United States Patent [19]

Bazzy

[11] **3,744,803**

[45] **July 10, 1973**

[54] **METHOD OF AND APPARATUS FOR TAPE CARTRIDGE DUPLICATION**

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[73] Assignee: **Make-A-Tape, Inc.**, Fraser, Mich.

[22] Filed: **Dec. 7, 1971**

[21] Appl. No.: **205,625**

[52] **U.S. Cl.** ..... **274/3**, 274/4 D, 179/100.2 E, 179/100.2 Z

[51] **Int. Cl.** **G11b 15/24**, G11b 15/29

[58] **Field of Search** ..... 274/4 F, 3; 242/180, 242/181; 179/100.2 E; 226/34, 35

[56] **References Cited**

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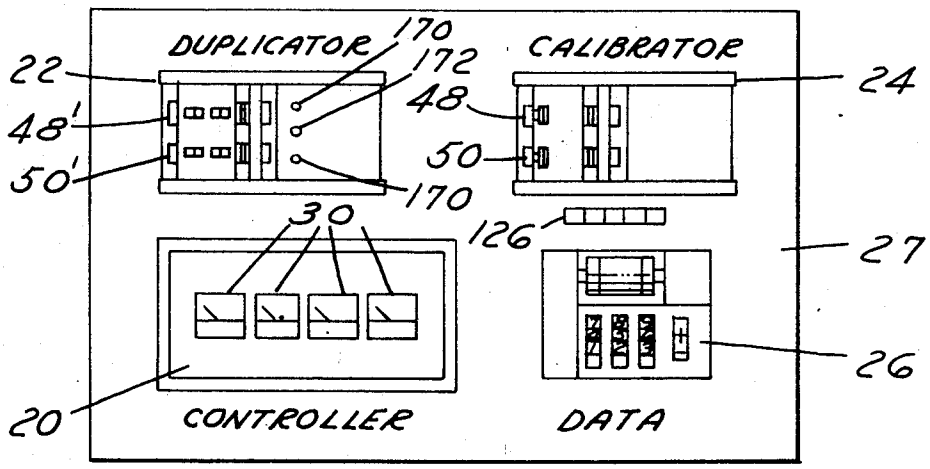
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[57] **ABSTRACT**

A method of and apparatus for measuring the length of magnetic tape contained in tape cartridges, cueing the magnetic tape in reference to the tape splice, and rapidly duplicating the magnetic signals from one cartridge on to another.

14 Claims, 12 Drawing Figures



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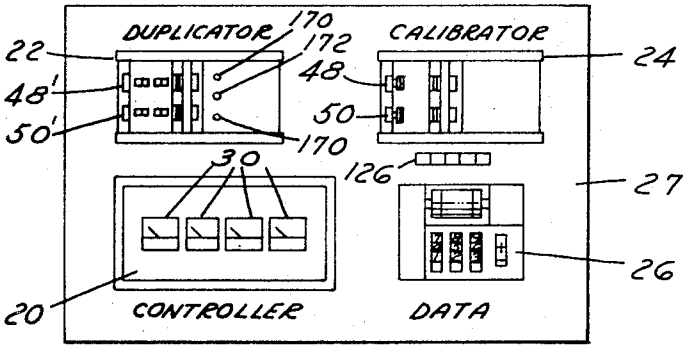


FIG. 1

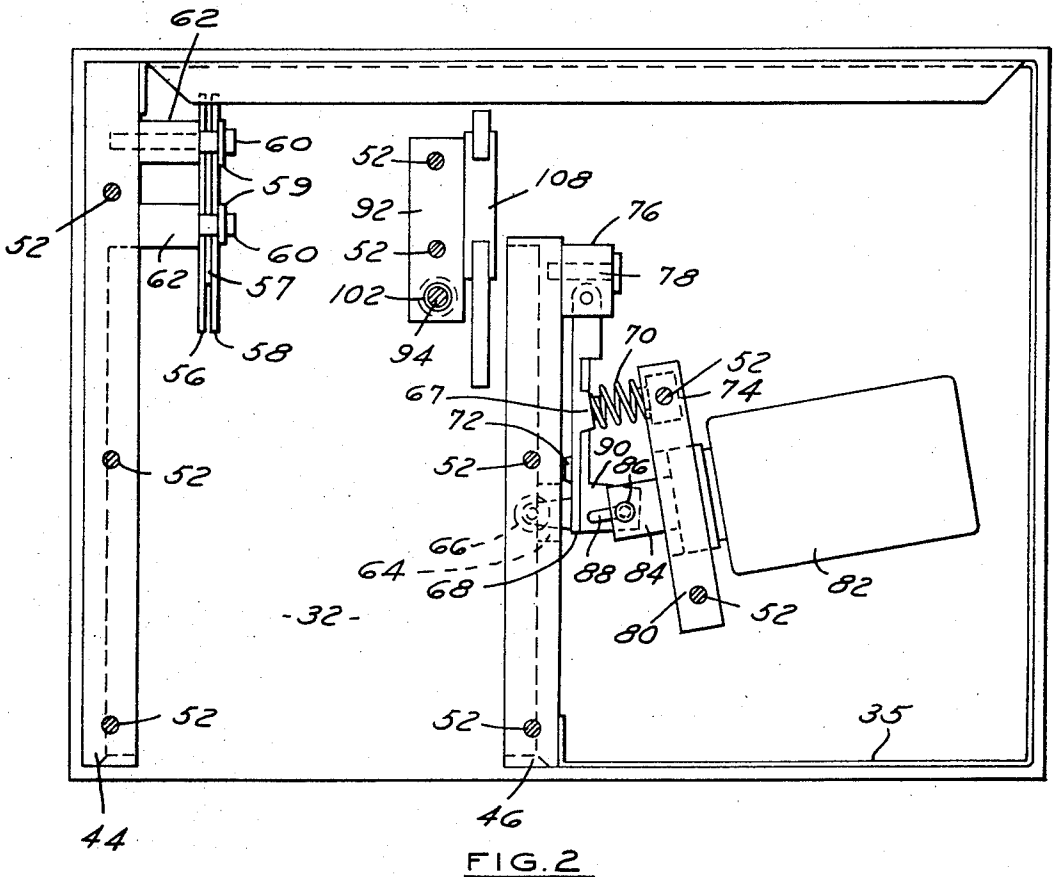
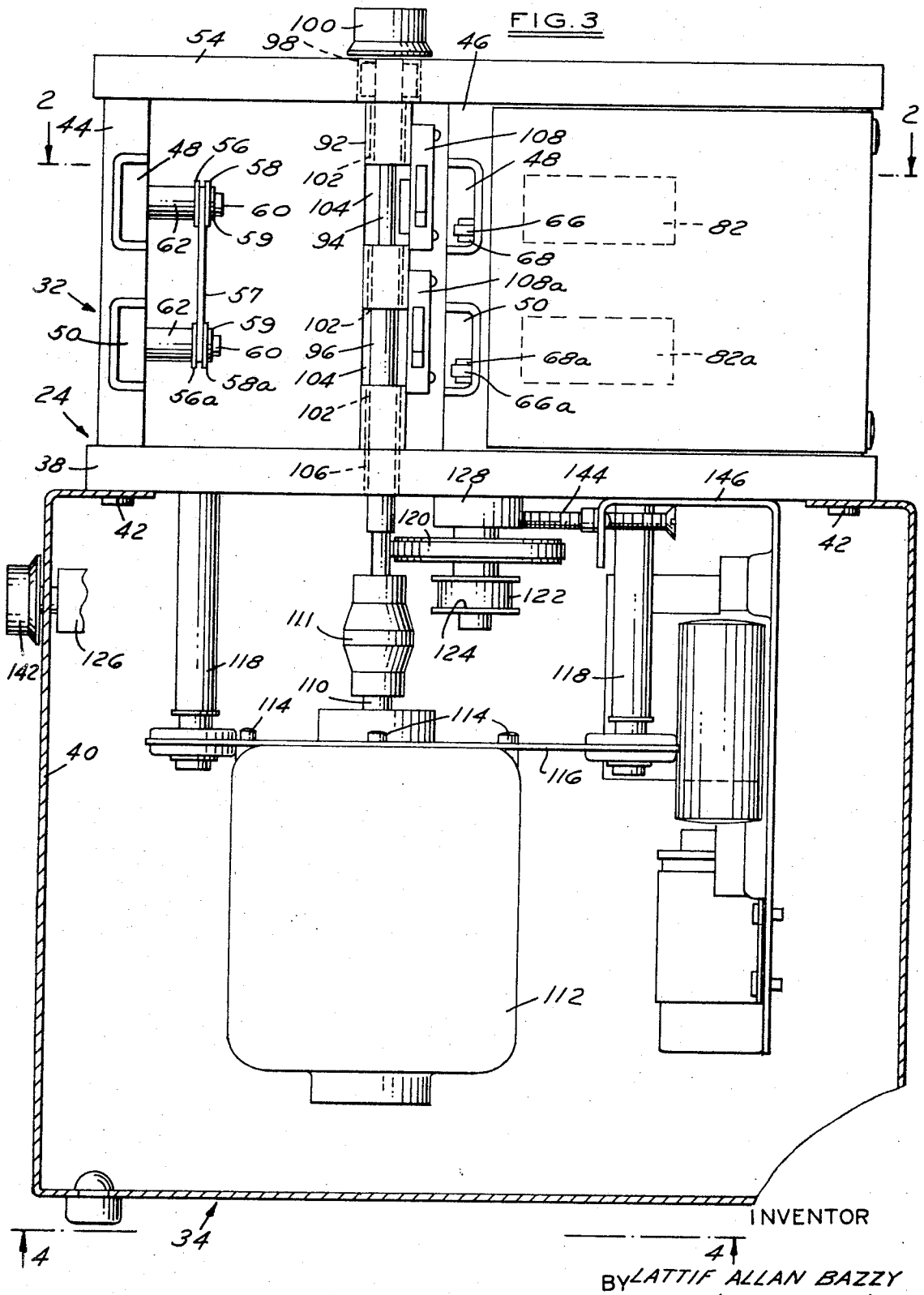


FIG. 2

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FIG. 3



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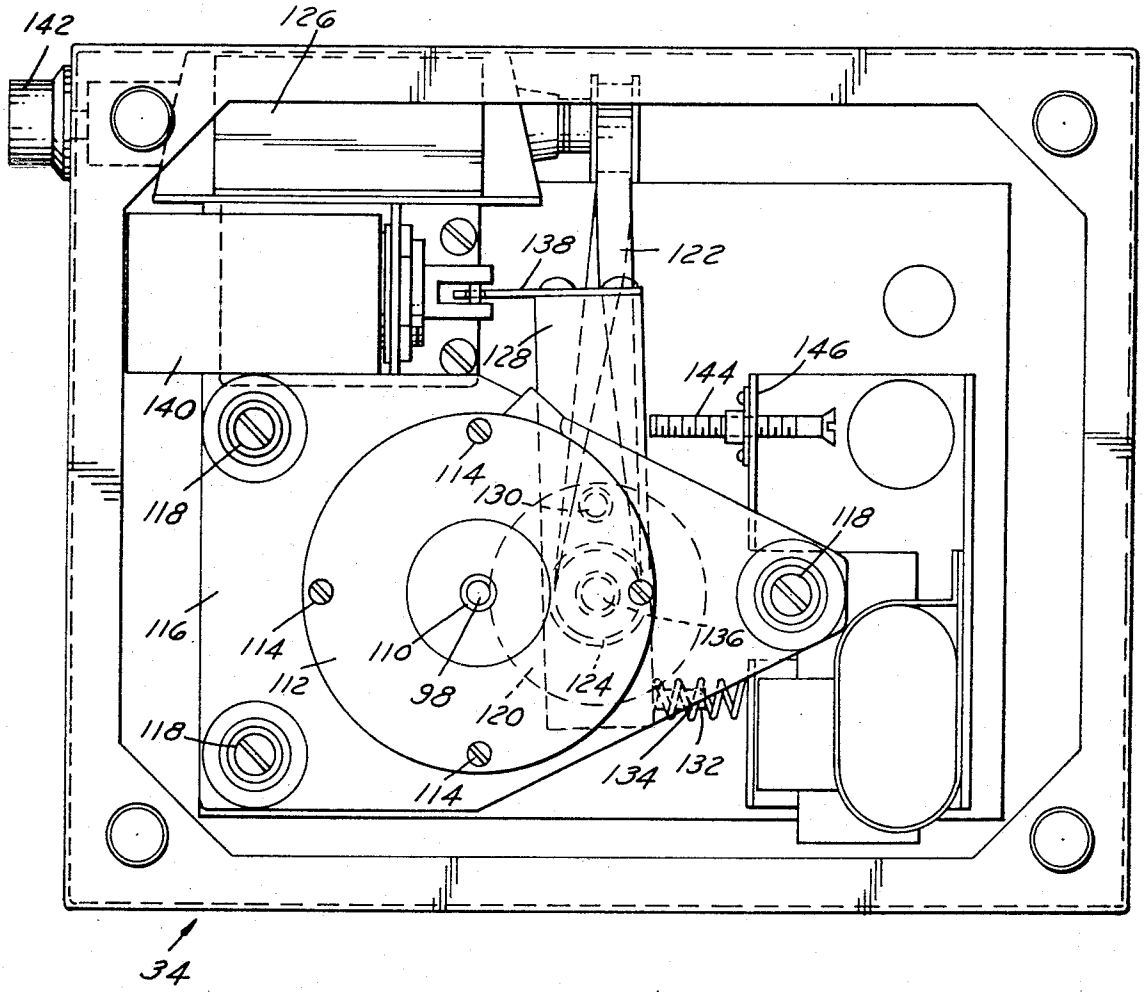


FIG. 4

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FIG. 5

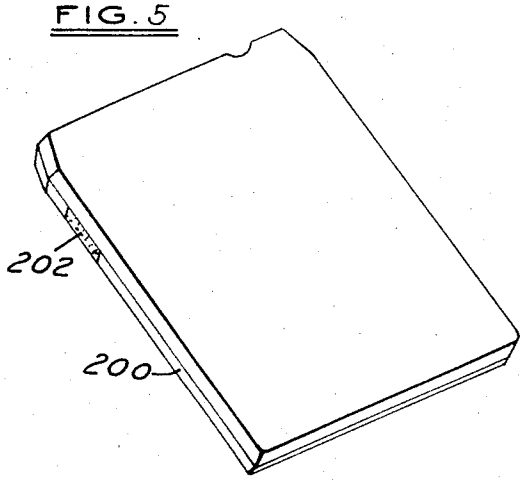


FIG. 8

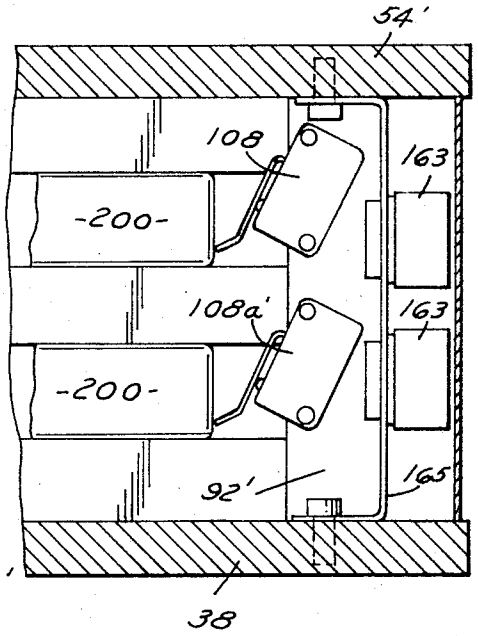


FIG. 6

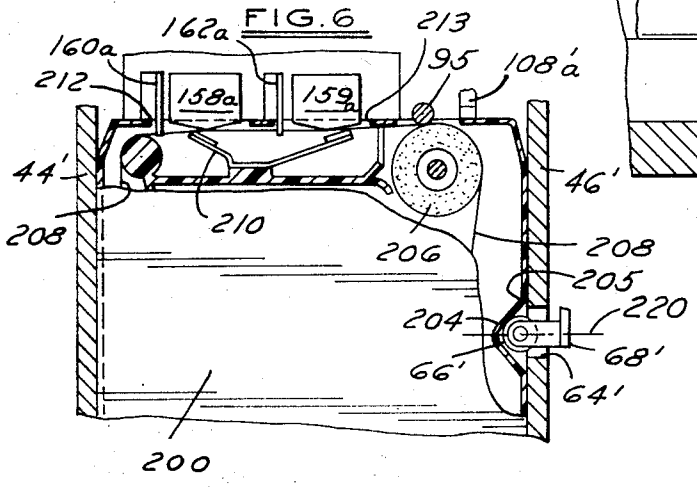
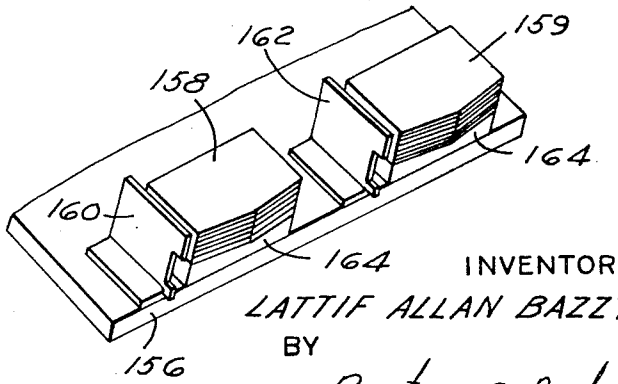
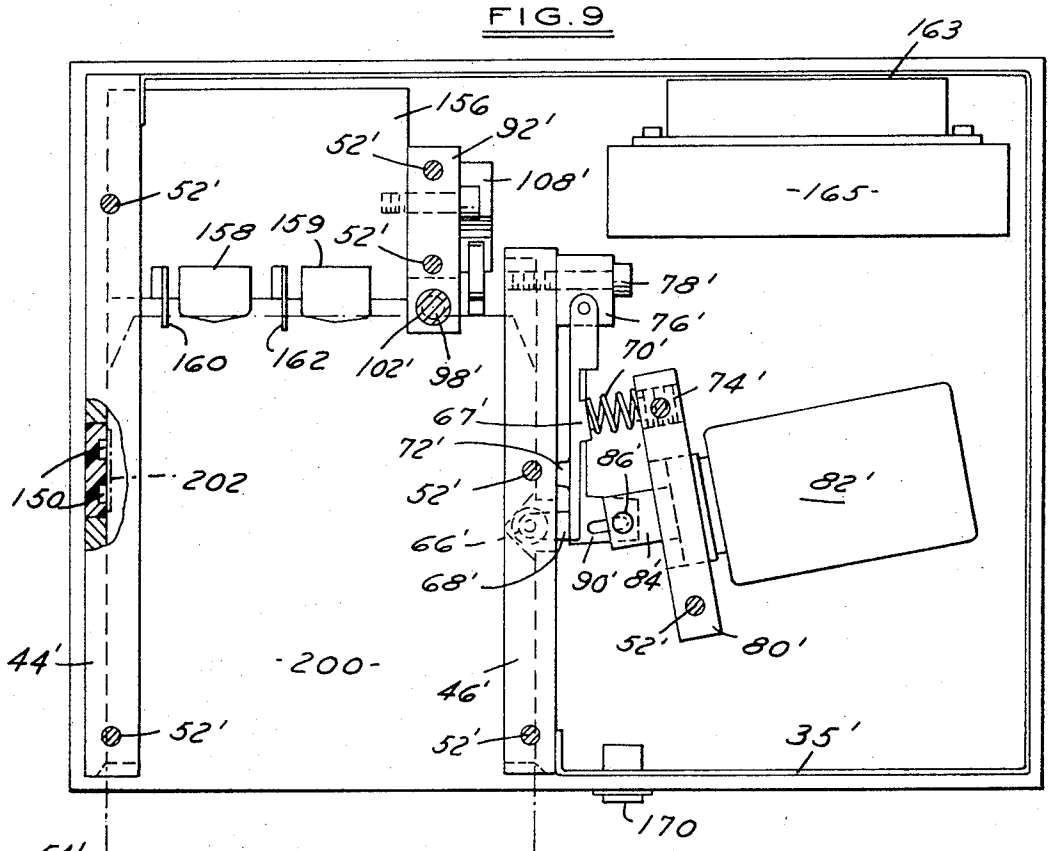


FIG. 7



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FIG. 9



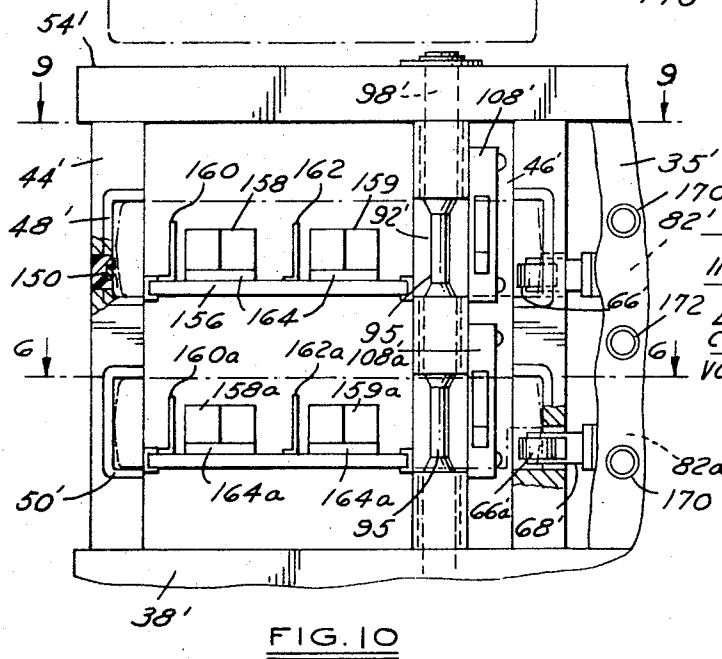
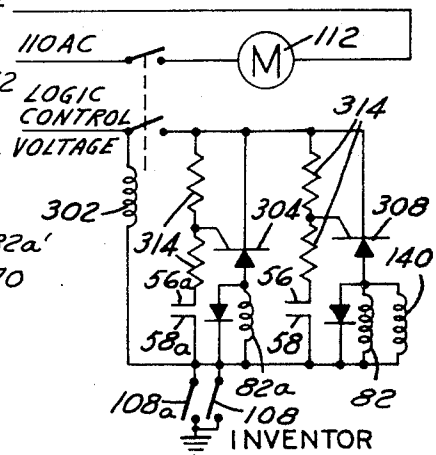


FIG. 10

FIG. 11



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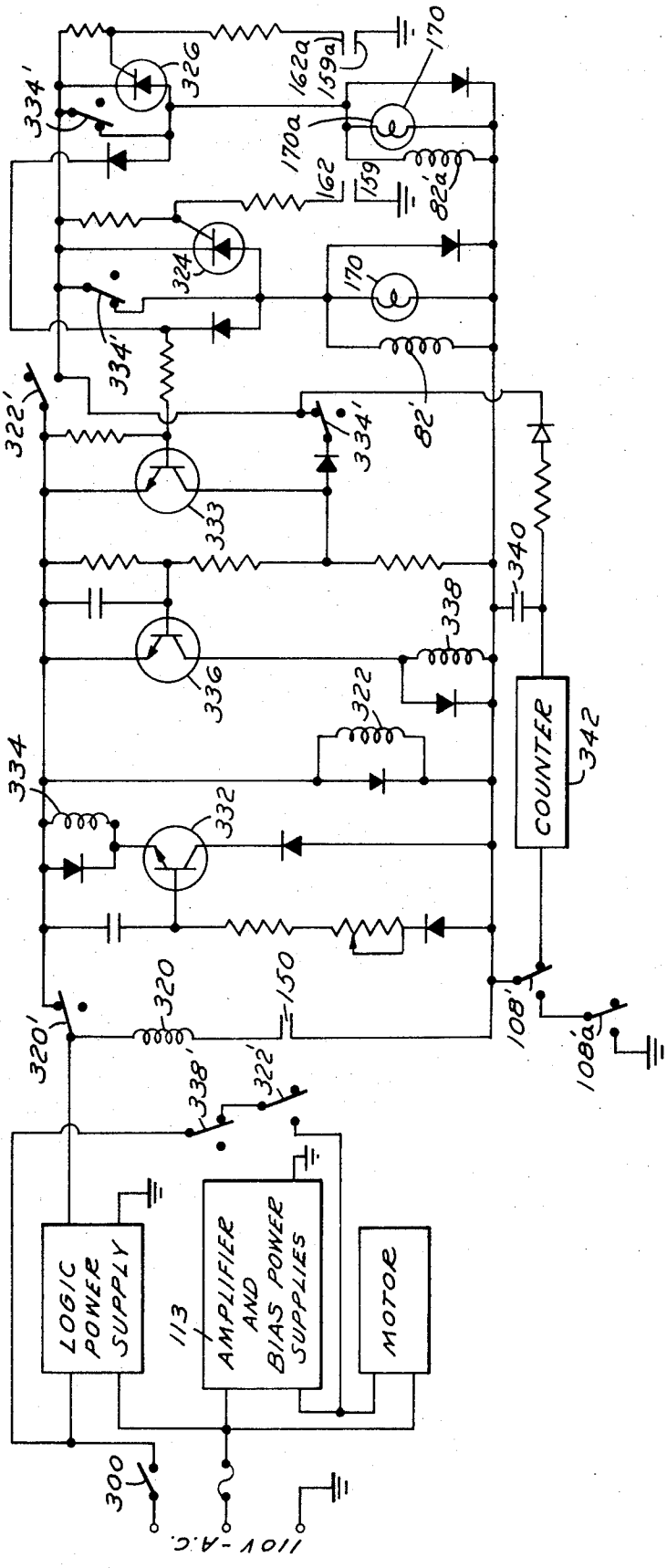

334'
326
162a
159a
170
170a
162
159
82'a
324
334'
170
322'
82'
334'
333
340
338
336
322
334
332
COUNTER
342
320'
320
150
108'
108'a
338'
322'
LOGIC POWER SUPPLY
113
AMPLIFIER AND BIAS POWER SUPPLIES
MOTOR
300
110 V - A.C.

FIG. 12

METHOD OF AND APPARATUS FOR TAPE CARTRIDGE DUPLICATION

FIELD OF INVENTION

This invention relates to methods and apparatus for high speed duplication of magnetic signals from one tape to another while the tape is contained in magnetic tape cartridges.

BACKGROUND OF THE INVENTION

In the consumer entertainment field, cartridge recorders using prerecorded tape cartridges have achieved wide popularity, and are available for car, boat, home and portable uses. However, up to now prerecorded cartridges, except so-called "pirated" tape cartridges, have been costly for the consumer to purchase. This expensiveness has several causes. First, it has not been possible using unsophisticated methods to produce a high quality recording on tape already contained within a conventional cartridge. Consequently, the recording must be made on the tape before insertion into the cartridge. Second, prior methods of manufacture require a high degree of centralization of manufacturing and consequent expensive investment in distribution and inventory stocks. In the highly volatile world of popular music, where only a small fraction of recordings become popular enough to pay for their overhead costs, those few recordings that do achieve popularity must recoup the losses incurred by the remaining recordings. This requires a much higher price to the consumer than would be required if no large inventories or complicated systems were required.

The local record shop, according to present methods of manufacture and distribution, is required to maintain a substantial inventory of prerecorded cartridges of each new cartridge offered by the recording companies because it is never known for certain which prerecorded cartridge will be a "hit", and once a cartridge becomes a "hit" the record dealer often is confronted by such delays in obtaining delivery on reorders from the recording company or distributor that the peak demand passes before replacement of his exhausted stock can be made. On the other hand, his inventory of new cartridges which do not sell well ties up his available capital and thus reduces his profit-making ability.

Once a tape has been recorded and placed in a cartridge it is uneconomic to reopen the cartridge, remove the tape, re-record on it and then repackage the tape in the cartridge. If reasonably priced equipment were available for quickly re-recording the tape in a cartridge with a high measure of fidelity, such equipment could be utilized to advantage in salvaging stagnant inventories of both recording companies and local record dealers.

One consequence of the current high price for the prerecorded cartridges has been the appearance of the tape pirate who purchases popular prerecorded cartridges and duplicates the hit songs therefrom, packages the duplicates in cartridges, and offers the duplicates at wholesale prices to the record stores far below the wholesale price of the original prerecorded tapes.

SUMMARY OF THE INVENTION

The present invention overcomes these drawbacks by providing a high quality, high speed duplicating system for recording a master cartridge onto a cartridge containing "blank" tape and a method utilizing this system

to eliminate large inventories and expensive distributor systems.

As disclosed herein the apparatus includes means for measuring the tape length of either unknown length master or blank cartridges so that proper length blanks can be matched with the masters, and means for cueing, when necessary, the cartridges to their tape splices so that the duplication from a master and onto a blank may start at the splices of each. The apparatus also includes means for rapidly effecting the duplication so that a cartridge which might normally require 45 minutes to play back can be duplicated in 2 to 3 minutes. The various functions mentioned, viz., tape measurement, cueing and duplication are performed automatically by simply inserting the cartridges in suitably provided cartridge receiving slots in the apparatus.

According to the method aspects of the invention, duplicating apparatus of the hereindescribed character may be geographically located at numerous points, such as record dealer stores or other places frequented by the public, and with a library of masters and a suitable quantity of blank cartridges of a length to accommodate the masters, either the record dealer or the customer may duplicate the master cartridges desired. Substantial savings in inventory costs and handling charges would thereby be realized with consequent possible lowering of both wholesale and retail prices, amounting annually in total savings to many millions of dollars if the method was widely adopted, and neither the recording companies nor record dealers would be caught in short supply when a particular cartridge became suddenly very popular. One consequence of the lower prices possible to the ultimate consumer would be to seriously hinder, if not eliminate, the tape piracy business.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view showing the major components of the system;

FIG. 2 is a top view of the calibrator unit along the line II—II in FIG. 3;

FIG. 3 is a front view of the calibrator unit with the front wall of the motor compartment removed for clarity;

FIG. 4 is a bottom view of the calibrator unit along the line IV—IV in FIG. 3;

FIG. 5 is a perspective view of a master cartridge having a strip of sensing foil attached so that the same will render the duplicating apparatus inoperative to erase its tape;

FIG. 6 is a top detail of a cartridge in the duplicator unit along the line VI—VI in FIG. 10;

FIG. 7 is a partial perspective view of a tape head assembly in the duplicator unit;

FIG. 8 is a side view showing the initiating switches in the duplicator unit;

FIG. 9 is a cross-sectional view through the duplicator unit taken along line 9—9 of FIG. 10;

FIG. 10 is a front detail of the duplicator unit;

FIG. 11 is a schematic diagram of a suitable logic control circuit for the calibrator unit; and

FIG. 12 is a schematic diagram of a suitable logic control circuit for automatic operation of the duplicator.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows all of the components of the cartridge duplication system conveniently arranged. The main component units are a controller 20 which contains the logic circuits, amplifiers and power supplies for the duplicator 22 and calibrator 24; the duplicator 22 in which a prerecorded master tape cartridge is recorded onto a slave cartridge containing a length of blank tape equal to or greater than the length of the master tape; the calibrator 24 on which the tape contained in a cartridge can be measured for length and cued to a known point on the tape for further use; and, for convenient compliance with the copyright laws or other data recording purposes, a data accumulation unit 26 may be provided in the system where a code number for each master cartridge copied can be recorded. The aforementioned units may be conveniently housed in an enclosure 27 or may be independently free standing as desired.

The controller 20 can be supplied with volume meters 30 to show the user that the amplifiers are operating properly. It has been found convenient to provide the controller with a mother circuit board into which the logic, bias oscillator, power supply and amplifier boards can be plugged. Multi-pin connectors are used to connect the controller to the duplicator and calibrator units. Conventional amplifier, bias oscillator and power supply circuits are used. However, in choosing the amplifier frequency response range and bias oscillator frequency, the high speed operation of the system must be kept in mind so that the full range of frequencies on the master is reproduced on the duplicated cartridges.

Turning more specifically to the calibrator unit 24, FIG. 2 shows a top view into the cartridge compartment 32 and FIG. 4 shows a bottom view into the motor compartment 34. These two compartments are separated by a plate 38 made of a substantial structural material, such as aluminum. The plate 38 serves as a mounting base for the elements in both compartments as shown in FIG. 3. Plate 38 may be mounted in turn in a rectangular casing 40 by screws 42. This unit may be either free standing as in FIG. 3, or incorporated without casing 40 into an integrated unit as in FIG. 1. The motor compartment 34 in FIG. 3 is shown with the casing 40 cut away while the cartridge compartment 34 is not shown with its cover 35 cut away. In the cartridge compartment 32, two upright members 44 and 46 are formed from machined aluminum to form two channels in each upright. Corresponding channels in opposite members form slots 48 and 50 for accurately holding and positioning tape cartridges. These slots open outwardly toward the front of the machine enabling them to receive a tape cartridge. Machine screws 52 securely bolt the uprights 44 and 46 to the plate 38 as well as to a top plate 54. Top plate 54 is made in similarly solid manner to provide a rigid box-like compartment whose side walls 44 and 46 will securely hold and position tape cartridges. Into side wall 44 at the non-open back end of each of the slots 48 and 50 are fastened tape splice sensing means in the form of contacts 56 and 58 by screws 60 and spacers 62. The contacts are insulated from each other by insulators 57 and 59. The function of these sensors will be discussed below during the discussion of the machine function.

A roller 66 on a movable arm 68 is tensioned by spring 70 which is held by flange 67 on the arm 68 and protrudes through an aperture 64 in the other side wall 46. The movable arm 68 is pivoted on a bracket 76 which is attached to the side wall 46 by screw 78. There is an aperture 64 and roller 66 located in the lower half of each of the slots 48 and 50 to detent a standard cartridge in each slot. When no cartridge is inserted in a slot a stop 72 engages the outside of the side wall 46. When a cartridge is inserted the roller 66 is pushed back until a detent receiving edge notch 204 (see FIG. 6) in the cartridge is reached. The roller 66 then exactly positions the cartridge with a tension force of three to five pounds into a desired preset position. The tension force is provided by spring 70 and is adjustable by means of set screw 74. Set screw 74 is mounted in an upright support 80 which also supports a retraction solenoid 82 for each slot. Support 80 runs from the separation plate 38 to the top plate 54 and is secured similarly to the slot-forming members 44 and 46 by machine screws 52. However, support 80 is at a slight angle to members 44 and 46 to provide for the angular pivoting of the arm 68.

Each retraction solenoid 82 is mounted in support 80 so that its moving arm 84 is engaged by pin 86 to a closed slot 88 formed in flange 90 of the arm 68.

Thus in operation roller 66 and arm 68 can freely retract from the detent notch when inserting or withdrawing a tape cartridge and automatic retraction is accomplished through flange 90 when the solenoid 82 is actuated in response to a logic signal.

A fourth upright member in the cartridge compartment is the capstan housing 92. This member is likewise made of heavy structural material and is secured to the top and bottom plates 38 and 54 by screws 52. It is positioned near the channel-forming member 46 in such a position as to provide a firm pressure to the pinch roller of a tape cartridge when the cartridge detent notch is gripped by roller 66. The capstan housing has two recesses 104 cut into its front edge to provide exposure for the capstan 98 to the tape cartridge pinch roller. Oil impregnated bushings 102 provide a low friction mounting for the capstan. The capstan 98 protrudes through top plate 54 and ends in a knob 100 which can be hand-turned to unwrap any tape that may have become accidentally wound around the capstan. Likewise the capstan extends through the bottom plate 38 through aperture 106 for connection to the driving motor. The capstan 98 may have different diameter portions exposed to the tape cartridge pinch rollers, as at 94 and 96, to drive the tape at any desired speed as described below.

Also attached to the capstan housing 92 are switching means such as microswitches 108 and 108a whose triggers sense the physical presence of a tape cartridge within a slot whether or not gripped by the detent roller 66.

In the motor compartment 34 the capstan 98 is connected by a flexible coupling 11 to the drive shaft 110 of an electric motor 112. Motor 112 is mounted by screws 114 onto a plate 116 which is suspended by shock mounts 118 from plate 38. A rubber wheel 120 runs against the capstan 98. The shaft of the wheel 120 in turn drives a pulley 124 having a belt 122 driving a conventional mechanical counter 126. The counter 126 can count in any arbitrary units; it has been found convenient to have the counter calibrated in half feet.

The wheel **120** and pulley **124** are mounted on a bracket **128** pivoted at **130** and attached by the pivot to the plate **38.** The bracket **128** has a stud **132** over which a spring **134** is held to tension the wheel **120** against the capstan **98.** On the opposite side of the pivot **130** from the center **136** of the wheel **120,** a tongue **138** is attached to the bracket **128.** This tongue is connected to a solenoid **140** which is connected to plate **38** such that when the solenoid is actuated in response to a command from the logic system, the wheel **120** will be pulled away from the capstan **98** thus causing the counter **126** to cease registering. Knob **142** is provided for convenient resetting of the counter. Adjustable screw **144** provides a stop so that wheel **120** will not be pushed too forcefully against the capstan **98** causing the wheel to develop a deformity during periods of non-use. Both the screw **144** and the spring **134** are attached to a frame **146** which is suspended from plate **38.** The frame **146** contains a terminal strip and all the components necessary for the simple logic required in the calibrator (See FIG. **11**).

Like the calibrator unit, the duplicator unit includes a cartridge compartment and a motor compartment. Both units are very similar in construction and primed reference numbers designate similar parts. The motor is the only element in the motor compartment of the duplicator; there is no counting assembly or logic component included in the motor compartment. However, the motor is mounted in the same fashion as the calibrator unit motor.

The cartridge compartment of the duplicator unit has the same slot-forming uprights **44'** and **46'**, the same solenoid detent assembly and the same capstan arrangement **92'** as the calibrator. However, the sensing contacts **56** and **58** of the calibrator are replaced by a tape recording and playback assembly as shown in FIGS. **6** through **11.**

In FIG. **9,** the left upright member **44'** may have a pair of insulated contacts **150** embedded in the upper channel **48'** to sense the presence of a marked master cartridge in the recording channel as described below. In the duplicator unit the left upright member **44'** and the capstan housing **92'** have horizontal slots milled out to accept a flat plate **156** and **156*a*** cemented therein and on which are mounted the recording or playback heads **158** and **158*a*, 159** and **159*a*,** and tape guides **160, 160*a*, 162** and **162*a*.** The plate **156** is positioned so that the recording and playback heads and guides are at the proper height to accurately playback and record the cartridges. Accurate positioning of the heads is achieved by cementing each head to a brass pad **164** and **164*a*** and then machining the pad bottom to ensure that the head tracks are accurately aligned with respect to the bottom of the pad and are at a specified distance. This can be done accurately to within 0.0005 inch which is well within the tolerances permissible for accurate recording. The brass pads are then securely bolted to the flat aluminum plate as shown in FIG. **7.** Recording and playback heads **158** and **159** are set at different heights as are heads **158*a*** and **159*a*,** whereby the transducers in the paired heads are in effect interleaved. Since each head records or plays back four tracks, all eight tracks can thus be recorded with one cycle of the cartridge. The tape from each cartridge is oriented by means of a guide which is positioned to accurately guide the recording tape past the head. The guides are securely attached by screws to the plate **156.** Guides **162** and **162*a*** are insulated from the plate and acts as a tape splice sensing means to trigger the logic means as hereinafter described.

Also contained in the cartridge compartment of the duplicator unit are multi-pin connectors **163** mounted on a bracket **165** to provide connection between the recording and playback heads and the amplifiers contained in the controller unit as well as the logic signals and commands from the controller.

The casing **35** of the cartridge compartment may for convenience include lights **170** to indicate when each cartridge has reached its splice and light **172** to indicate to the consumer when the duplication is completed.

The positioning of the cartridge sensing means microswitches **108'** and **108*a'*** are shown in FIG. **8** in contact with cartridges **200.** FIG. **5** shows a typical master cartridge having a triggering means in the form of a piece of conductive foil **202** to protect the master against accidental erasure as described below. Except for the foil **202,** master and blank cartridges are of identical construction.

FIG. **6** shows a close-up of a cartridge **200** engaged in the master slot. The detent receiving edge notch **204** is securely gripped by the roller **66'** to hold the cartridge pinch roller **206** securely against the capstan diameter **95** pinching the tape **208** and driving the tape. The resilient pressure pad means **210** contained within the cartridge, firmly presses the tape **208** against the playback heads through the two open windows **212** and **213** of the cartridge. Guides **160*a*** and **162*a*** accurately position the tape so that the tape is properly aligned when it passes over the recording or playback heads. When the cartridge **200** is first inserted into the slot, switching means **108*a'*** is switched after the front edge **205** of the detent receiving edge notch **204** is beyond the centerline **220** of the roller **66'** and arm **68'** so that when the consumer releases the cartridge, the machine will automatically position the cartridge in proper position.

It is of course possible to provide for making more than one copy of a master tape at any time by simply using the top plate **54'** of the duplicator as the bottom plate **38'** for another cartridge compartment having a pair of slots and heads and extending the common capstan **98'** to the length needed. Even more duplicates can be made by further stacking of cartridge compartments as desired.

The operation of the schematic diagrams of the logic shown in FIGS. **11** and **12** can be best understood with reference to the normal operation of the machine.

Electrical power to all machine functions is controlled by means of on-off switch **300.** When this switch is turned on the logic systems only are energized and this controls the operation of the machine from this point on in response to certain operator actions.

If the master cartridge to be duplicated has not previously had its length determined, this is first done by using the calibrator. It is of course to be understood that the tape contained in the cartridges handled by this equipment is in the form of an endless loop, with the meeting ends spliced together to form the loop. If the tape splice is not visible in the window of the cartridge teh cartridge is inserted in the cue slot **50** in the calibrator unit. As the cartridge is inserted, sensing means, such as microswitch **108*a*** in FIGS. **3** and **11,** is closed as the detent receiving notch **204** of the cartridge is gripped by the roller **66,** as in FIG. **6.** When switch **108**

in the calibrator unit is closed, relay **302** closes supplying the logic voltage to the calibrator logic unit at the same time supplying power to the capstan driving motor **112.** The tape contained within the cartridge is then driven at high speed until the tape splice makes contact with the sensing means **56***a* and **58***a*. Since the tape splice utilizes a piece of conducting foil, the sensing means comprising a pair of contacts **56***a* and **58***a* are momentarily contacted as the conductive foil passes over them. This triggers a silicon controlled rectifier (SCR) **304** which applies a voltage across the detent retracting solenoid **82***a* causing the detent to pull back and releasing pressure between the capstan diameter **96** and the cartridge pinch roller **206** causing the tape to stop moving. The cartridge now has its tape end splice visible in either window **212** or **213** and can now be measured. Because cueing is only desired to locate the tape splice in the cartridge, the faster cueing is accomplished the more desirable. Consequently it is desirable to have the capstan **98** present a large diameter to the pinch roller, as at **96** in FIG. **3.** A driving speed of about 30 inches per second will conveniently and quickly cue a cartridge.

After a tape cartridge has been cued so that its tape splice appears in the window, it is then measured to determine its length so that a blank cartridge of comparable length may be used for duplicating the master. To measure the length of any cartridge, the cartridge with the splice showing in the window, but beyond the splice sensing means, is inserted in the calibration slot **48** after the counter **126** has been reset to zero by knob **142.** When the cartridge is inserted, the cartridge sensing switch **108** for that slot starts the motor **112** which drives the tape through a complete cycle until the tape splice sensing means **56** and **58** for that slot triggers another SCR **308** which activates both the detent retracting solenoid **82** and the counter stopping solenoid **140.** The length of the tape in the cartridge then corresponds to the number on the counter. A blank tape of the proper length can then be selected to ensure that the entire master can be recored onto the blank without losing part of the recording. Similarly, if the blank cartridge is of unknown length, it can be cued and measured the same as the master.

The speed of calibration should be slower than cueing so that a more accurate measurement can be made. The capstan **98** must have a diameter as at **94** in FIG. **3** so that the wheel **120** running against the capstan will proportionately drive the counter in proportion to the circumferential distance travelled by the capstan. Measurement of cartridge lengths to within a half foot has been found practical and convenient.

In the logic system of the calibrator unit in FIG. **11,** the resistors **314** act as a voltage divider to provide the proper triggering voltage to the SCR's **304** and **308.** Diodes **316** prevent surges in voltages from unexpectedly actuating solenoids **82***a*, **82** and **140.**

After the master cartridge has been cued and calibrated and a blank cartridge of comparable length selected, the duplicator unit is then used to transfer the master recording onto the blank. As used in this invention, "master" means any prerecorded tape cartridge which it is desired to duplicate onto one or more other cartridges while "blank" means any cartridge, whether or not it has a previous recording on it, upon which it is desired to reproduce the recording contained in the master cartridge.

The master is inserted into the master slot **50'** in the duplicator unit. If the master were to be put into the wrong slot, the desired recording would be erased if another cartridge were put into the other slot. To prevent this occurrence, each master may be encoded by having a strip of conducting foil **202** placed on the side of the cartridge so that if it is inserted into the wrong slot, contacts **150** will be closed actuating relay **320** which will remove power from the logic circuit thus preventing any operation of the duplicator as long as the master is in the wrong slot. For each relay in the logic of FIG. **12** the primed reference numerals indicate that that switch is controlled by the numbered relay.

Before any cartridge is used in the duplicator unit, the tape splice must be positioned over the pinch roller **206.** If the calibrator unit has been used, it may be necessary to move the tape by hand to position it over the pinch roller. This is due to the fact that the tape splice sensing means on the calibrator unit is located at the edge of the opening where the tape emerges since it is necessary to account for the coasting of the tape after the detent has retracted since the tape has been moving at high speed. The tape splice sensing means in the duplicator, however, is between the last head **159** or **159***a* and its guide **162** or **162***a*, which is nearer the pinch roller end of the cartridge. If the momentum of the tape as it is cued or calibrated does not carry the splice beyond the position of the sensing means in the duplicator, it is necessary to do this manually.

After the master has been inserted in the correct slot, the master slot cartridge sensing switch **108***a'* closes when the detent roller **66***a'* engages the detent receiving edge notch **204** on the master cartridge. When the blank cartridge is inserted in its slot, switch **108'** closes to ground one side of the logic. This causes relay **322** to close starting the drive motor **112** and turning on the amplifiers and bias oscillator **113,** and applying the logic voltage directly to the SCR's **324** and **326** controlling the detent retraction solenoids **82'** and **82***a'* which are thereby actuated to withdraw the detent rollers **66'** and **66***a'* out of the cartridge notches, and thus prevent the pinch roller from tightly engaging the capstan to drive the tapes. At the same time the start delay transistor **332** starts its timed delay and after three to five seconds, during which time the driving motor comes up to speed, actuates the starting relay **334** which disconnects the logic power from the detent retraction solenoids **82'** and **82***a'* and enables the shutoff of transistor **336.** With deenergization of the solenoids, the detents **66'** and **66***a'* shift back into firm engagement with the cartridge notches **204** to shift the cartridges back toward the capstan bringing the pinch rollers of the cartridges into tape driving relation with the capstan, and thus simultaneously starting both the master and the blank cartridge tapes. Thus both cartridges are started together, and if the capstan **98'** has the same diameter **95** exposed to both cartridges, the blank will be recorded at the same speed as the master is played, ensuring an accurate copy.

When the first cartridge, either the blank or the master, returns its tape splice to the window, it triggers its SCR **324** or **326** by making contact across the conducting foil of the tape splice between guide post **162** or **162***a* and the tape head **159** or **159a**. This causes the detent retraction solenoid **82'** or **82***a'* to be actuated along with its notification light **170** or **170***a* thus disengaging the pinch roller from the capstan. When the

other cartridge tape splice triggers its SCR and detent solenoid, it also triggers transistor **333** which in turn switches transistor **336** to supply power actuating relay **338** which shuts off the driving motor **122**, the amplifiers **113** and the indicator lamp **172.** When the formerly blank cartridge is removed, the switch **108'** opens and discharges capacitor **340** through a standard electrical pulse counter **342** registering each duplicate made on the machine. Then the logic returns to its quiescent floating state to await the next duplication, provided either the momentum of the master cartridge has carried the tape splice off the splice sensing contacts or the master has been removed.

While it is possible to duplicate a master onto a blank by the method at any speed which the structure of the tape and cartridges will withstand, consideration of the frequency range of the system become of considerable importance as the duplicating speed is raised. For example, if a master cartridge is duplicated at the normal playback speed of approximately 3-¾ inches per second, a 45-minute cartridge will take 45 minutes to record, then the amplifier, playback and record heads need only accommodate the normal frequency range, 50 to 11,000 hertz, and the bias oscillator can be set for 23 kilohertz. But if the cartridge is duplicated at sixteen times normal speed, viz. 15 inches per second, which is the preferred speed, although a 45-minute cartridge will only take three minutes to duplicate, the amplifier, playback and record heads will have to accommodate a frequency range of from 800 to 177,000 hertz to make a duplicate which will fully reproduce the frequency range of the master, and the bias oscillator will have to be set at least to 355 kilohertz. Thus high speed duplication as herein contemplated requires professional quality recording and playback heads as well as high quality amplifiers.

Since this method contemplates recording every track of the master onto the blank with only one cycle of the tape, it is necessary that more than one playback head read the master and more than one record head transduce the amplified signal from the master onto the blank tape. Four-track playback and record heads are available, thus two heads are necessary to record all eight tracks of the standard cartridge. Record and playback heads are paired, **158** and **158*a***, **159** and **159*a*** to ensure that corresponding points on the master tape will have the same relative positioning on the blank tape. The guides **160, 162, 160*a*** and **162*a*** perform the function of preventing the tape from oscillating vertically across the recording and playback heads. The cartridge pressure pads **210** provide sufficient pressure to hold the tape against the record and playback heads when the detents are engaged in the cartridge notches as shown in FIG. **6.** The pressure pads also serve to thrust the cartridges outwardly away from the capstan to disengage the tapes from driving engagement therewith during start-up of the capstan motor as hereinbefore described.

Once a master cartridge has been calibrated to determine its length, it is only necessary to use a blank cartridge having at least that long a length of tape in it to duplicate the master. In the duplication process the master is inserted in the slot **50'**, the blank in slot **48'** and as both switches **108'** and **108*a'*** are thereupon closed, the duplicator will commence operation as above described and the entire duplication will be carried out automatically. Upon energization of the notification light, the operator removes the finished duplicate and master cartridges from the machine.

The simplicity and ease of producing high quality duplicate recordings by this equipment lends itself to novel use. It is now possible for a consumer to do the duplication himself. For example, since some music stores maintain a library of master cartridge recordings, it is now possible for the customer to buy a blank cartridge and utilize this machine to duplicate a master onto the blank tape. Other retail stores may have exchange plans where a customer can exchange cartridges based upon popularity ratings of the new and returned selections.

Now if a library of master recordings were available in the store, the consumer could rent a master cartridge from the library, buy the right length blank cartridge and duplicate the master himself. Coin-operated duplication is also possible, thus unattended machines could be available for duplication at any time, anywhere, such as gas stations, drug stores and shopping centers.

Recording companies could locate these machines at numerous distribution points throughout the country, stock a master copy of their recordings at each location and numerous blank tapes, and fill orders from retail stores without the necessity of maintaining a large inventory of every recording. Because of the simplicity of operation, only unskilled labor is necessary at these locations to rapidly produce numerous duplicates, thus reducing the high cost to consumers of prerecorded tape cartridges.

What is claimed is:

1. In a machine for duplicating from a master tape cartridge the sounds onto a blank tape cartridge, a plurality of cartridge receiving slots opening outwardly of the machine at one end for insertion of cartridges, a motor driven capstan common to the slots and extending alongside each for driving engagement of the tapes in cartridges in the slots, magnetic signal duplicating means including a pickup head associated with one slot and a recording head associated with each other slot for duplicating the magnetic signals from a tape cartridge received in said one slot to each tape cartridge received in each other slot, means associated with each slot for simultaneously establishing driving engagement between the capstan and all cartridges in the slots and releasably holding the individual cartridges in the aforesaid tape driving engagement with the capstan, and means responsive to the full cycling of the tape in individual cartridges for causing the cartridge holding means to release a full cycled cartridge from driving engagement with the capstan while an incompletely cycled tape cartridge remains in driving engagement with the capstan.

2. The invention defined in claim **1** characterized by the provision of means for discontinuing operation of the motor driven capstan upon completion of a full cycle by the last cartridge in tape driven engagement with the capstan.

3. The invention defined by claim **1** characterized in that one of said slots is provided with a magnetic pickup head responsive to magnetic signals on a prerecorded tape cartridge inserted in the slot, amplifier means connected to said head and including a magnetic transcribing head for each other slot disposed to impress magnetic signals on tape in a cartridge received therein, and means responsive to the presence of tape cartridges in all the slots for simultaneously actuating

the cartridge holding means associated with each slot to simultaneously hold the cartridge in tape driven engagement with the capstan.

4. The invention defined by claim **1** characterized by the provision of control means connected to said motor driven capstan and to said cartridge holding means and responsive to the introduction of cartridges into the slots to initiate operation of the capstan and withhold the cartridges from driving engagement between the capstan and magnetic tape in the cartridges while the capstan attains operating speed and thereafter cause said holding means to establish driving engagement between the capstan and magnetic tape in all of the cartridges simultaneously.

5. The invention defined by claim **4** characterized in that said cartridge holding means includes a spring biased part for engaging a cartridge upon introduction into a slot and urging the cartridge into tape driven relation with the capstan, and said control means includes cartridge sensing means in each slot responsive to the initial introduction of a cartridge into the slot for momentarily actuating said cartridge holding means to cause release of the cartridge by said spring biased part from tape driving engagement with the capstan while the capstan attains operating speed and thereafter cause said spring biased part to shift the cartridge to reengage the cartridge tape with the capstan.

6. The invention defined by claim **4** characterized in that said control means includes serially connected cartridge sensing means for the slots with the control means responsive only to the presence of cartridges in all the slots to initiate operation of the motor driven capstan.

7. In an automatic tape cartridge duplicating machine:

a master tape cartridge receiving slot and a blank tape cartridge receiving slot,

motor driven capstan means having a capstan common to and extending alongside the slots for driving the tapes of cartridges received therein at a common speed in excess of normal tape playback speed,

cartridge engaging means associated with each slot to engage a cartridge in the slot and shift it into or releaae it from driving engagement with the capstan,

magnetic signal transcribing means including playback and transcribing heads adjacent respectively the master and blank tape cartridge receiving slots for duplicating the magnetic signals of the master tape onto the blank tape,

and a control system connected to the motor driven capstan means and the cartridge engaging means for controlling the sme through a cycle of operation comprising initiating operation of the motor driven capstan means and thereafter initiating the cartridge engaging means to simultaneously shift the cartridge into driving engagement with the capstan for duplication of the magnetic signals from the master to the blank cartridge tape and initiating the cartridge engaging means to release driven engagement of each cartridge with the capstan upon completion of one full cycle of its tape and initiating the motor driven capstan means to stop the capstan upon the release of all cartridges from driven engagement with the capstan.

8. The invention defined in claim **7** characterized in that said control system includes cartridge sensing means associated with each slot and responsive to the presence of cartridges in each slot for initiating said cycle of operation.

9. The invention defined in claim **8** characterized in that said means to engage a cartridge in each slot includes a spring loaded part yieldable to the insertion of a cartridge in the slot and cooperable with a recess in the cartridge to bias the cartridge into tape driven relation with the capstan, and said control system is operable to shift momentarily said spring loaded detent to release the cartridge from driven engagement with the capstan during starting of the motor driven capstan while the capstan attains operating speed.

10. The invention defined by claim **7** characterized in that said cycle of operation of the control system includes momentary actuation of the cartridge engaging means to release each cartridge from driven relation with the capstan during starting of the motor driven capstan while the same attains operating speed.

11. In a machine for automatically and rapidly duplicating multitrack magnetic tape cartridges each of which has window means at one end exposing a length of the tape:

at least two cartridge receiving slots, one for a master cartridge and another for a blank cartridge, with each slot arranged to receive a cartridge thereinto window-end-first,

a motor driven capstan common to and extending across the inner ends of the slots for driving engagement with tape in cartridges received in the slots, and operable to drive the tapes at a common speed substantially in excess of normal playback speed,

a magnetic signal duplicating system including pickup head means at the inner end of said one slot for engagement with precorded tape through the master cartridge window means and recording head means at the inner end of the other slot for engagement with tape through the blank cartridge window means,

said pickup and said recording head means each having a magnetic signal transducer for each magnetic track of the tape such that upon a single passage of the tape all tracks of the tape will be presented in signal transfer relation with the head means and the signals of all tracks on the master duplicated on corresponding tracks of the blank,

cartridge holding means for releasably holding the cartridges in tape driven engagement with the capstan,

a starting circuit for the motor driven capstan including means responsive to the presence of a cartridge in each of the slots for enabling starting of the capstan motor,

and tape splice sensing means at the inner end of each slot connected to the respective cartridge holding means of such slot and responsive to the passage of a tape splice at the window means of a cartridge inserted in the slot for causing the holding means to release such cartridge from driving engagement with the capstan.

12. In a machine for duplicating from a master tape cartridge the sounds onto a blank tape cartridge, a plurality of cartridge receiving slots opening outwardly of the machine at one end for insertion of cartridges, motor driven capstan means for the slots for driving engagement of the tapes in cartridges in the slots, mag-

netic signal duplicating means including a pickup head associated with one slot and a recording head associated with each other slot for duplicating the magnetic signals from a tape cartridge received in said one slot to each tape cartridge received in each other slot, means for initiating operation of the capstan means, means associated with each slot for releasably holding the individual cartridges in the aforesaid tape driving engagement with the capstan means and operable upon initiation of the capstan means to withhold tape driving engagement between the cartridges and capstan means until the capstan means has attained operating speed and thereafter establish tape driving engagement of all cartridges simultaneously, and means responsive to the full cycling of the tape in individual cartridges for causing the cartridge holding means to release a full cycled cartridge from driving engagement with the capstan means while an incompletely cycled tape cartridge remains in driving engagement with the capstan means until it has been fully cycled.

13. A high speed cartridge-to-cartridge duplicating machine for multitrack magnetic tape cartridges:

a master cartridge receiving slot and a blank cartridge receiving slot,

capstan means for each slot for driving engagement with the tape contained in a cartridge in the slot,

motor means connected to the capstan means for driving the same at identical rates sufficient to cause driving of tape engaged with the capstan means substantially faster than normal tape playing speed,

magnetic signal duplicating means for duplicating in a single pass all magnetic track signals from a master tape cartridge to a blank tape cartridge,

said duplicating means including a pair of fixed pickup heads for the master cartridge slot and a pair of recording heads for the blank cartridge slot with each head having a plurality of magnetic track signal transducers spaced apart across the width of the tape to receive signals from alternate tracks with each pair of heads arranged in offset spaced relation along the tape presented by each cartridge to interleave the signal transducers such that each track of the tape mates with a transducer,

cartridge holding means for each slot for holding a cartridge therein in driving engagement with the capstan means and releasing the cartridge from driving engagement with the capstan means,

and control means connected to said motor means and to said cartridge holding means and including serially connected cartridge sensing means in the slots for enabling operation of the motor means only when there is a cartridge in each slot in a ready to duplicate position, with said control means operable to actuate the cartridge holding means upon full cycling of the magnetic tape in a cartridge to release such cartridge from driving engagement with the capstan means while the other cartridge remains in driving engagement with the capstan means until it is fully cycled.

14. In a machine for duplicating from a master tape cartridge the sounds onto a blank tape cartridge,

a plurality of cartridge receiving slots opening outwardly of the machine at one end for insertion of cartridges,

motor driven capstan means for the slots for driving engagement of the tapes in cartridges in the slots,

magnetic signal duplicating means including a pickup head associated with one slot and a recording head associated with each other slot for duplicating the magnetic signals from a tape cartridge received in one slot to each tape cartridge received in each other slot,

cartridge holding means associated with each slot for releasably holding the cartridges in the aforesaid tape driving engagement with the capstan,

and means connected to the motor driven capstan means and to the cartridge holding means for controlling the same through a cycle of operation comprising initiating operation of the motor driven capstan means while simultaneously with-holding driving engagement between the cartridge tapes and capstan means by said cartridge holding means until the capstan means has attained operating speed and thereupon initiating operation of the cartridge holding means to establish tape driving engagement between the capstan means and all the tape cartridges simultaneously and thereafter initiate operation of the cartridge holding means to selectively release the cartridges from tape driving engagement with the capstan means as each is fully cycled.

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