FIG. 5

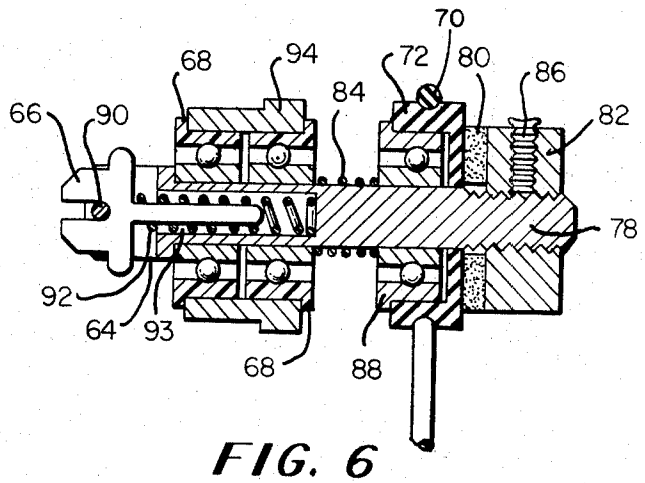


FIG. 6

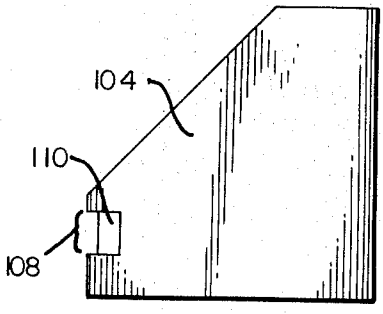


FIG. 7

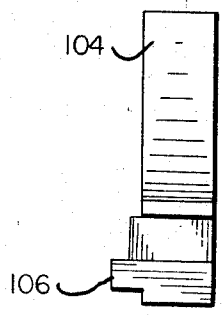


FIG. 8

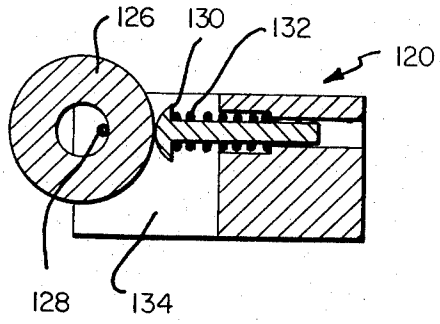


FIG. 9

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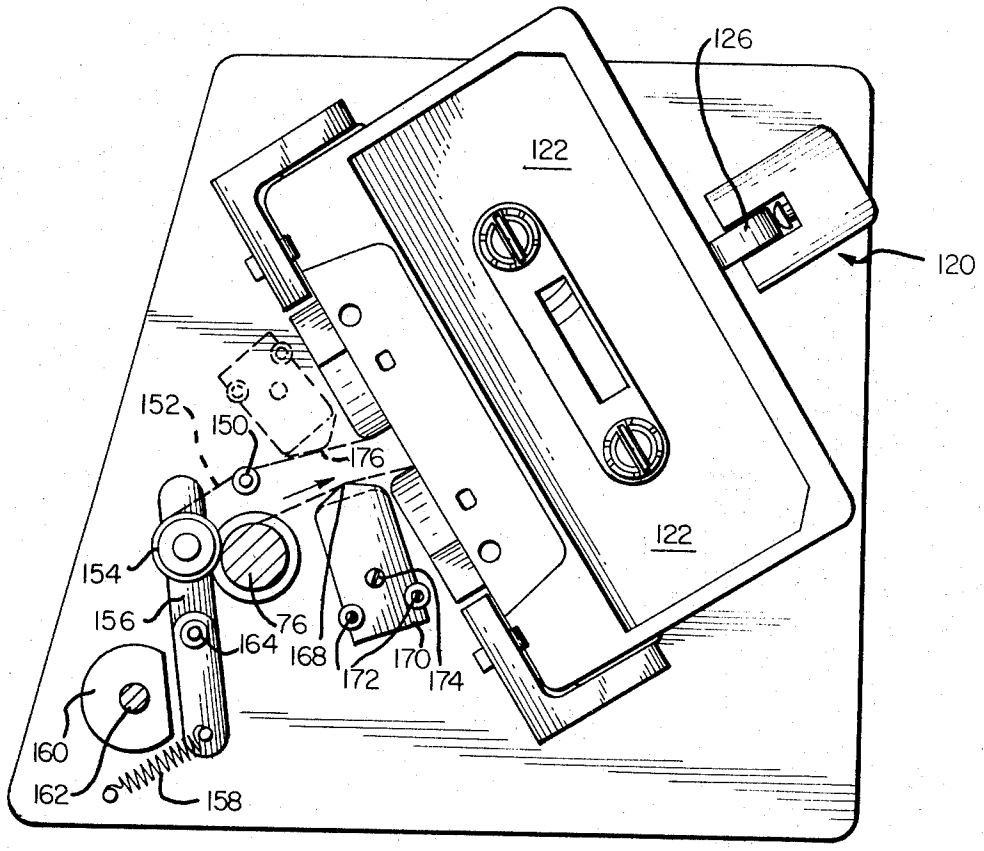


FIG. 10

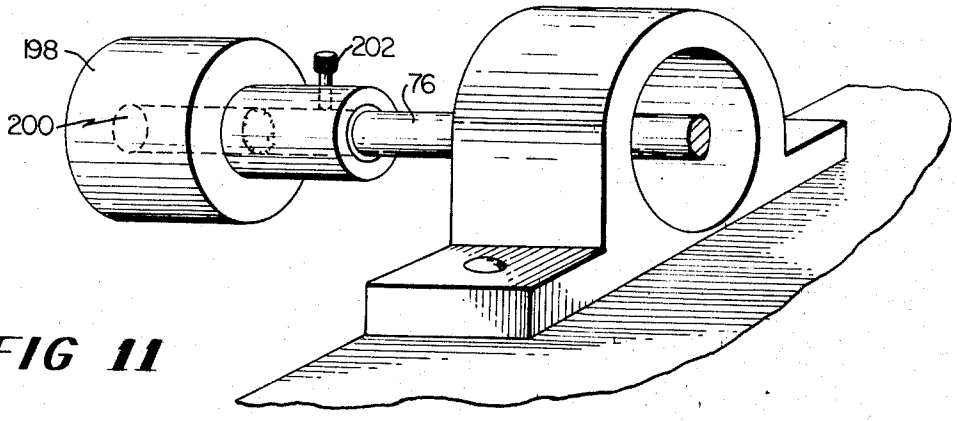


FIG 11

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DUPLICATING APPARATUS FOR CASSETTES

This invention relates to the playing and duplication of magnetic tape, primarily magnetic tapes in cassettes.

In cassettes, the two ends of magnetic tape are permanently attached internally within the cassette housing. Heretofore the duplication on to and from magnetic tape mounted into cassette-type cartridges was seriously limited by the structure of the cartridges.

The size of the reel hub openings provided in cassettes for the drive capstans limits the capstan size to approximately one-eighth inch in diameter. This small diameter greatly increases the tendency of the tape to "crawl" rather than move an amount more exactly corresponding to the movement of the associated capstan. Moreover, the small diameter results in wear in the capstan and in the drive train to the capstan being manifested by a proportionally greater timing error. A small diameter capstan is mechanically weak and rotates in an eccentric path. Eccentric rotation of the capstan contributes greatly to undulatory tape speed variations causing "wow" and "flutter", to the end that the duplicate tapes are of seriously deficient quality.

The opening provided in each cassette housing to receive the magnetic head limits the head dimensions which may be used and also the size and shape of guides for the tape inserted in the cassette opening. Such limitation prohibit accurate transverse head alignment while using the opening for insertion of the head into operative relationship with the magnetic tape. Transverse alignment is quite important to assure that registration is repeated with subsequent playing of the tape. Such registration should be very accurate and consistent to preserve the exceptionally short wavelengths included in even ordinary audio recordings as a result of the slow playback speed of cassettes. Otherwise, the high frequency response of the recordings will be poor.

Recording on cassette tapes in the normal manner entails the use of a pressure pad (often felt or the like) built into the cassette at the opening under the exposed magnetic tape. As may be readily appreciated, the pressure of such pads against the tape and head will be uneven, and consequently, the head will wear unevenly. This uneven wear results in what is commonly known as "drop-outs" in the duplicates, since the tape is not able to follow the non-linear contour of the recording head. In addition, during recording in the normal manner small amounts of tape oxide accumulate on the pressure pad, digging pits in the sensitive recording head and causing poor reproduction.

It is the primary object of this invention to eliminate the foregoing disadvantages and to make possible a number of advantages representing further important improvements in the art.

It is another primary object of this invention to provide apparatus for high quality and high speed duplication of magnetic tapes and particularly on to and from cassettes.

It is another object of this invention to provide improved apparatus to mount cassettes and to drive tapes from cassettes in operative relationship to a transducer.

It is another object of this invention to provide apparatus for driving tapes from cassettes conveniently and accurately at high speeds in operative relationship to a transducer.

It is similarly an object of this invention to provide an apparatus to make multiple copies with speed and precision on to cassettes from a master recording wound on a standard reel or from a master recording held in a cassette.

It is another object of this invention to provide selectable means to readily adjust the relative speeds of a standard reel master and a cassette duplicate so that recording on the cassette tape will be at proper speed for different master reels, each recorded for reproduction at different speeds.

It is another object of this invention to provide a duplication apparatus which may be conveniently and efficiently switched from duplication either from reels or other tape having a free end to duplication from cassettes.

It is another object of this invention to provide a high speed rewind mechanism to rewind recorded cassettes.

In accordance with this invention, a "loop-out-of-cassette" technique is employed. A loop of tape is extracted from the cassette and the cassette is placed in a mount where it is firmly held with the loop extending out of the mount. The loop is positioned around a short idler structure, and the idler structure is then moved into pressure contact with a drive mandrel or capstan. A number of such stations may be provided, with a common capstan extending to each station.

An attachment to the drive capstan where used with a master reel may be interchanged so as to present drive surfaces of different diameter. The larger diameter is used for driving tapes for which high speed is specified.

During duplication the take-up reel in the cassette is maintained in tension by a drive train which overdrives in speed, but automatically disengages at significant tension, as by slipping. High speed rewind is accomplished by reversing the cassette and allowing this drive train to operate on the tape directed freely from one reel of the cassette to the other.

This invention is similar in many respects to the subject matter represented by U. S. Pat. No. 3,177,299 and assigned to the same assignee to which this invention is assigned. Both duplicating devices use a common drive capstan driving both the master tape and copying tapes to achieve accurate synchronization and control of relative speeds among the tapes. While the duplicating device of the patent contributed greatly to the advancement of the art — enabling rapid, convenient, accurate, and extremely fruitful tape duplication and reproduction — such apparatus is not suited to the duplication of cassette tapes. The mounting and manipulation of cassettes and tapes in cassettes in accordance with this invention is not known to be suggested by any prior description or publicly used device. Similarly not known are the interchange of tape drive spindles for adaptation to proper speed, and the high speed rewind of magnetic tape by allowing an automatically disengaging clutch used as a tensioning device during recording to operate freely during rewind.

Other characteristics, objects, features, and advantages of this invention will be apparent with reference to the following detailed description of this invention as illustrated by the accompanying drawings in which:

FIG. 1 is a perspective view from a short distance away of the tape transducing apparatus embodying the present invention;

FIG. 2 is symbolic diagram of the basic electrical circuits for duplication;

FIG. 3 is a side view of a cassette station or channel;

FIG. 4 is a top view of a cassette station or channel;

FIG. 5 is a front view of the take-up spindle;

FIG. 6 is a sectional side view of the take-up spindle illustrated in FIG. 4 showing the spring bias and the slip clutch assembly;

FIG. 7 is a plan view of one cassette registration plate showing part of the guide and the nylon guide lining;

FIG. 8 is an end view of the registration plate illustrated in FIG. 7;

FIG. 9 is a sectional side view of the retainer which biases the cassette when mounted;

FIG. 10 is a side view of a cassette station or channel with cassette loaded and tape positioned in the path in which the tape is driven; and

FIG. 11 is a perspective view of the dual-diameter capstan sleeve employed at the standard reel station.

STRUCTURE

The preferred embodiment of the duplication device for playing from one master tape at one station or channel and recording simultaneously upon tapes in cassettes at other stations or channels is shown in external form in FIG. 1. Station 1 at one side is equipped to receive a standard reel of tape to serve as the master tape. The structure of station 1 is generally as described for the master station in the previously mentioned U. S. Pat. No. 3,177,299 with an exception, as will be

described in detail, of the provision of interchangeable drive members. Cassette stations 3 (four shown in this preferred embodiment) as well as station 1 are supported by frame members 5.

Frame members 5 also support a housing 7 which contains the electrical components and circuits serving the units. One of the stations 1, 3 serves as the master station at which the reel or cassette having magnetic tape carrying signals to be duplicated is played or reproduced. Designation of which of the stations 1, 3 is to serve as the master is selectable by one of the external switches 9 on housing 7 controlling the circuitry. Each of the stations 3 not selected as a master station becomes a recording unit which receives signals taken at the master station from the master tape.

The electronic circuits and arrangements are illustrated in FIG. 2 may be essentially the same as those of the prior device represented by the previously mentioned U. S. Pat. No. 3,177,299 with the addition of a switch 11 operative by external switch 9 to connect either station 1 or a pre-determined one of the cassette stations 3 as the master station. The head at station 1 has a winding 13 while the head at the pre-determined one of stations 3 has winding 15. Windings 17 are those of the other stations 3. The winding 13 or 15 operatively connected by switch 11 is in electrical circuit through lead 19 to the input of a preamplifier 21 whose output is connected by a lead 23 to the input of an equalizer 25. The equalizer output is connected by a lead 27 to the input of a signal amplifier 29 whose output is fed by a lead 31 through resistors 33 to the windings 17 of the recording heads. The output of an oscillator 35 is fed by a lead 37 to a bias amplifier 39 whose output lead 41 is connected to the windings 17 of the recording through capacitors 43.

FIG. 3 is a side view of a cassette station 3 showing the mounting plate 50 supporting supply spindle 52 which extends perpendicularly from plate 50 and spindle bearing 54. On the end of spindle 52 is reel key 56, a relatively thin member adapted to interconnect with the sprocket hub of a cassette reel. A spring 58 (FIG. 4) mounted on a shaft 60 provides a frictional drag on bearing 54, the amount of which may be adjusted by threading end plate 62 on shaft 60 toward or away from plate 50.

Similarly, a take-up spindle 64 is provided, which is equipped with a reel key 66, also suitable to mesh with the hub of a cassette reel. Spindle 64 is mounted on plate 50 by a bearing 68.

As shown in FIG. 4, spindle 64 is driven by a slip clutch assembly. A drive belt 70 is looped around the take-up spool driving plate 72 and also around retaining groove 74 in main drive mandrel or capstan 76. As best seen in FIG. 6, plate 72 rotates on a shaft 78 with its face against felt take-up clutch pad 80. Pad 80 is attached to the driven clutch plate 82.

Spring 84 on shaft 78 physically biases plate 72 toward plate 82. Clutch tension at which slipping occurs can be adjusted by threading the driven clutch plate 82 forward and back on shaft 78.

Locking screw 86 holds driven plate 82 in position. Plate 72 is mounted on ball bearings 88 and is free to move along the length of shaft 78 to a tight contact defined by the force of spring 84.

At the other end, key 66 is mounted for limited lateral movement, but is otherwise constrained by retaining pin 90. Spring 92 in slot 93 physically biases key 66 outward toward pin 90. Take-up spindle housing 94 is mounted on ball bearings 68.

Although not shown in a separate drawing, corresponding parts and arrangements of the parts associated with the supply spindle 52 are essentially the same as that shown in FIG. 6. The supply spindle 52 is, however, mounted on nylon bearing 54. Bearing 54 is attached to a housing essentially identical to housing 94. Key 56 is yieldably spring biased in a manner essentially identical to that of key 66.

As shown in FIGS. 3 and 4, mounting plate 50 has secured to it a pair of right-angle mounting guides 100, which form opposite sides and part of the base in the mount for the cassette. Journaled to the base part of each guide 100 is a round, kick roller 102.

Secured to plate 50 between guides 100 and making up most of the remaining base are registration plates 104 (also FIGS. 7 and 8). Plates 104 are spaced apart to leave an opening for a loop of magnetic tape. A pin 106 is on each plate 104, perpendicular to the plate 104 and positioned at the edge of the opening between plates 104.

Pins 106 are located at a distance from mounting plate 50 an amount just sufficient to accommodate the width of a cassette. Kick rollers 102 have a maximum height just greater than the height of pins 106 so that rollers 102 lift a cassette over pins 106 during loading.

As shown in FIGS. 7 and 8, registration plates 104 have a tape guide 108 in the form of a notch of width to just accommodate the width of the magnetic tape. Within each guide is a polished nylon insert 110 which provides, along with the small opening between guides 108 of the two plates 104, a free, smooth path for a loop of tape as it leaves the enters the cassette housing. Inserts 110 extend somewhat past the surface of plates 104 for extension into the opening of a cassette.

Retainer 120 provides pressure on an inserted cassette to hold it in place. FIG. 10 shows retainer 120 with a cassette 122 held by pressure from ring 126 of retainer 120 and by the other mounting structures.

FIG. 9 shows a sectional view of retainer 120 with the ring 126, the ring retaining pin 128, the internal plunger 130, which is biased into the ring 126 by spring 132. All are held by bracket 134, which is welded to plate 50.

As best shown in FIG. 10, an intermediate tape support guide 150 guides the magnetic tape 152 to the idler roll 154. Idler roll 154 is mounted on idler arm 156 and is of limited length, having a free end opposite arm 156 around which a loop of magnetic tape 152 may be brought. Arm 156 is equipped with a spring 158 which urges roll 154 under pressure toward capstan 76 so as to press tape 152 against capstan 76.

An eccentric cam 160 controls engagement and disengagement of idler roll 154. A cam rod 162 rotates cam 160 counterclockwise to encounter the bottom part of arm 156, which is pivoted centrally at pivot 164, and cam 160 thereby moves roll 154 counterclockwise out of close proximity to capstan 76.

Cam rod 162 is common to all stations 3, providing simultaneous actuation of cams at all stations. Rod 162 is controlled manually by control lever 166. Capstan 76 is also common to all stations 1, 3.

Tape 152 from a mounted cassette is driven by capstan 76 over the face of transducer head 168. Head 168 is mounted on a bracket 170, which is provided with two, spaced apart alignment screws 172 and position locking screw 174. The screws 172, 174 thread into mounting plate 50.

Distinguishing one of the cassette stations 3 is a second transducer head 176, mounted basically the same as head 168 and spaced a short distance above head 168. Head 176 is at the station 3 on the far left in FIG. 1, that station 3 therefore being the one selectable as a master station by external switch 9 controlling electrical switch 11 to connect winding 15 (FIG. 2). (Head 176 is also shown mounted, all in dotted outline, in FIG. 10 to illustrate its position with respect to a tape 152).

The station 1 for conventional reels serves as the master station when so selected by electrical switch 11. Station 1 includes a pay-off reel support 180 mounted on reel supply motor 182. Motor 182 provides back tension while duplicating and high speed winding for rewind.

Motor 182 is mounted on a vertical column 184, which is suitably secured to the frame 5. Also secured to frame 5 is a generally horizontally extending mounting plate 186.

The forward end of plate 186 carries take-up reel support 188, mounted on take-up motor 190. As in the previously referenced U. S. Pat. No. 3,177,299, at the end near drive capstan 76, plate 186 supports three tape guides 192 and a

reproduce transducer head 194. An idler 196 is positioned for holding a magnetic tape in contact with the capstan.

As distinguished from the prior device, station 1 is characterized by a capstan sleeve 198 which is changeable in diameter. Thus capstan 76 extends to station 1, where it terminates in a free, unobstructed end. At station 1, a dual-diameter sleeve 198 fits over the end of capstan 76.

Sleeve 198 is shown in some detail in FIG. 11, which illustrates that sleeve 198 is a single part with an internal hole 200 adapted to receive capstan 76, and having a cylindrical part of different diameter on each end. By reversal of the sleeve 198, either the large diameter or the small diameter may be made the operative drive surface at the station 1. The sleeve is held in place on capstan 76 by a knurled thumbscrew 202.

On the right of the duplication device as shown in FIG. 1 in the rear is capstan drive motor 204, which drives small pulley 206. Through belts 208, motor 204 drives large, flywheel pulley 210, to which capstan 76 is mounted.

OPERATION - SINGLE CASSETTE STATIONS

A loop of tape is first extracted from the cassette 122 by use of a vacuum tool or any other suitable means. The cassette 122 with a loop of tape protruding is placed with the side having the looped tape against the registration plates 104. The cassette 122 is positioned within the mounting guides 100 and is therefore approximately at the upright angle defined by those guides.

The cassette 122 is then slid down the plates 104 toward mounting plate 50. Kick rollers 102 are encountered and the cassette 122 rotates with rollers 102 away from plates 104 a distance which brings the cassette 122 over the retaining pins 106. The lateral motion is continued with the cassette 122 riding down the far side of the rollers 102 and the outer side end of the cassette 122 being brought to side-by-side engagement with the pins 106. Ring 126 of retainer 120 is engaged by the side of cassette 122 with the result that cassette 122 is firmly biased into contact with plates 104 and will remain in position during subsequent operation without other external support.

The cassette 122 is thus mounted, in a position parallel to mounting plate 50 and with the two tape drive hubs of the cassette registered over spindles 52 and 64. The side of cassette 122 from which the looped tape extends is against plates 104 and held laterally by pins 106.

The two spindles 52 and 64 have on their ends keys 56 and 66, which are flat and ride in a slot in the respective spindle 52 and 64 (slot 93 in FIG. 6). The protruding lobes on opposite sides of the keys 56 and 66 extend to a dimension greater than the respective spindles 52 and 64. These extended parts engage the spokes of the reels in the cassette 122, thereby keying the two reels in the cassette 122 to the corresponding one of the spindles 52 and 64.

The keys 56 and 66 are spring loaded for movement in a direction parallel with spindle axis. During loading of a cassette, should the spokes of a cassette reel coincide with the spindle key lobes, the key 56 or 66 will depress against its spring (spring 92 in FIG. 6). A subsequent motion of the spindle will then allow the key 56 or 66 to move off the reel spokes. The key spring will then push the key 56 or 66 in between the spokes, engaging the reel with the corresponding one of the spindles 52 or 64.

The retainer ring 126 of retainer 120 has a very large hole compared to the pin 128 that retains it, allowing limited free, lateral and pivotal movement of the ring 126. When a cassette 122 is mounted in the station, the top edge of the cassette 122 is presented to retainer ring 126 and depresses the ring 126. Ring 126 is then also pushed off center, but remains in contact with the plunger 130. The portion of ring 126 generally opposite the plunger 130 presses on cassette 122 with a force having a component parallel to plunger 130 and a component perpendicular to plunger 130. Since the outer radius of ring 126 is greater than the width of cassette 122, ring 126 is displaced away from plate 50 to overlap a mounted cassette, and the two components of force are directed toward registration plates 104 and back toward mounting plate 50.

During recording, magnetic tape 152 is pulled from the supply reel of cassette 122, which is mounted on spindle 52. Spindle end-play is absorbed by a spring 58 which is pressed between the side of bearing 54 and end plate 62, creating friction adequate to create a back-tension in tape 152 which prevents tape 152 from piling up on idler roll 154. This tension is adjusted to accommodate variations in friction of bearing 54 by threading plate 62 in and out on shaft 60.

The tape 152 extends from the supply reel through the guides 108, which are bounded by a polished nylon insert 110. Inserts 110 protrude into the opening of the cassette. Tape 152 can be pulled from the cassette 122 through guides 108 and is freely movable on inserts 110, by-passing the pressure pad in cassette 122. Tape damage is prevented because the tape 152 does not contact any of the irregular surfaces of the cassette.

Past the location at which tape 152 extends beyond guide 108 from the supply reel of cassette 122, tape 152 passes over intermediate guide 150. Guide 150 determines the path of the tape 152 to the idler 154 and capstan 76.

From the guide 150, tape 152 next is initially passed over the free end of idler roll 154 and subsequently tightened against idler roll 154. Roll 154 is mounted on idler arm 156 which is biased by spring 158. When the duplicating control lever 166 is operated, eccentric cam 160 allows spring 158 to move roll 154, through arm 156, into an engagement position in which tape 152 is pressed against capstan 76. This automatic response of the idler insures the desired engagement in which spring 158 will maintain proper pressure to prevent slipping of tape 152 as it is driven by capstan 76.

From the idler roll 154, tape 152 next extends to partially wrap around the drive capstan 76 before encountering the record head 168. This is a necessary feature in the preferred embodiment so that the tape path from the precision drive capstan 76 to the record head 168 will not have any rotating devices in the path which will compromise constant tape speed.

The drive capstan 76 is approximately one-half inch in diameter and, consequently, quite rigid. The eccentricity of the capstan 76 can be held very low over a long capstan. The precision obtained in the preferred embodiment allows the capstan 76 to drive a number of cassettes and a standard reel of magnetic tape in close synchronism, providing extremely low timing error between recorded copies and between copies and master. Since all tapes are driven in synchronization, any variations in capstan speed will not be reflected in the copies.

When standard reels are to be duplicated, the master tape is reproduced at station 1. The tape is driven by contact with capstan sleeve 198 under pressure from idler 196. Sleeve 198 may be positioned to present the large diameter or the small diameter to make possible duplication from standard reels recorded for different speeds of reproduction. The control hole 200 of sleeve 198 is slipped over the end of capstan 76, and knurled thumbscrew 202 is tightened to hold sleeve 198 firmly. One end of the sleeve 198 has a diameter twice the diameter of the capstan 76 which drives the cassette tapes directly. The other end of sleeve 198 has a diameter four times that of the capstan 76.

The end of sleeve 198 used is determined by the effective size required for the playing speed of the master. The duplication of a tape recorded at 7.5 ips requires a sleeve four times the diameter of the portion of the capstan driving the cassette tapes since the normal playback speed of cassettes is 1.875 ips or one-fourth of 7.5 ips.

During duplication, all tapes, both master and cassette copies, are driven at a much higher speed than their normal playing speed. Speed ratios of 8:1 are standardly used with the apparatus of this invention.

A channel 3 that normally records onto a cassette tape can be converted electrically with switch 9 to become a playing channel. In that condition, electrical switch 11 connects

windings 15, the windings of head 176, as the operative reproduction windings in the circuit. In that status, copies of a pre-recorded cassette can be made.

From the capstan 76 at the cassette stations 3 at which the tape 152 is driven, tape 152 next extends across record head 168 in close contact so as to provide an operative relationship for the transducing function. Head 168 has a face of hyperbolic contour. This contour allows the pressure of the tape 152 against the face to be concentrated on the recording magnetic path gap of the head 168. Head 168, mounted on bracket 170, is manually positioned precisely by use of adjustment screws 172. Head 168 is then locked in position with screw 174 to maintain the accurate head alignment necessary for quality reproduction.

After moving past head 168, tape 152 passes through the other guide 108 in the registration plate 104, in contact with the other polished nylon insert 110, which lines the side of guide 108 and protrudes into the cassette 122. The proximity of the take-up guide 108 to the head 168 fixes the path of tape 152 as it moves across head 168.

Tape 152 then passes on to the take-up reel of the cassette 122. The take-up reel is driven by spindle 64, linked by key 66 to the reel, in essentially the same manner as described with regard to the connection of spindle 52.

Spindle 64 is driven by a friction clutch assembly which allows spindle 64 to continuously take up tape 152 which is driven by the capstan 76 while regulating the pressure of tape 152 against the record head 168. As shown in FIG. 4, the assembly includes belt 70 looped around capstan 76 and driving plate 72. Plate 72 is pressured against and drives felt pad 80, which is attached to plate 82. Plate 82 turns spindle 64.

Upon substantial increase in force, plate 72 slips against felt pad 80, thereby terminating motion, but maintaining tension on tape 152. Adjustment of the force of contact and, correspondingly, the take-up force at which slipping occurs, is by threading plate 82 in or out on shaft 78 (FIG. 6).

OPERATION - DUPLICATION

The cam operating rod 162 is common to all stations 3. Similarly, the capstan 76 is a single shaft common to all stations 1, 3. If a cassette tape is to be the master, the cassette is loaded onto the left station 3 in the preferred embodiment illustrated, the station equipped with reproduction head 176. If a standard reel is to be the master, the reel is loaded into station 1. The tape of a standard reel master is threaded around the drive sleeve 198, through the guides 192, over the reproduction head 194, and onto a take-up reel mounted on support 188. At reel station 1, both the master channel supply spindles 180 and the take-up spindles 188 are equipped with a torque motor, 182 and 190 respectively. Supply motor 182 provides load tension during duplication and power for high speed rewind. The take-up motor 190 provides tape-to-head pressure and tape take-up power.

At least one cassette is inserted as described in a station 3. The duplicating process starts by actuation of the duplication switch control lever 166. The lever rotates cam rod 162 at all stations to cause engagement of all idler rolls 154 simultaneously. The duplication lever 166 is also connected to a switch which applies power to drive motor 204, which drives the capstan 76. That switch also applies power to the reel station 1 take-up supply motors 182 and 190.

After the duplication process is complete and the duplicating switch lever 166 is thrown to stop, power will continue to be applied to the reel channel 1 motors 182 and 190 for a brief period. This is to insure take-up of all tape that is being driven by the capstan due to the inertia of the capstan flywheel assembly as it comes to a stop.

The duplicated cassettes are then removed from the duplicator and their tape loops withdrawn manually.

Cassettes may be rewound at a high rate of speed, conveniently and efficiently without danger of harm to the tape. Cassettes to be rewound are loaded as described on stations 3, but without loops, and with the loaded reels mounted on the supply spindle 52. The duplicating switch is actuated, resulting in the take-up spindle 64, driven by belt 70 from capstan 76 operating at a speed greater than the duplicating speed since the tape is not looped through the drive structures used during a duplication operation.

As is presently available with the similar reel duplicators, the reel station 1 is equipped with at least one tape guide that has two electrical contacts spaced a short distance apart. When a length of metal foil is applied to the tape that passes through this guide, the two contacts will be electrically connected, which closes a circuit designed to stop the drive motor. In this manner an automatic stop is provided for optional use.

A commercial device in accordance with the foregoing has the following characteristics and capabilities, which, of course, are strictly exemplary as other devices in accordance with one or more aspects of this invention might have quite different characteristics.

FREQUENCY RESPONSE: For a 7.5 ips master, response is ± 1.5 db from 50 to 12,000 Hz; for a 3.75 ips master, ± 1.5 db, 50 to 8,000 Hz.

HARMONIC DISTORTION: On copies, harmonic distortion is less than 0.5 per cent at standard level, and less than 1.5 per cent at maximum output.

MISCELLANEOUS DISTORTION: Special playback and record head design, special tape guides, a bias frequency of 500 kHz and excellent waveform give virtually complete freedom from drop-outs, hiss, high frequency "tweets" and similar miscellaneous forms of distortion.

SIGNAL-TO-NOISE RATIO: Within 2 db of the theoretical limit possible for a magnetic tape recording system. Even professional playback equipment of the highest quality can detect virtually no added noise on a duplicate.

WOW AND FLUTTER: A 3,000 cycle test tape duplicated on the machine yields copies on which the measured combined wow and flutter is less than 0.3 per cent rms.

TIMING: The length of any duplicate does not vary by more than 0.25 inch in 300 feet (C60 cassette).

CAPSTAN: The common capstan/mandrel used to drive the master and all record channels results in a timing accuracy unobtainable with independently driven systems. Also, variations in mandrel speed will not produce wow and flutter on the copies since all tapes are driven in synchronization.

OUT OF CASSETTE TAPE DRIVE: With the tapes driven and recorded completely out of the cassette, all of the disadvantages of "in cassette" recordings are eliminated. The cassette duplicators employ a 0.5 inch diameter capstan, which eliminates the characteristic "tape crawl" of small capstans. All heads and drive components are free of covers and are completely accessible for ease of maintenance. Record and playback heads are rigidly mounted to preserve factory alignment accuracy.

REWIND: Cassettes are rewound at an average speed of 30 ips.

MASTER DRIVE SPEED: 7.5 ips masters are driven at 60 ips; 3.75 ips masters at 30 ips.

DUPLICATING SPEED: Duplicates are driven at 15 ips.

AUTOMATIC STOP: The cassette duplicators are equipped with a device which shuts off the equipment at the end of the duplication process.

NUMBER OF CHANNELS: The standard models has one master and four record channels.

SPACE REQUIREMENT: The cassette duplicators are only 20 × 30 × 20 inches high and can be set up on a side table or desk top.

It will be clear that parts of the device described have individual value and utility, and that many modifications and variations within the essential contribution of the invention are possible, and that the invention may be improved upon or certain features sacrificed, while basic contributions of the invention are still utilized, so that accordingly the coverage granted should not be limited to specific details and forms

described, but should be as provided by law with particular reference to the accompanying claims.

What is claimed is:

1. Tape drive apparatus comprising:
   a. mechanical means for supporting a magnetic tape cassette of the type which is adapted to have inserted therein a capstan for driving the tape enclosed in said cassette, said mechanical means comprising a support surface having an opening for said tape to pass freely through and resiliant retainer means located to contact said cassette and bias said cassette toward said support surface;
   b. guide means for guiding a portion of said tape outside of said cassette; and
   c. drive means external to said cassette and in contact with said tape for driving said tape.

2. In apparatus having a master tape station and a plurality of slave tape stations for use with a plurality of tape cassettes, each of said cassettes of the type which is adapted to have inserted therein a capstan for driving the tape enclosed in the cassette, in operative relationship with each cassette, the improvement comprising:
   a. means for removing a portion of said tape from said cassette;
   b. mechanical guide means for guiding said tape outside of said cassette;
   c. a head positioned against said tape; and
   d. drive means external to said cassette in contact with said tape for driving said tape past said head.

3. Apparatus as in claim 2 wherein said tape proceeds around said mechanical guide means.

4. Apparatus as in claim 2 wherein said drive means is a mandrel.

5. Apparatus as in claim 4 wherein said tape proceeds around said mechanical guide means.

6. Apparatus as in claim 4 wherein the mandrel is too large to fit into said cassette.

7. Apparatus as in claim 6 wherein said tape proceeds around said mechanical guide means.

8. Tape drive apparatus comprising:
   a. means for supporting a magnetic tape cassette of the type which is adapted to have inserted therein a capstan for driving the tape enclosed in said cassette;
   b. guide means for guiding a portion of said tape outside of said cassette; and
   c. drive means external to said cassette in contact with said tape for driving said tape.

9. Apparatus as in claim 8 further comprising means for providing a free smooth path for tape as it enters and leaves the cassette housing.

10. Apparatus as in claim 8 further comprising a head positioned adjacent said tape.

11. Apparatus as in claim 8 wherein said drive means is a capstan drive and said tape is removed in a loop.

12. Apparatus as in claim 11 wherein said capstan drive is a single capstan drive.

13. Apparatus as in claim 8 wherein said tape proceeds around said guide means.

14. Apparatus as in claim 13 wherein said guide means comprises a roller.

15. Apparatus as in claim 8 wherein said drive means is a mandrel drive.

16. Apparatus as in claim 15 further comprising an idler support mounted to effect pressure engagement with said mandrel drive.

17. Apparatus as in claim 15 wherein said tape proceeds around said guide means.

18. Apparatus as in claim 15 wherein said mandrel drive is a single capstan drive.

19. Apparatus as in claim 18 further comprising sleeve means attachable around said capstan to change the effective size of the capstan.

20. Apparatus as in claim 15 wherein the mandrel is too large to fit into the cassette.

21. Apparatus as in claim 20 wherein said tape is removed in a loop.

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