

- [54] **AUTOMATIC SEQUENCE CONTROL FOR REPRODUCING APPARATUS**
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- [73] Assignee: **International Tapetronics Corporation**, Bloomington, Ill.
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- [52] U.S. Cl. **360/72, 360/71, 360/74**
- [51] Int. Cl. **G11b 15/48, G11b 15/02**
- [58] Field of Search **360/72, 74, 71, 96, 83, 360/93, 12, 13; 242/199, 197, 186, 195; 35/35 C**

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Attorney, Agent, or Firm—**Davis, McCaleb & Lucas**

[57] **ABSTRACT**

Automatic sequence control circuit for magnetic tape reproducing apparatus in which the tape has beginning and end clear leaders and an opaque intermediate portion having one or more recorded programs. The tape may have more than one recorded program, each being respectively preceded and followed by primary and end-of-program control signals. An end-of-tape control signal may follow the last program.

32 Claims, 14 Drawing Figures

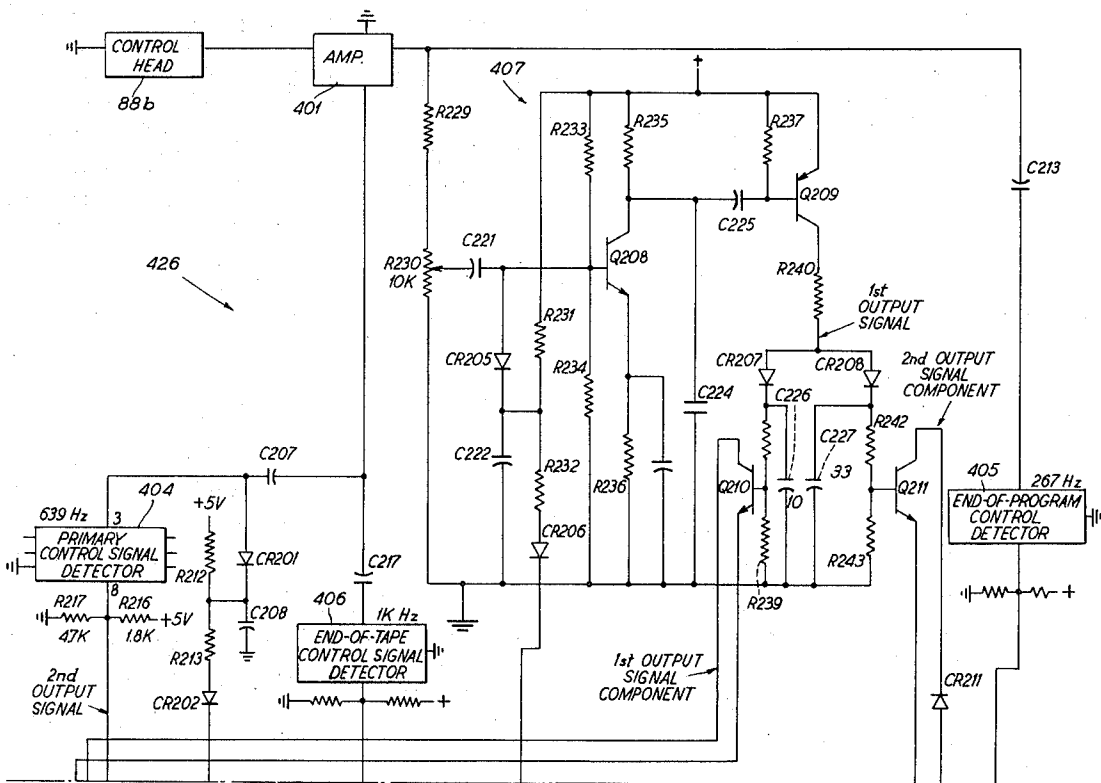


Fig. 1

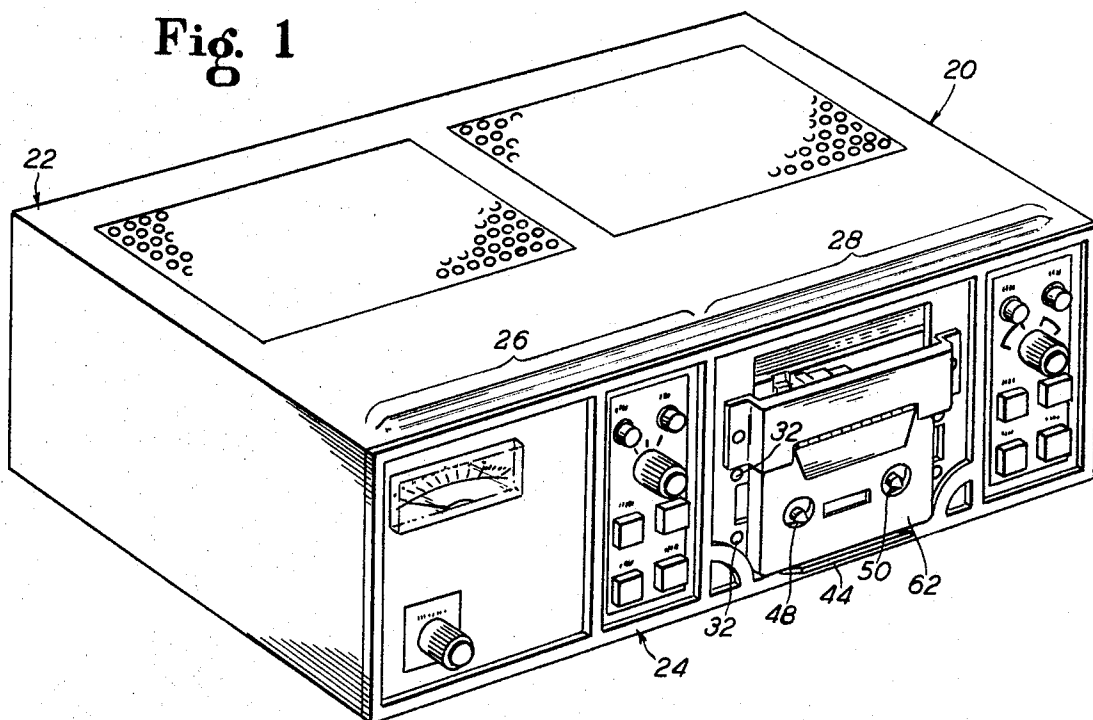
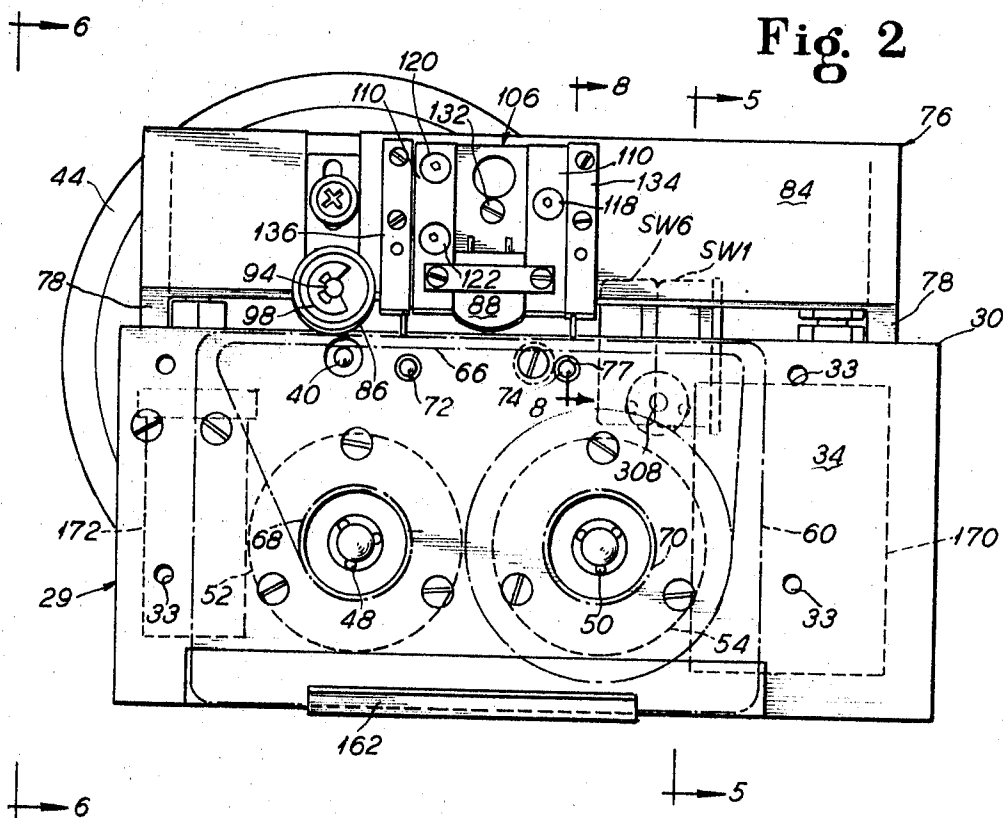


Fig. 2



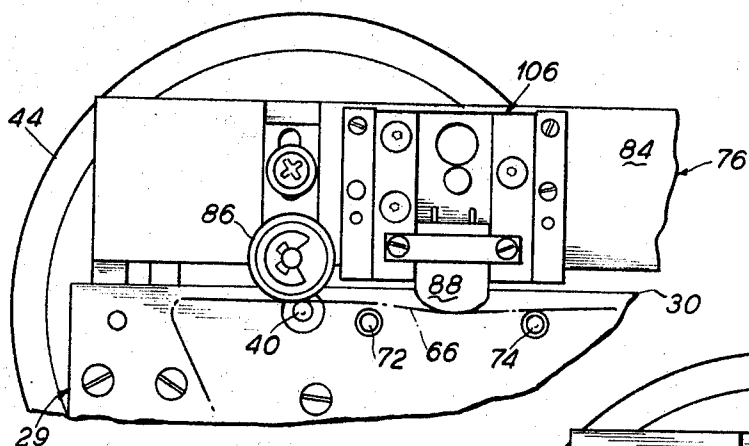


Fig. 3

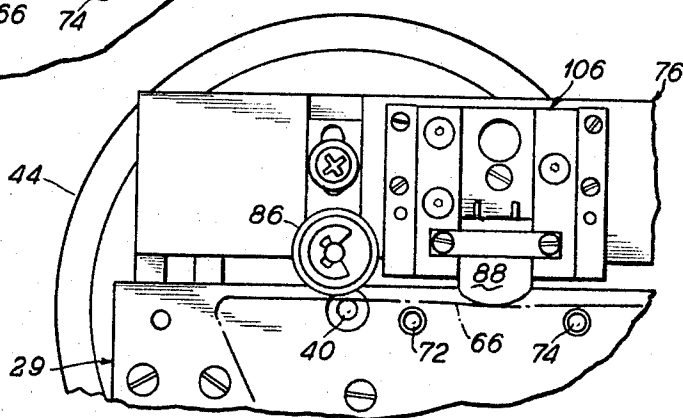


Fig. 4

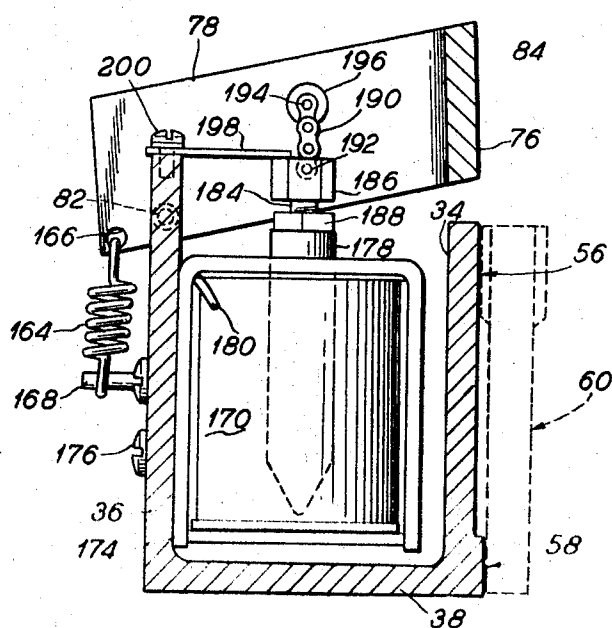


Fig. 5

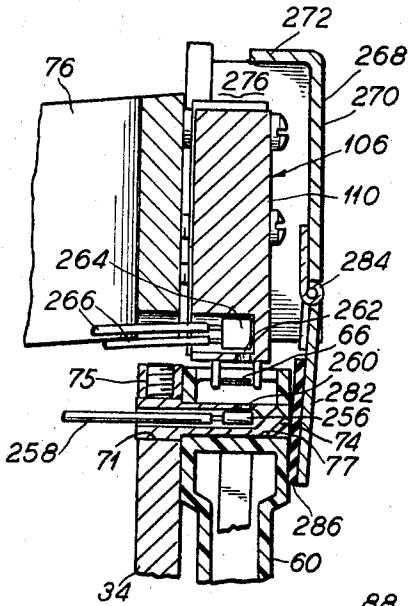


Fig. 8

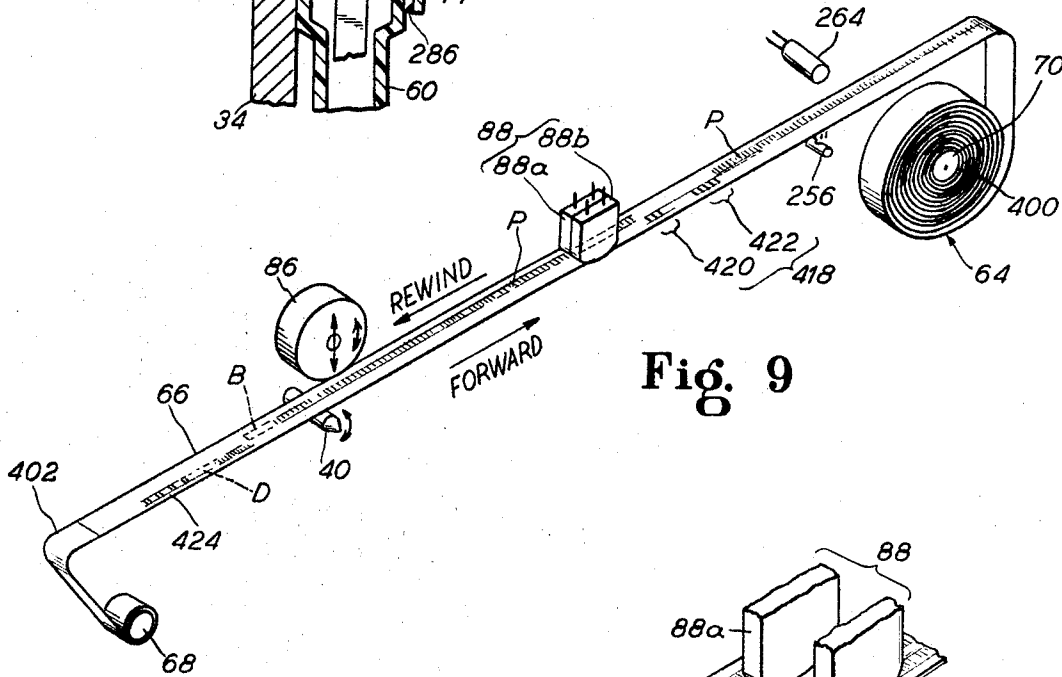


Fig. 9

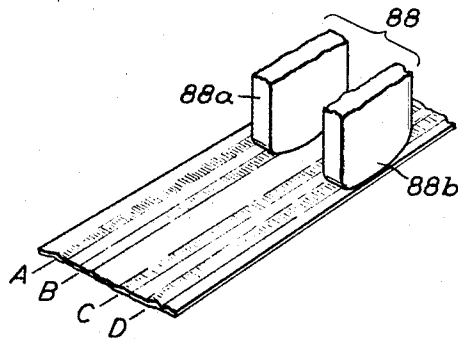


Fig. 9a

FIG. 10
FIG. 11
FIG. 12

Fig. 13

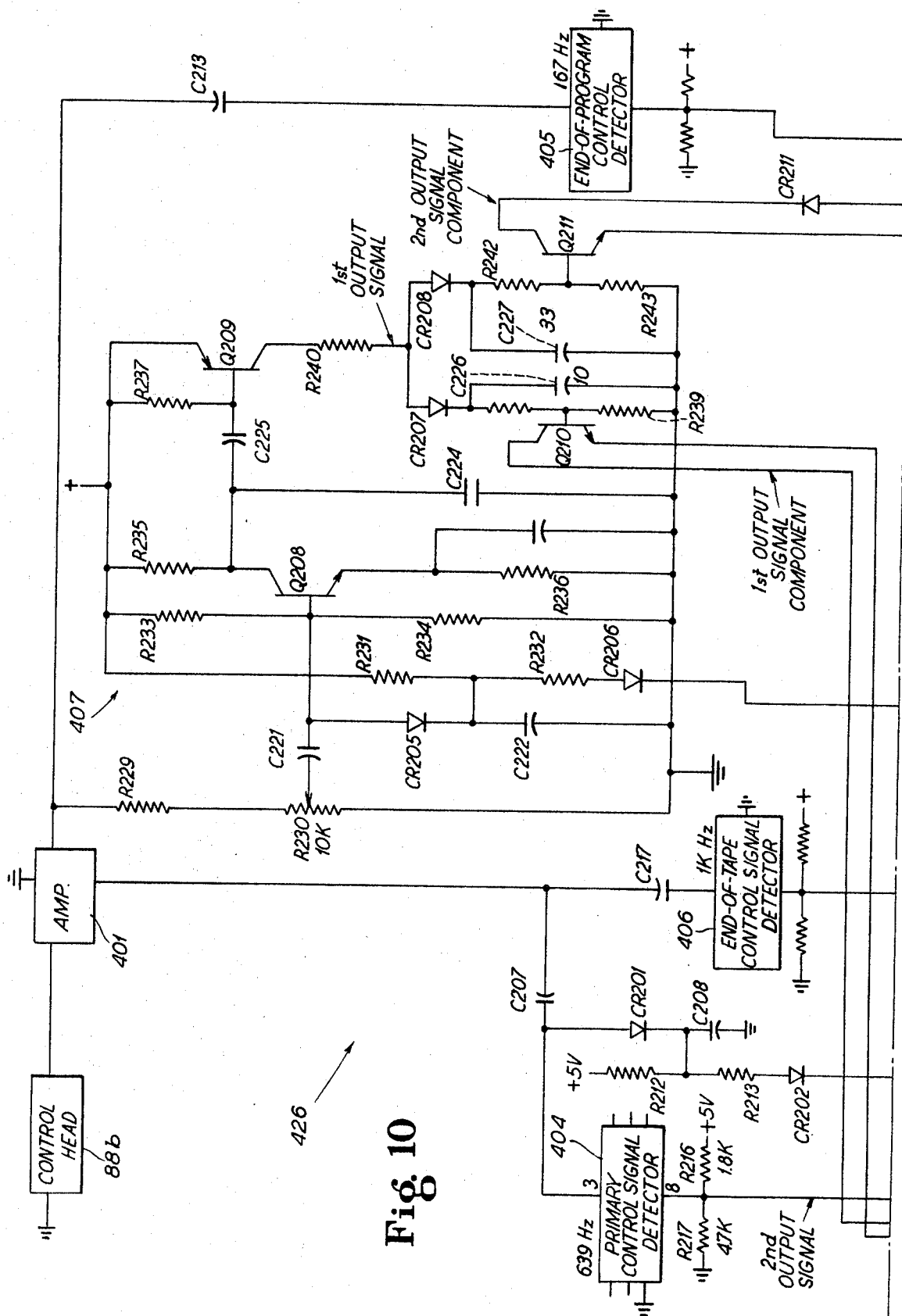


Fig. 10

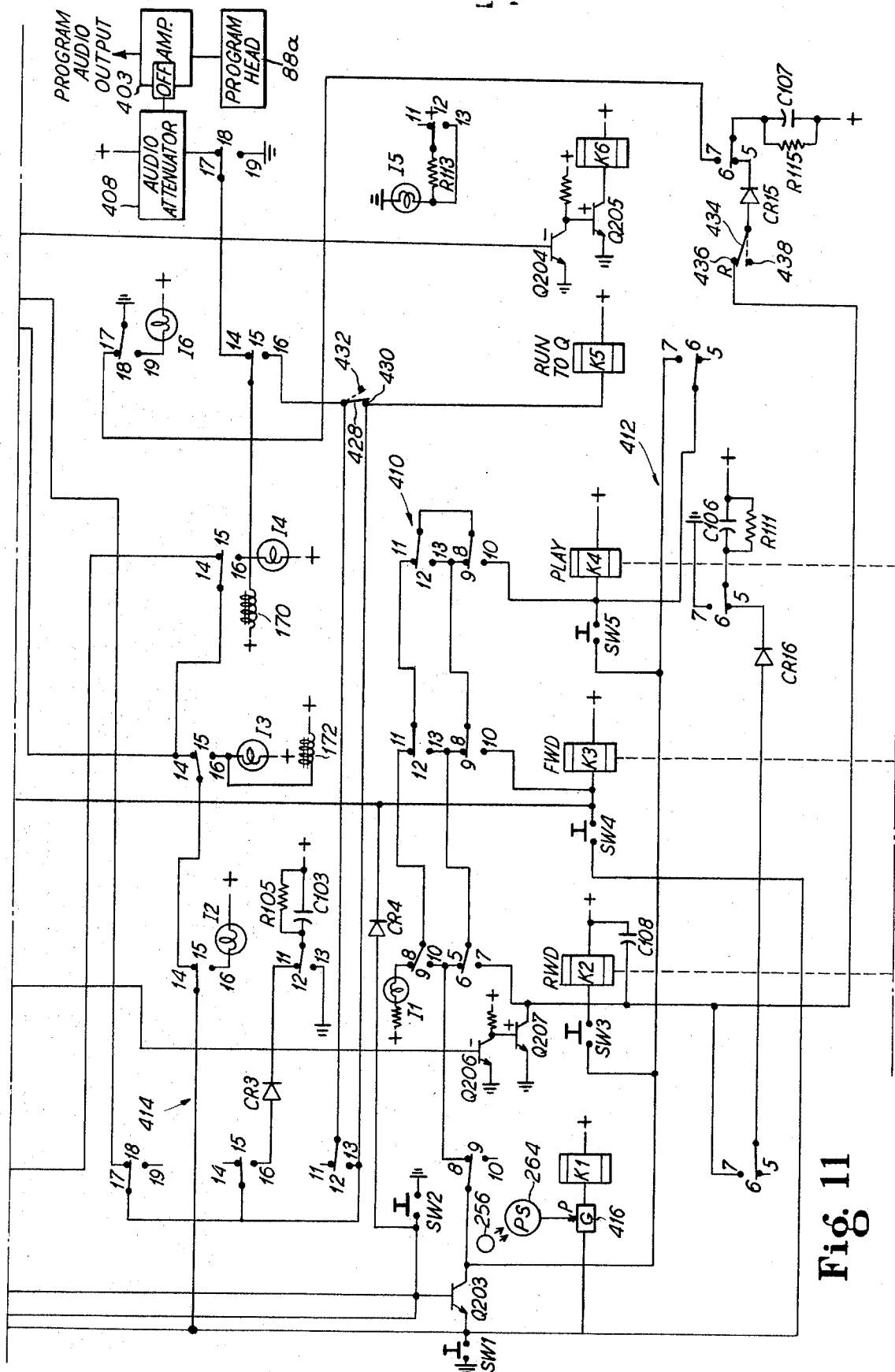


Fig. 11

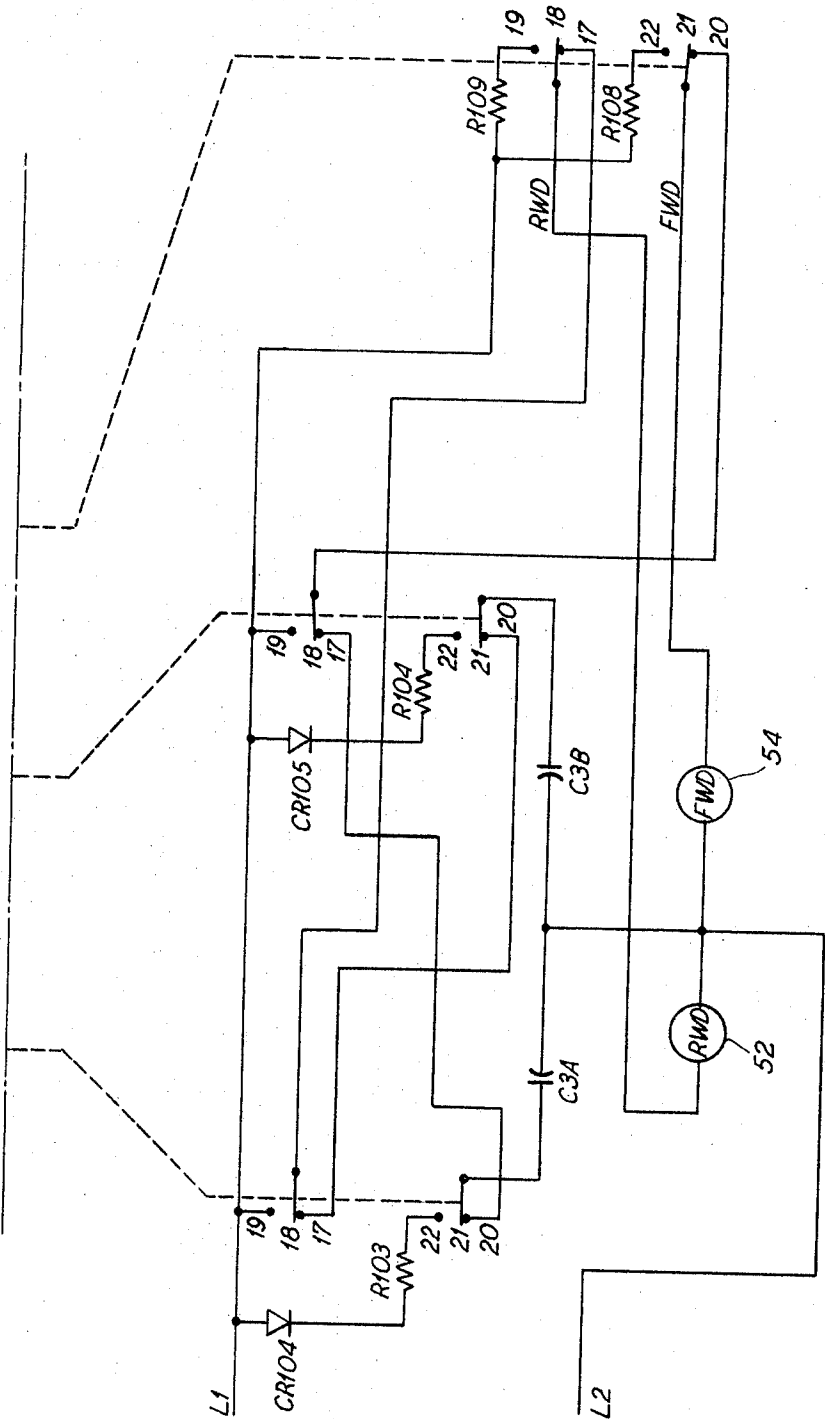


Fig. 12

AUTOMATIC SEQUENCE CONTROL FOR REPRODUCING APPARATUS

A primary control signal detector blocks the gate and stops tape movement when a primary control signal is detected. An end-of-tape control signal detector initiates the automatic rewind sequence when an end-of-tape control signal is detected. An end-of-program control signal detector initiates the automatic rewind sequence when an end-of-program control signal is detected. And, when activated by the fast forward switch, a broad band detector initiates a sequence for braking the tape to a complete stop, and restarting and running it forward at play speed, and then restopping at the next primary control signal ready to play the next recorded program.

CROSS REFERENCES TO RELATED APPLICATIONS

Reference is made to the following copending, related patent applications, assigned to the same assignee:

Jenkins application Ser. No. 237,707, filed Mar. 24, 1972 on COMPACT CASSETTE TAPE TRANSPORT WITH DIRECT CAPSTAN AND TORQUE MOTOR DRIVES, now U.S. Pat. No. 3,801,043 issued Apr. 2, 1974;

Jenkins application Ser. No. 237,762, filed Mar. 24, 1972 on CASSETTE TAPE TRANSPORT WITH PIVOTALLY SUPPORTED, UNIVERSALLY ADJUSTABLE HEAD AND UPRIGHT FRONT-MOUNTED CASSETTE, now U.S. Pat. No. 3,800,323 issued Mar. 26, 1974;

Jenkins application Ser. No. 341,769, filed Mar. 15, 1973 on TAPE TRANSPORT WITH AUTOMATIC TORQUE MOTOR BRAKE, now U.S. Pat. No. 3,809,329 issued May 7, 1974; and

Jenkins application Ser. No. 349,677, filed Apr. 10, 1973 on CASSETTE TAPE TRANSPORT WITH UNIVERSALLY ADJUSTABLE HEAD AND UPRIGHT FRONT-MOUNTED CASSETTE now U.S. Pat. No. 3,833,925.

BACKGROUND OF THE INVENTION

This invention relates to reproducing apparatus for magnetic tape and particularly to such apparatus for use in commercial radio broadcasting where it is well-established practice to pre-record a wide variety of programs, from short time announcements and commercials to entire hour-long entertainment and educational packages. Some radio stations are one hundred percent automated, using only pre-recorded material.

To avoid the relatively inflexible scheduling which would result if the programs for an entire day were recorded on one or more large tapes, individual cassettes and small reels are often used, each having a single recorded program. A full day's schedule will, of course, require many such cassettes or reels, and the equipment for handling them on a completely automatic basis is substantial, complex, and costly. In broadcasting operations which are not so fully automated, but which make substantial use of pre-recorded material, the format for a day may be scheduled by means of a written list of tape or reel numbers and the precise playing times for each. In such cases the operator or engineer spends much of his time selecting cassettes and readying them for play while others are playing. Tape

reproducers are almost always used in pairs, so one can be readied for play while the other is playing. An additional advantage is that one is available in case the other malfunctions or is out of use for periodic maintenance. Even with such duplicate equipment, there is considerable pressure on the operator or engineer, especially when the schedule calls for a series of short, tightly-cued cuts.

Thus, conventional tape reproducing apparatus for broadcasting pre-recorded programs involves either large, expensive, complex automatic cassette- and reel-handling equipment; or requires constant attention and considerable manual work by the operator to keep the tapes arranged in the right sequence and on cue.

BRIEF SUMMARY OF THE INVENTION

A general object of this invention is to provide magnetic tape reproducing apparatus having an automatic sequence control circuit enabling any specific one of several programs on a tape to be placed quickly and positively in ready-start condition, and enabling the tape to return automatically to a beginning position after playing a single program, or after playing the entire tape, as selected by the operator.

Another object is to provide magnetic tape reproducing apparatus having an automatic sequence control circuit which is effective on tapes with beginning and end clear leaders, and on tapes with or without program-identifying and end-of-tape control signals.

Another object is to provide magnetic tape reproducing apparatus having an automatic sequence control circuit with the following automatic sequence and mode capabilities under the operator's control:

- a. Move the tape forward at play speed with the audio activated to play a single program, and stop at a primary control signal in position ready to play the next succeeding program, thereby establishing a play mode in response to momentary actuation of a start switch;
- b. Move the tape at fast rewind speed with the audio deactivated, and stop at the first primary control signal on the tape, or at the end of the beginning clear leader, as selected by the operator, thereby establishing a rewind mode in response to momentary actuation of a rewind switch;
- c. Move the tape forward at play speed with the audio activated to play a single one of a series of programs on the tape, and then automatically change to rewind mode and return the tape to a selected restart position at the beginning of the tape, thereby establishing a play and return mode in response to momentary actuation of the start switch;
- d. Move the tape forward at play speed with the audio activated, to play the last or only program on the tape, and then automatically change to rewind mode and return the tape to a selected restart position at the beginning of the tape, thereby establishing another kind of play and return mode in response to momentary actuation of the start switch;
- e. Move the tape at fast forward speed with the audio deactivated, and stop at a primary control signal preceding the next succeeding program, thereby establishing a fast forward mode to skip a single program in response to momentary actuation of a fast forward switch; and

- f. Move the tape at fast forward speed with the audio deactivated, to scan the tape, skip successive programs, and locate a specific program by monitoring control signals on the tape, thereby establishing a scanning mode while the fast forward switch is held closed.

Another object is to provide magnetic tape reproducing apparatus in which a transducing head and pinch roller are mounted on a common support which is movable to a play position where the head engages the tape and the pinch roller presses the tape into frictional speed-limiting engagement with the capstan; to a fast forward position where the head but not the pinch roller engages the tape; and to an off position where neither the head nor the pinch roller effectively engages the tape.

Other objects and advantages will be apparent from the following description taken in connection with the drawings in which:

FIG. 1 is a perspective view of a combined recorder and reproducer, illustrating the kind of tape reproducing apparatus in which the present invention may be applied;

FIG. 2 is a fragmentary front view of FIG. 1 with portions stripped away to expose the tape transport showing supports for a tape cassette, a transducing head, a capstan, a pinch roller, a light source, and a light sensor, the apparatus being shown in OFF mode;

FIG. 3 is a fragmentary view of FIG. 2, in play mode;

FIG. 4 is a view similar to FIG. 3, in fast forward or scanning mode;

FIG. 5 is a vertical cross-sectional view of FIG. 2 taken along the line 5—5;

FIG. 6 is a side view of FIG. 2 as seen in the direction of the arrows 6—6;

FIG. 7 is an enlarged fragmentary view of FIG. 1, with some forward portions removed, showing the transducer head and its immediate supporting components;

FIG. 8 is a fragmentary vertical cross-sectional view of FIG. 2, taken along line 8—8, showing the light source and light sensor on opposite sides of the tape;

FIG. 9 is a schematic view of a magnetic tape with various operating components of the apparatus positioned along the tape intermediate run between forward and rewind reels;

FIG. 9a is a fragmentary enlarged view of FIG. 9;

FIGS. 10, 11 and 12 are control circuit diagrams providing automatic sequencing of the apparatus shown in the preceding figures; and

FIG. 13 is a schematic illustration showing the relationship of FIGS. 10, 11 and 12.

Like parts are referred to by like reference characters throughout the figures of the drawings.

GENERAL DESCRIPTION

The mechanical arrangement of the reproducing apparatus illustrated is identical with that shown in the above-identified U.S. Pat. No. 3,800,323. For consistency, the same reference characters are used in the present description for the major mechanical components. For a detailed description, and to avoid unnecessary repetition of non-inventive details here, reference should be made to that copending application.

A recorder and reproducer 20 incorporates a tape transport 29 (FIG. 2). The tape transport has a housing 22 with a front panel 24 comprising a recording portion

26 and a reproducing portion 28. The reproducing portion is of special interest in connection with the present invention.

The tape transport 29 includes a main motor supporting frame generally designated 30, a capstan motor 44, a forward torque motor 54, a rewind torque motor 52, and a swing arm 76.

As best shown in FIGS. 5 and 6, the motor supporting frame 30 is U-shaped in cross section. It has an upright forward wall 34, an upright rearward wall 36, and a bottom wall 38 rigidly interconnecting the two upright walls.

A capstan 40, driven by motor 44, extends forwardly beyond forward wall 34, being held by an extended bearing member supported between the walls 34, 36. A pair of reel-engaging spindles 50 and 48 extend forwardly from wall 34, being directly driven by torque motors 54 and 52, respectively, mounted between walls 34, 36. The capstan motor and torque motors are described in detail in the above-identified U.S. Pat. No. 3,801,043. Reference may be had to that application for details of the motor mounting arrangement which form no part of the present invention.

As shown in FIGS. 5 and 6, the forward wall 34 has a major upper front surface portion 56 and a minor lower front surface portion 58 disposed to support a cassette 60 in an upright operating position (shown in broken lines in FIG. 5). Although the invention is here illustrated using a cassette for compactness and handling convenience, a reel-to-reel tape mounting may be used. The cassette illustrated conforms to the standards of the National Association of Broadcasters, so its dimensions and characteristics will not be repeated here. For the purposes of the present description, the standard cassette has a plastic case 62, a magnetic tape 64 with a central run 66 and opposite ends wound upon reel hubs 70 and 68. When the cassette is in the upright operating position shown in FIGS. 2 and 5, against the front surfaces of wall 34, the hubs are engaged respectively with the torque motor spindles 50 and 48; the central run 66 is trained for movement between capstan 40 which extends through a standard opening in the case; and a pair of locating pins 72 and 74, mounted on the front wall 34, will fit standard detent openings in the case.

A swing arm generally designated 76 is U-shaped, having a pair of rearwardly extending lever portions 78, 78 interconnected at their forward, vertically movable ends by an upright cross member 84. Each lever portion 78 is journaled about a pivot pin 82 outstanding from the back wall 36 (FIG. 6) enabling the swing arm 76 to pivot up and down about a horizontal axis determined by the pins. The central run 66 of the tape is also trained for movement between the capstan 40 and a pinch roller 86, between a light source 256 and a light sensor 264 (FIGS. 8 and 9), and past transducing head means 88 (FIGS. 7, 9 and 9a).

The pinch roller 86, head 88, and light sensor (used for recording or reproducing, or both) are all carried on the forward side of the swing arm cross member 84. Standard openings (not shown) are provided in the cassette case edges enabling the pinch roller to engage the capstan, enabling the head to engage the tape, and enabling a clear light transmission path between elements 256 and 264 and through beginning and end clear leaders 400 and 402 at the terminal portions of the tape.

As described in detail in the above-identified patent application Ser. No. 237,762, the swing arm 76 comprises a common support for the pinch roller 86, head 88, and light sensor 264, which is movable to three operating positions as follows: It is normally urged by biasing spring 164 to an off position shown in FIGS. 2, 5 and 6 where neither the head nor the pinch roller effectively engages the tape; it is moved by energization of a full stroke main solenoid 170 to a play position shown in FIG. 3 where the head engages the tape and the pinch roller presses the tape into frictional, speed-limiting engagement with the capstan; and it is moved by energization of a partial stroke auxiliary solenoid 172 to a fast forward/scanning position shown in FIG. 4 where the head engages the tape only lightly and the pinch roller is displaced slightly upwardly to disengage the tape from the capstan.

The transducing head means, generally designated 88, preferably comprises separate program and control heads 88a and 88b as shown in FIGS. 9, 10 and 11. As shown in FIGS. 9 and 9a, the control and program heads are aligned with separate control and program tracks B and D, respectively. (Tracks A and C are omitted from FIG. 9 to simplify the schematic showing.) When the cassette is reversed, as is standard practice, the heads 88a and 88b will be aligned with program and control tracks C and A, respectively. Throughout the drawings, and as best shown in FIG. 9, forward and play movement of the tape will be considered toward the right, and rearward or rewind movement will be considered toward the left.

GENERAL DESCRIPTION OF ELECTRICAL OPERATING AND CONTROL CIRCUITS

As shown in FIGS. 10, 11 and 12, there are six operating relays K1 through K6. Relay K4 establishes a play mode. Relay K2 establishes a rewind mode. Relay K3 establishes optional fast forward and scanning modes. Relays K5 and K4, when energized simultaneously, establish a run-to-cue mode which moves the tape forward and stops it in a position ready to play the next recorded program. Relay K6 is effective at the operator's option to initiate a rewind mode automatically after playing any one of a series of recorded programs. Relay K1 is effective at the operator's option to initiate a rewind mode at the end clear leader, and automatically changes operation from rewind mode to run-to-cue mode when the tape rewinds to the beginning clear leader.

Electrodynamic braking means shown in FIG. 12 includes capacitors C3A and C3B for stopping the tape instantly when either relay K2 or K3 is deenergized to terminate the rewind or fast forward mode. This electrodynamic braking is the subject of the applicant's above-identified U.S. Pat. No. 3,809,329 on TAPE TRANSPORT WITH AUTOMATIC TORQUE MOTOR BRAKE to which reference should be made for a detailed description.

A feature of the present invention is that the tape 64 is tensioned from both ends by energizing both torque motors 52 and 54 urging them in winding directions, for improved wrap of the tape about the head means 88, during the play mode when tape speed is determined solely by the capstan 40.

An important feature of the present invention is that it is useful with standard tapes having the conventional beginning and end clear leaders 400 and 402, respec-

tively; it is additionally useful for tapes having a plurality of programs separated by recorded control signal means; and it is further useful in multiple program tapes where such control signal means comprises a primary control signal and an end-of-program control signal respectively preceding and following each recorded program.

Control signals are picked up by the control head 88b and amplified by amplifier 401. When the tape is moving at play speed, the primary control signal 420 which may, for example, have a frequency of 639 Hz., will be detected by the primary control signal detector 404. The end-of-program control signal 422, for example, 167 Hz., will be detected by the end-of-program detector 405. The end-of-tape control signal 424, for example, 1000 Hz., will be detected by the end-of-tape signal detector 406. A broad band detector 407, activated when the apparatus is placed in either fast forward or scanning mode, will detect primary or end-of-program signals at any tape speed because of its broad band characteristics.

Program signals are picked up by the program head 88a. Unless the amplifier 403 is disabled by an audio attenuator 408, it generates program audio output signals which are transmitted to a use point such as audio reproducing or broadcasting equipment (not shown). The audio attenuator 408 normally disables the amplifier 403 so it does not produce any program audio output. However, during the play mode, the attenuator will be grounded and itself disabled, so a program audio output will be produced by the amplifier 403. Stripped of the double negative grammatical complexities in describing attenuating an attenuator, this simply means that the program amplifier 403 produces a program output signal only when the attenuator is grounded in the play mode. Program audio output from the amplifier 403 would be distorted or meaningless in the rewind, fast forward, and scanning modes.

DETAILED DESCRIPTION OF ELECTRICAL OPERATING AND CONTROL CIRCUITS

The relays K1-K6 are energized, through various control switches to be described, by connections to a direct current electrical power source indicated by the ground and positive voltage symbols in FIGS. 10 and 11. In actual practice, the electrical power source for the components shown in FIG. 11 may be a 24 volt supply, and for some of the components shown in FIG. 10, it may be a 5 volt supply.

The control circuitry utilizes ground switching. A ground is supplied through deck switch SW1 when a cassette 60 is inserted in the play position shown in FIG. 1. The cassette holds plunger 308 (FIG. 2) displaced inward to maintain switch SW1 closed. Plunger 308 likewise holds switch SW6 closed, thereby energizing capstan motor 44 through a circuit (not shown) to keep the capstan 40 rotating at all times that a cassette is in play position.

Ground is supplied through switch SW1 to the emitter of an NPN transistor Q203. This transistor may be considered broadly a gate which is normally forwardly-biased to render it conductive by a positive potential applied to the base, but is back-biased and rendered non-conductive by grounding the base. The collector, which in this case is the output side of the transistor, is connected to a common holding circuit 410 for relays K2, K3 and K4, and is connectable through normally

open rewind switch SW3 to energize rewind relay K2. Likewise, it is connectable through normally open play switch SW5 to energize play relay K4. And it is connectable through contacts 6 and 7 of run-to-cue relay K5 to energize play relay K4 when transistor Q203 is forwardly biased.

If transistor Q203 is back-biased and therefore rendered non-conductive by grounding its base, any one of relays K2, K3 and K4 which may be held energized through the holding circuit 410 will be deenergized. Likewise, if transistor Q203 is back-biased, relay K2 cannot be energized through switch SW3, and relay K4 cannot be energized through switch SW5 or through contacts 6 and 7 of relay K5. As will be seen, the connection between the output side of transistor Q203 and relay K4 via contacts 6 and 7 of relay K5 may be considered an auxiliary holding circuit for relay K4 and is designated 412 in FIG. 11.

A normally open stop switch SW2 is effective when closed to ground the base of the gate transistor Q203 to back-bias it and make it non-conductive.

There are three other connections to the base of the gate transistor Q203, each of which grounds the base to render the gate non-conductive during certain portions of the automatic operating sequences. One of these connections is to the output terminal 8 of the primary control signal detector 404. The second connection is to the collector of transistor Q210 in the broad band detector 407. The third connection is to the output side of switch SW4. These connections to the detector means will be described in more detail with the description of FIG. 10.

Ground connections through switch SW1, which bypass the gate transistor Q203, are as follows: Ground connection through switch SW4 energizes relay K3. Ground is made to the audio attenuator 408 through a ground control circuit generally designated 414 and including contacts 14 and 15 of relays K2, K3 and K5, contacts 15 and 16 of relay K4, and contacts 17 and 18 of relay K6. As will be seen, this ground control circuit 414 serves a double function, also being part of a run-to-cue holding circuit for relay K5 during one automatic operating sequence. A ground connection is also provided from switch SW1 to light-responsive relay K1 via a gate 416 which is made conductive by a signal from the light sensor 264. The latter may, for example, by a Darlington photoresistor. The gate 416 may be any suitable transistor or cascade arrangement of transistors to provide suitable operating potential to energize relay K1 when light from the source 256 passes through either tape end clear leader 400 or 402.

TORQUE MOTOR OPERATING AND CONTROL CIRCUIT

Referring to FIG. 12, the torque motor operating and control circuit, with the electrodynamic braking referred to above, is schematically shown.

When the reproducing apparatus is in the play mode, and play relay K4 is energized, the full stroke solenoid 170 is energized to swing the support arm 76 sufficiently to cause the pinch roller 86 to press the tape into frictional driving engagement with the capstan 40. It will be understood that the capstan is constantly rotating when the cassette 60 is in place because of the closing of switch SW6 previously referred to. An alternating current power source indicated by lines L1 and L2, used for the capstan motor, is also used for the forward and rewind torque motors 54 and 52. When the play relay K4 is energized, its movable contacts 18 and 21 are closed against stationary contacts 19 and 22 respectively. This energizes the rewind motor 52 through resistor R109 and contacts 18 and 19 of relay K4. It likewise energizes the forward torque motor 54 through resistor R108 and contacts 21 and 22. Thus, in the play mode, the two torque motors are energized to tension the opposite ends of the tape and wrap the tape firmly about the program and control heads 88a and 88b. With the two torque motors neutralizing one another in this manner, the tape is then moved in a forward play direction by its frictional driven engagement with the capstan.

When the reproducing apparatus is placed in fast forward mode by energizing relay K3, this places its movable contacts 18 and 21 against stationary contacts 19 and 22 respectively. As previously described, this also energizes the partial stroke solenoid 172, disengaging the tape from the capstan, while leaving the heads 88a and 88b in light contact with the tape. This energizes the forward torque motor 54 through contacts 18 and 19 of relay K3 and contacts 20 and 21 of relay K4, moving the tape at full speed not limited by the capstan, in a forward direction. At the same time capacitor C3B is charged through diode CR105, resistor R104, and contacts 21 and 22 of relay K3. When the fast forward mode is subsequently terminated by deenergizing relay K3, this returns its movable contacts 18 and 21 to its back contacts 17 and 20 respectively. At that instant, capacitor C3B, charged as aforesaid, begins to discharge through rewind motor 52, quickly bringing the tape to a stop through an electrodynamic braking action. The discharge circuit includes contacts 20 and 21 of relay K3, contacts 17 and 18 of relay K2, and contacts 17 and 18 of relay K4.

When the reproducing apparatus is placed in rewind mode by energizing relay K2, neither of the solenoids 170 or 172 will be energized, enabling the pinch roller and head to be moved completely out of engagement with the tape by the action of biasing spring 164. This will also move its contacts 18 and 21 against stationary contacts 19 and 22 respectively. Rewind motor 52 will be energized through a circuit including contacts 18 and 19 of relay K2 and contacts 17 and 18 of relay K4, moving the tape backward at full speed. At the same time, capacitor C3A will be charged through a circuit including diode CR104, resistor R103, and contacts 21 and 22 of relay K2. Subsequently, upon termination of the rewind mode and deenergization of relay coil K2, capacitor C3A will discharge through the forward motor 54, tending to drive it in a tape winding direction and stop movement of the tape instantly. This discharge circuit includes contacts 20 and 21 of relay K2, contacts 17 and 18 of relay K3, and contacts 20 and 21 of relay K4.

Referring to FIGS. 9 and 9a, programs such as designated P, etc. may be recorded at intervals along the tape in program track B. Control signal means 418 are recorded in track D between the recorded programs P. The control signal means include primary control signals 420 having a frequency of 639 Hz., recorded on the tape at the beginning of each program. Each primary control signal comprises a pulse, preferably of a definite duration, for example, three-fourths of a second. In addition, the control signal means includes an end-of-program control signal 422 recorded on the

tape at the end of each program at a frequency of 167 Hz. After the last recorded program, and prior to the end clear leader 402, an end-of-tape control signal 424 is recorded at 1000 Hz. All control signals, as well as the program signals are recorded at play speed determined by the capstan 40.

When the tape is moving, control signals are picked up by the control head 88b, amplified by amplifier 401 and then conducted into detector means generally designated 426 which includes the previously mentioned primary, end-of-program, end-of-tape, and broad band control signal detectors 404, 405, 406 and 407, respectively.

The individual control signal detectors will now be described.

The specific details of the primary control signal detector 404 form no part of the present invention and for this reason is shown only schematically. In practice, it may comprise an NE567V integrated circuit having an input pin 3 coupled to the control signal amplifier 401 through a capacitor C207. The output pin 8 is connected to the base of the gate transistor Q203 and, in the absence of a primary control signal 420 it is forwardly biased by a positive potential through resistor R216 which is connected to the positive side of the direct current power source described. When a 639 Hz. primary control signal is detected, the output at pin 8 becomes grounded, thereby back-biasing transistor Q203 and rendering it non-conductive.

A control signal protection circuit is provided to delay back-biasing the gate transistor Q203 when a play mode is initiated by the switch SW5. This enables the tape to move beyond any residual primary control signal which may have been on the tape at the point where the play mode was initiated. Inasmuch as the primary control signal is of only limited duration, preferably about three-fourths of a second, the required delay is of short duration and is provided as follows.

As stated, when the machine is in a stop-ready condition, gate transistor Q203 is forwardly biased, that is, conductive, by a positive connection through resistor R216 to the base. Capacitor C208 is discharged through resistor R213 and diode CR202 back to switch SW1 through the ground control circuit 414 previously described. Thus, both sides of capacitor C208 are grounded and it is completely discharged.

Next, assume the reproducing apparatus is started by energizing play relay K4. This lifts the ground from the side of capacitor C208 communicating with resistors R212 and R213. Assuming the tape had been started in the middle of a primary control signal, that control signal is simply discarded to ground through diode CR201 and capacitor C208. Because the latter is discharged at this particular moment, diode CR201 is conductive through it. At this same moment, capacitor CR208 begins to charge through resistor R212. This is the start of a time delay period of approximately one and one-half seconds in which any residual primary control signal is diverted from the input pin 3 of detector 404 to keep the tape from stopping before it moves beyond such residual primary control signal. It will be remembered that the control signal is an alternating current signal and passes readily through capacitors C207 and C208.

One and one-half seconds or so later, capacitor C208 is fully charged, above the potential at the input pin 3 of the primary control signal detector 404. Whatever

residual primary control signal may have been under the control head 88b when the play mode was initiated is now gone. Gate transistor Q203 is forwardly biased through resistor R216, and this bias will not be changed until the next primary control signal reaches the control head.

Next, the tape plays through the program. It passes the end-of-program control signal to which the detector 404 is non-responsive, and reaches the next primary control signal immediately following it. At this point, because capacitor C208 is fully charged above the potential at input pin 3, the primary control signal cannot pass through diode CR201 to ground. Instead, it enters detector 404 at input pin 3, output pin 8 changes to grounded or negative state, and this back-biases transistor Q203 to non-conductive condition, thereby deenergizing the holding circuit 410, deenergizing the play relay K4 and stopping the tape.

End-of-program control signal detector 405 is identical with the detector 404 with the exception of the frequency selective components enabling it to generate an output signal in response to a 167 Hz. end-of-program control signal 422. Detector 405 is coupled to the control signal amplifier 401 through a capacitor C213 and its output conductor is normally biased positive in the same manner as pin 8 of detector 404. When an end-of-program control signal is detected, the output bias changes to negative or ground. This output back biases transistor Q204 which in turn forwardly biases inverting transistor Q205 which thus becomes conductive in the presence of an end-of-program control signal thereby energizing relay K6.

The end-of-tape control signal detector 406 is coupled to the amplifier 401 through a capacitor C217 and is identical to the detectors 404 and 405 except for the frequency selective components. The output of detector 406 is normally positive but in the presence of a 1000 Hz. end-of-tape control signal, its output becomes grounded or negative. This output back biases transistor Q206 which in turn forwardly biases inverting transistor Q205 which becomes conductive and energizes relay K2.

BROAD BAND DETECTOR

The broad band detector 407 is activated when the fast forward switch SW4 is closed to place the apparatus in fast forward mode. This moves the tape rapidly in a forward direction without limitation by the capstan. A broad band detector is advantageous in detecting a control signal during the fast forward mode because the detected signal frequency varies with the tape speed which itself varies from point to point depending on the tension applied by the forward torque motor 54, the thickness of tape wrap on forward reel hub 70, and other factors such as frictional drag. For this reason, a specific frequency detector such as 404, 405 or 406 would be unreliable or ineffective.

As will be described, a major function of the broad band detector 407, when activated by closing fast forward switch SW4, is to provide a completely automatic sequence in which the tape is run at fast forward speed while the audio is deactivated, stopped and restarted at play speed determined by the capstan at the next succeeding end-of-program signal, and stopped again at the immediately following primary control signal in position ready to play the next program. A fast forward control signal protection circuit is provided for the

broad band detector to delay the slowing and stopping of tape in response to a control signal for a sufficient time to enable the tape to move beyond a residual control signal which may be under the head at the moment the fast forward mode is initiated by switch SW4.

The control signal protection circuit for the broad band detector is here shown as identical with the one described above for the detector 404. It is especially important for the broad band detector which responds to the end-of-program control signal 422 because the end-of-program control signal may be considerably longer in duration than the three-quarter second duration of the primary control signal 420, thereby increasing the likelihood that the fast forward switch SW4 will be closed when some residual end-of-program signal is on the tape under the head 88b.

The broad band detector 407 will now be described in detail. Refer to FIGS. 10 and 11. The level at the input is controlled by an adjustable potentiometer R230 which is coupled to the base of a transistor Q208 by a capacitor C221. The signal control protection circuit at the base of transistor Q208 is identical to that previously described at the input pin 3 of the primary control signal detector 404. The collector of transistor Q208 is coupled to the base of transistor Q209 through capacitor C225. When the apparatus is in stop-ready condition transistor Q209 is back-biased by a positive potential applied to its base through resistor R237.

Referring back to the control signal protection for the broad band detector, the detector is activated by closing fast forward switch SW4 to initiate the fast forward mode. This discharges capacitor C222 by grounding both sides, one side being connected directly to ground as shown in FIG. 10 and the other side being connected to ground through switches SW4 and SW1 as shown in FIGS. 10 and 11. Assuming some residual control signal on that portion of the tape under the control head 88b at the instant switch SW4 is closed, this control signal would be picked up immediately after closing switch SW4 and would be shorted through diode CR205 and capacitor C222 direct to ground. This marks the beginning of a time delay or control signal protection period during which the control signal is diverted away from broad band detector input transistor Q208. At the same time, capacitor C222 begins to take a charge through resistor R231. It will be assumed for the present explanation that it takes a predetermined time X to charge capacitor C222.

When capacitor C222 is so charged, after such a time X, it blocks transmission of a control signal through diode CR205; however, the size of capacitor C222 is chosen so that after the time X, when C222 is charged sufficiently to block further diversion of control signals to ground, there will be no further residual control signal because the tape has moved any such control signals beyond the head and is moving at fast forward speed to bring the next control signal under the head. PNP transistor Q209 remains back-biased through resistor R237.

When the next end-of-program control signal 422 reaches the control head 88b, the signal will no longer be diverted to ground because of the charge in capacitor C222. Instead, it will be applied to the base of transistor Q208 to forward bias it. This, in turn, forward biases transistor Q209. The resulting output signal passing through resistor R240 and through parallel diodes CR207 and CR208 is applied simultaneously to the

bases of transistors Q210 and Q211 to forwardly bias them, and to capacitors C226 and C227, the latter being significantly larger for a time delay purpose which will be described. By way of example, C226 and C227 may have capacities of 10 and 33 mfd respectively.

At the instant transistors Q210 and Q211 become so forwardly biased, they start a sequence which turns gate transistor Q203 off long enough to stop the tape, restart it, and re-stop it at the next primary control signal 420.

This sequential operation under the control of transistors Q210 and Q211 is as follows. At the instant the output signal from transistor Q209 is applied simultaneously to transistors Q210 and Q211 and capacitors C226 and C227, the resulting forward bias of Q210 grounds the base of gate transistor Q203 through main switch SW1. This back biases transistor Q203 and de-energizes relay K3 by blocking the ground connection through the common holding circuit 410 which had held relay K3 energized.

At the same instant that transistor Q203 is back-biased and rendered non-conductive through transistor Q210, transistor Q211 is likewise forward-biased and energizes run-to-cue relay K5 by connecting it to ground through contacts 17 and 18 of relay K1, diode CR211, contacts 14 and 15 of relay K3, and main switch SW1. Although run-to-cue relay K5, when so energized, closes the K4 auxiliary holding circuit 412 through contacts 6 and 7 of K5, this does not result in energizing the play relay K4 because that auxiliary holding circuit 412 is blocked from ground by transistor Q203 and remains so blocked as long as gate transistor Q203 remains back-biased by ground potential from transistor Q210.

When the end-of-program signal which generated the output signal through transistor Q209 ceases, transistors Q210 and Q211 will continue to be forward-biased by discharges from capacitors C226 and C227 respectively. The discharge from capacitor C226 will be of sufficient duration to enable the tape to come to a complete stop, this being almost instantaneous as a result of the electrodynamic braking circuit described in connection with FIG. 12.

The discharge from capacitor C226 will be completed sooner than that from the larger capacitor C227. Therefore, transistor Q210 will return to its normal back-biased condition and the gate transistor Q203 will return to its normal forward-biased or conductive condition to ground the common holding circuit 410 substantially before the discharge of capacitor C227 is completed.

At the instant that gate transistor Q203 returns to its normally forward-biased, conductive condition, play relay K4 is energized by connection to ground through the auxiliary holding circuit 412 and contacts 6 and 7 of relay K5 which had been held closed since transistor Q211 was first forwardly biased by the output signal through transistor Q209.

With relays K5 and K4 thus simultaneously energized, a run-to-cue mode is established and the tape moves forward at constant play speed, thereby enabling detectors 404, 405 and 406 to detect the specific frequencies to which they are tuned.

If the next control signal, following change from fast forward to run-to-cue modes in response to an end-of-program signal as above described, is a primary control

signal, the resulting output signal applied to the base of gate transistor Q203 back-biases it, rendering it non-conductive, deenergizing play relay K4, and stopping the tape.

If, on the other hand, the next signal on the tape is an end-of-tape control signal, instead of a primary control signal, this will be detected by the end-of-tape control signal detector 406 and will generate an output signal to ground the base of transistor Q206 to back-bias it. Transistor Q206 in turn will drive inverting transistor Q207, forwardly biasing it, to provide a ground connection which will energize rewind relay K2 and initiate an automatic rewind sequence to be described.

Summarizing operation of the broad band detector, it is activated in response to momentary closing of fast forward switch SW4. The fast forward control signal protection circuit diverts any residual control signal that may be under the control head for a short time enabling the tape to move any such residual signal past the head. Detection of the next succeeding control signal forward-biases transistor Q209 and causes a first output signal to pass therethrough to the transistors Q210 and Q211 and their associated small and large capacitors C226 and C227. A first output signal component through transistor Q210 blocks gate transistor Q203 long enough to bring the tape to a complete stop and enable the electrodynamic braking to be effective. A second output signal component through transistor Q211 is effective, as soon as gate transistor Q203 regains its forward bias, to energize both relays K5 and K4 to place the apparatus in run-to-cue mode. The tape is then stopped when the detector 404 generates a second output signal in response to the next primary control signal thereby grounding the base of transistor Q203, back-biasing and rendering it non-conductive, deenergizing relays K4 and K5, and stopping the tape.

The above-described sequence of "fast forward—stop—run-to-cue—stop" is completely automatic and initiated simply by momentarily closing fast forward switch SW4.

READYING THE APPARATUS FOR PLAY

Placing a cassette 60 in play position as shown in FIGS. 2 and 5 displaces plunger 308, simultaneously closing switches SW1 and SW6. SW6 starts capstan motor 44 through conductors (not shown) to rotate capstan 40 at constant speed. Because gate transistor Q203 is normally conductive, being forwardly biased as described, closing SW1 activates the common holding circuit 410 and lights ready lamp I1. The apparatus is now in stop/start mode, ready for operation by either the start switch SW5, the rewind switch SW3, or the fast forward/scanning switch SW4, provided the tape when last used was rewound to the beginning.

PLAY MODE

Momentary closing of switch SW5 places the apparatus in play mode. This energizes play relay K4. Main play solenoid 170 and play lamp I4 are energized by connection to ground through contacts 15 and 16 of relay K4, contacts 14 and 15 of relays K3 and K2, and switch SW1. The audio attenuator 408 is energized by connection to ground through contacts 17 and 18 of relay K6 and contacts 14 and 15 of relays K5, K3 and K2, contacts 15 and 16 of relay K4, and switch SW1, thereby enabling amplifier 403 to produce program audio output signals. Contacts 11 and 12 of relay K4

open, thereby extinguishing ready lamp I1. Relay K4 is held energized by the common holding circuit 410 through contacts 9 and 10 and contacts 12 and 13 of K4, contacts 8 and 9 of K3, contacts 5 and 6 of K2, contacts 8 and 9 of K1, Q203, and SW1. Contacts 6 and 7 of K4 close and connect capacitor C106 to a DC power source to store an electrical charge in it.

During the play mode, the tape moves forward at play speed determined by frictional engagement with the capstan. The program signal on track B is picked up by program head 88a to produce the program audio output generated by amplifier 401.

After the tape play to the end of the program, it will move an end-of-program control signal 422 and a primary control signal 420 past the control head 88b. The end-of-program control signal will have no effect on the tape movement, but when the primary control signal is detected by detector 404, it applies an output grounding signal to the gate transistor Q203, back-biasing it, and rendering it non-conductive; this deenergizes the common holding circuit 410, deenergizes the play relay K4, and stops the tape at such primary control signal, ready to play the next recorded program (and stop automatically) in response to the next momentary closing of switch SW5.

REWIND MODE

Momentary closing of switch SW3 places the apparatus in rewind mode. Closing contacts 15 and 16 lights rewind lamp I2 and opening of contacts 8 and 9 extinguish ready lamp I1. The program amplifier 403 is disabled, being turned off by attenuator 404. An electrical charge is stored in capacitor C103 by connection to a DC power source through contacts 12 and 13 of K2. Relay K2 is held energized by the common holding circuit 410 through its contacts 6 and 7.

Such momentary closing of switch SW3 initiates a completely automatic sequence rewinding the tape to the beginning clear leader and then moving it forward either to the end of the beginning clear leader or to the first primary control signal as selected by the operator. This automatic sequence will now be explained.

Energization of relay K2 starts the rewind torque motor 52 and runs the tape backward at high speed not limited by the capstan. As soon as the beginning clear leader 400 reaches the light sensor 264, the latter is energized by the light source 256. An output signal from the light sensor forward biases the gate 416 rendering it conductive and energizing the light responsive relay K1. This opens contacts 8 and 9 of K1, thereby deenergizing the holding circuit 410 for relay K2. K2 thus deenergizes, stops rewind motor 52 and the tape quickly by means of the electrodynamic braking means described in connection with FIG. 12. Capacitor C103 begins to discharge through run-to-cue relay K5 via contacts 11 and 12 of K2, and 15 and 16 of K1, thereby energizing K5, closing its contacts 6 and 7 to energize play relay K4 by ground connection through transistor Q203. Relay K4 is held by the common holding circuit 410 through its own closed contacts 9 and 10, and 12 and 13. This now establishes a run-to-cue mode and moves the tape forward at play speed determined by the capstan.

At this stage, the tape will stop automatically at one selected tape beginning position or another depending on the position of a movable contact or jumper 428.

If the movable contact 428 is adjusted to engage the contact 430, the run-to-cue relay K5 will be energized by a connection to ground through contacts 15 and 16 of relays K5 and K4, contacts 14 and 15 of relays K3 and K2, and switch SW1. Thus, contact 428 bypasses contacts 12 and 13 of K1. Otherwise, if movable contact 4228 is adjusted to engage the open contact 432, the same ground connection for the run-to-cue relay K5 will have to go through contacts 12 and 13 of K1, and K5 will be energized only if K1 is energized.

Reverting back to the above-described rewind sequence, to the point where the beginning clear leader 400 is moving forward past the light sensor 264 at play speed in run-to-cue mode, assume first that jumper 428 is connected to contact 430. Both relays K4 and K5 are energized, being held by a holding circuit means which energizes K5 through closed contacts 15 and 16 of relays K5 and K4 so that even after capacitor C103 completes discharging, relays K5 and K4 remain energized through such holding circuit means, and relay K1 is still energized because the beginning clear leader is still between the light source 256 and sensor 264.

Moments later, the tape runs out of the beginning clear leader and into the beginning opaque portion, deenergizing relay K1. Relay K4 is held momentarily through two holding circuits: through the common holding circuit 410; and through the above-mentioned holding circuit means involving closed contacts 15 and 16 of relays K5 and K4.

Next, the beginning opaque portion of the tape runs past the head until the first primary control signal reaches the head. Primary control signal detector 404 then grounds the base of gate transistor Q203 and blocks the common holding circuit 410 thereby deenergizing relay K4 both through the common holding circuit and the auxiliary holding circuit 412 through contacts 6 and 7 of K5. This opens contacts 15 and 16 of relay K4, deenergizing the holding circuit means for relay K5, thus stopping the tape on the first primary control signal 420.

If, on the other hand, the jumper 428 is adjusted to engage open contact 432, the holding circuit for relay K5 during the run-to-cue mode will be through closed contacts 12 and 13 of relay K1 as long as the beginning clear leader is moving past the light sensor 264. As soon as the beginning opaque end of the tape covers the light sensor, relay K1 deenergizes and opens its contacts 12 and 13. This deenergizes relay K5, opening its contacts 6 and 7, thereby deenergizing relay K4, before a new hold circuit for the latter can be established through contacts 8 and 9 of K1. This completely deenergizes both relays K5 and K4, stopping the tape at the end of the beginning clear leader ready to play the first program on the tape in response to the next closing of play switch SW5.

Thus, once the apparatus has been placed in rewind mode, it automatically rewinds the tape to the beginning regardless of how the rewind mode was initiated.

AUTOMATIC INITIATION OF THE REWIND MODE

The rewind mode described in the preceding section may be initiated automatically either at the end of the tape or after playing one of a series of programs on the tape as selected by the operator.

Automatic rewind may be initiated at the end of the tape either in response to the end clear leader, or in re-

sponse to an end-of-tape control signal 424 recorded thereon. Automatic rewind may be initiated after playing any selected program in response to an end-of-program control signal 422 when a selector R is appropriately adjusted.

As one of the options, this apparatus may be used without the end-of-tape control signal 424, making an end-of-tape control signal detector 406 unnecessary. In the absence of such an end-of-tape control signal, adjustment of the movable contactor or jumper 434 in the selector R determines how automatic rewind will be initiated.

By adjusting the movable contact 434 to engage open contact 438, automatic rewind is initiated at the end of the tape.

Assume contact 434 is adjusted to engage contact 438. Assume further that the apparatus is in play mode, playing the end program on the tape. Relay K4 is, of course, energized and capacitor C106 is charged through closed contacts 6 and 7 of relay K4 as explained above. After play of the end program is completed, tape continues to move, first passing through the last end-of-program control signal 422 with no effect other than to cause the detector 405 to detect the signal and energize relay K6 to close its contacts 12 and 13 for the duration of that signal. This is indicated at the combination power and end-of-program lamp 15 by increase in illumination when it is direct-connected to a DC power source, bypassing resistor R113 (normally lamp 15 is at a low level illumination energized through R113 merely to indicate that power is on). Next, the end clear leader 402 reaches the light sensor 264. The photosensitive relay K1 is energized by the light sensor and opens the holding circuit for the play relay K4 at contacts 8 and 9 of K1, thereby deenergizing the play relay K4 and the forward torque motor 54 to stop the tape. Stopping is accelerated by the electrodynamic braking means previously described. The capacitor C106, which was charged while the play relay K4 was energized, then discharges through closed contacts 6 and 7 of relay K1. Capacitor C106 discharges through the rewind relay K2, energizing it and charging capacitor C108. Capacitor C103 starts to charge by connection to a direct current power source through closed contacts 12 and 13 by relay K2. Tape then starts to rewind back toward the end opaque portion.

Next, the tape rewinds to the opaque magnetic portion, deenergizing photosensitive relay K1. For a very short period of time, before contacts 8 and 9 of relay K1 close to establish a holding circuit for relay K2 through the common holding circuit 410, relay K2 is kept energized by the charge stored in capacitor C108. It will be understood that capacitor C108 may not be required in every instance but may be employed as a useful safety feature to prevent contacts 6 and 7 of relay K2 from opening before contacts 8 and 9 of relay K1 close when K1 is deenergized.

At this point the rewind mode is established with rewind relay K2 being held energized through the common holding circuit 410. The ensuing automatic sequence which rewinds the tape back to the beginning and stops it either at the end of the beginning clear leader or at the first primary control signal, is the same as described above under the heading "Rewind Mode".

If the movable contact 434 of selector R is adjusted to engage the open stationary contact 436, operation will be as follows. Assume the apparatus is in play

mode, playing one of a series of programs in the middle of the tape. As stated above, the play relay K4 will be energized and capacitor C106 will be charged. When the tape reaches the end of the program, it will move on at play speed to the end-of-program signal on the tape immediately following the program just played. At that time the end-of-program control signal detector 405 will detect the end-of-program control signal and will ground the base of transistor Q204 which in turn will forwardly bias the transistor Q205, rendering it conductive and energizing end-of-program control signal relay K6. This closes contacts 6 and 7 of relay K6, connecting capacitor C107 to a direct current power source through contacts 17 and 18 of relay K5. This stores a charge in capacitor C107. At the same time, the power and end-of-program signal lamp 15 increases in intensity due to the closing of contacts 12 and 13, indicating the end-of-program signal. The program audio output from amplifier 403 is disabled during the end-of-program control signal, by opening contacts 17 and 18 of relay K6. Next, the end-of-program signal terminates, deenergizing relay K6, and connecting contacts 5 and 6 of relay K6 enabling capacitor C107 to discharge directly through rewind relay K2. This then locks rewind relay K2 energized; through the common holding circuit 410 and starts the rewind mode described above.

The third option for automatically rewinding the tape utilizes the end-of-tape control signal 424 recorded between the last program and the end clear leader 402. The selector R will be turned off, that is the movable contact 434 will be engaged with the open contact 438.

Upon completion of play of the last program, the tape will continue to move forward at play speed until the end-of-tape control signal 424 reaches the control head 88b. The end-of-tape control signal will be detected by the detector 406 and will generate an output signal resulting in grounding the base of transistor Q206; this, in turn will forward bias the inverting transistor Q207, rendering same conductive and energizing the rewind relay K2. This will place the apparatus in the automatic rewind sequence described above.

FAST FORWARD AND SCANNING MODES

The apparatus may be placed in fast forward mode, to skip one recorded program and automatically stop at the next primary control signal ready to play the next program, by momentarily closing fast forward switch SW4.

The apparatus may be placed in scanning mode by holding the fast I6 switch SW4 closed, to quickly traverse the tape in a forward direction while counting the illuminations of cue lamp 16 to monitor the programs.

First and fast forward mode will be described.

To avoid unnecessary duplication, the detailed operation of the broad band detector 407 during the fast forward mode will not be described, because this has already been done in the foregoing description of the broad band detector 407. Briefly, momentary closing of the fast forward switch SW4 activates the broad band detector by grounding the diode CR206. This also energizes fast forward relay K3 which is then held energized through the common holding circuit 410. Fast forward lamp I3 lights on closing contacts 15 and 16 of K3. The fast forward solenoid 172 is energized to move the support for the pinch roller 86 and head means 88 through only a partial stroke, enabling the control head

88b to touch the control track D but not moving the support sufficiently to press the tape into frictional engagement with the capstan 40. The forward torque motor 54 is energized to move the tape at full speed in a forward direction. The program amplifier 403 is disabled because the ground connector for the audio attenuator 408 is open at contacts 15 and 16 of relay K4 and contacts 14 and 15 of relay K3.

After the tape moves at fast forward speed through the program, and the end-of-program control 422 signal is detected by the broad band detector 407, there is a first output signal generated by transistor Q209 which is translated by the broad band detector into first and second output signal components. The first output signal component, from the collector of transistor Q210, back-biases the gate transistor Q203, blocking it, and deenergizing the common holding circuit 410 and the relay K3, thereby stopping the tape. At the termination of this first output signal component, the gate transistor Q203 is returned to its normally forward-biased condition, at which time the second output signal component, from the collector of transistor Q211, energizes the run-to-cue relay K5, which in turn energizes the relay K4, placing the apparatus in run-to-cue mode in which it runs forward at play speed until the primary control signal for the next succeeding program is reached at which time the primary control signal detector 404 generates a second output signal which blocks gate transistor Q203 and deenergizes the common holding circuit 410 and relays K4 and K5, stopping the tape.

Next, the scanning mode will be described.

If the fast forward switch SW4 is held closed, the fast forward relay K3 is held energized and the tape moves continuously forward. Each time a group of control signals between recorded programs pass the control head 88b, a "second output signal component" from the collector of transistor Q211 will momentarily actuate the run-to-cue relay K5, and close its contacts 18 and 19, thereby illuminating the cue lamp 16. In addition, an audible signal generator (not shown) may be connected in parallel with the lamp I6 so an operator can monitor the control signals both visually and audibly. Thus, by counting flashes of the cue lamp, with or without audible signals, or by counting pulses from the control circuitry by other apparatus or means, the number and location of the programs on the tape can be selected automatically. If, for example, there are 30 cuts or programs on a tape, separated by control signals, and it is desired to reach one intermediate the tape quickly, it is necessary only to hold the fast forward switch SW4 closed and count the flashes of the cue light until the desired program is reached. Use of the cue light signal in counting in either forward or rewind directions is advantageous because it enables digital counter controls (not shown) to be incorporated into the apparatus where a fully automated control system is required.

In summary, the reproducing apparatus of the present invention provides a high degree of versatility and time saving for the operator or engineer by the automatic sequence capabilities built into it. The circuit is conditioned for automatic operation by closing main switch SW1. Momentarily closing play switch SW5 automatically plays one program and stops at the next primary control or cue tone ready to play the next program. Momentarily closing rewind switch SW3 places

the apparatus in rewind mode in which it automatically rewinds to the beginning of the tape and stops at the end of the beginning clear leader if jumper 428 is open, or at the first primary control tone on the tape if the jumper is closed. Momentarily closing fast forward switch SW4 places it in fast forward mode in which it moves the tape forward at high speed with the audio off and stops it at the next primary control signal ready to play the next program. Holding the switch SW4 closed places it in scanning mode to move the tape forward continuously at high speed enabling the operator to monitor the tape by illuminations of the cue lamp 16 and quickly select a particular program ready for play. Three automatic sequences are available for initiating the rewind mode: if an end-of-tape control signal 424 is used with detector 406, it will automatically go into rewind mode at the end-of-tape signal; if the tape runs at play speed into the end-of-tape clear leader 402, it automatically goes into rewind mode; and, if the jumper 434 of selector R closed, it will go into rewind mode automatically after playing any selected single program.

While one form in which the present invention may be embodied has been shown and described, it will be understood that various modifications and variations thereof may be effected without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. In reproducing apparatus for a magnetic tape having discrete program-identifying control signals at intervals therealong, tape drive means for moving said tape past a transducing head, automatic sequence control means comprising:

a detector connected to said transducing head including means for detecting a control signal when the tape is moved past it;

tape drive control means including stop means for deenergizing said tape drive means to stop said tape in response to detection of a control signal, and means responsive to energization of said tape drive means to initiate tape movement for disabling said stop means for sufficient time period to enable the tape to move, beyond said head, a residual control signal at which movement of the tape was initiated.

2. In reproducing apparatus for a magnetic tape having discrete program-identifying control signals at intervals therealong, tape drive means for moving the tape past a transducing head, tape drive control means for said tape drive means selectively actuatable to move the tape at a constant forward speed and at a fast forward speed faster than said constant forward speed, automatic sequence control means comprising:

means for actuating said tape drive control means to initiate movement of the tape at said fast forward speed; and

control signal detector means connected between said transducing head and said tape drive control means effective to generate a first output signal in response to detection of a control signal at said fast forward speed, and effective to generate a second output signal in response to detection of a control signal at said constant forward speed;

said tape drive control means being effective in response to said first output signal to change movement of the tape from fast forward speed to con-

stant forward speed, and said tape drive control means being effective in response to said second output signal to deenergize said tape drive means and stop the tape.

3. In reproducing apparatus, automatic sequence control means according to claim 2 having means operable upon initiation of fast forward movement of the tape for delaying response of said tape drive control means to a control signal for sufficient time to enable the tape to move beyond a residual control signal at which fast forward movement of the tape was initiated.

4. In reproducing apparatus, automatic sequence control means according to claim 2 having means for temporarily deenergizing said tape drive means in response to said first output signal for a sufficient time to enable said tape to come to a complete stop before subsequent movement at said constant forward speed.

5. In reproducing apparatus, automatic sequence control means according to claim 2 having means responsive to initiation of fast forward movement of the tape for activating said control signal detector means to generate said first output signal in response to detection of a control signal at said fast forward speed.

6. In reproducing apparatus for a magnetic tape having discrete program-identifying control signals at intervals therealong, tape drive means for moving the tape past a transducing head, automatic sequence control means comprising:

tape drive control means including a constant forward speed relay effective when energized to energize said tape drive means to move the tape at a constant forward speed, a fast forward speed relay effective when energized to energize said tape drive means to move the tape at a fast forward speed faster than said constant forward speed, fast forward switch means connecting said fast forward speed relay to an electrical power source for initiating fast forward movement of the tape, a holding circuit for said relays, and a gate connecting said holding circuit to an electrical power source;

control signal detector means connected between said transducing head and said tape drive control means effective to generate a first output signal in response to detection of a control signal at said fast forward speed, and effective to generate a second output signal in response to detection of a control signal at said constant forward speed;

said tape drive control means having means responsive to said first output signal to temporarily block said gate and disconnect said holding circuit from said electrical power source to deenergize said fast forward speed relay, and to energize said constant speed relay and lock it through said holding circuit, thereby changing tape movement from fast forward speed to constant forward speed; and

said tape drive control means having means responsive to said second output signal to block said gate and disconnect said holding circuit from said electrical power source to deenergize said constant forward speed relay, thereby stopping tape movement.

7. In reproducing apparatus for a magnetic tape having discrete program-identifying control signals at intervals therealong, and electric motor powered means for moving the tape past a transducing head, automatic sequence control means comprising:

a drive control circuit including a play relay effective when energized to place said apparatus in a play mode in which the motor powered means is energized by an electrical power source to drive the tape past the head at a forward play speed, a fast forward speed relay effective when energized to place said apparatus in a fast forward mode in which the motor powered means is energized by the electrical power source to drive the tape past the head at a fast forward speed faster than said forward play speed;

a holding circuit for said relays connected to said electrical power source through a gate which becomes non-conductive in response to a blocking signal, either of said relays being unlocked from said holding circuit in response to energization of the other relay;

a fast forward switch connected between said electrical power source and said fast forward relay effective when actuated to energize said fast forward relay to initiate said fast forward mode;

control signal detector means including a broad band detector connected between the transducing head and the drive control circuit effective to generate a first output signal, having two successive output signal components, in response to detection of a control signal during fast forward mode, means for applying the first of said successive output signal components to block said gate for a predetermined time period, to thereby automatically deenergize the holding circuit and the fast forward relay, and enable said tape to come to a complete stop within said predetermined time period; means effective after said predetermined time period for applying the second of said successive output signal components to automatically energize said play relay and restart the tape at play speed;

said control signal detector means also including a relatively narrow band detector connected between the transducing head and the drive control circuit effective to generate a second output signal in response to detection of a control signal during play mode, and means for applying said second output signal to block said gate to automatically deenergize the holding circuit and the play relay and stop the tape.

8. In reproducing apparatus for a magnetic tape having an intermediate portion with at least one set of recorded program signals and at least a beginning clear leader driven by tape drive means, tape drive control means for connecting said tape drive means to an electrical power source for moving said tape at selected forward and rewind speeds past transducing head means, and between a light source and a light sensor, automatic sequence control means comprising:

a play mode circuit including a play relay which when energized places said apparatus in play mode to activate said tape drive control means to energize said tape drive means and move the tape at a forward play speed;

a rewind mode circuit including a rewind relay which when energized places said apparatus in rewind mode to activate said tape drive control means to energize said tape drive means and move the tape at fast rewind speed;

means for initiating energization of said rewind relay to place said apparatus in rewind mode;

means responsive to activation of said sensor by light transmitted through said beginning clear leader during tape movement at fast rewind speed to deenergize said rewind relay and energize said play relay, thereby automatically changing operation from rewind mode to play mode; and

stop means for activating said tape drive control means to deenergize said play relay and stop the tape at a predetermined position at the beginning of the tape following such change from rewind mode to play mode;

whereby said apparatus automatically returns said tape to a predetermined restart position at the beginning of the tape in response to initiating energization of said rewind relay to place said apparatus in rewind mode.

9. In reproducing apparatus for a magnetic tape, automatic sequence control means according to claim 8 in which said stop means includes means responsive to deactivation of said light sensor by a beginning opaque portion of the tape for activating said tape drive control means to deenergize said play relay and thereby automatically predetermine said restart position at the end of the beginning clear leader.

10. In reproducing apparatus for a magnetic tape having a control signal on said tape between the beginning clear leader and the first set of recorded program signals, automatic sequence control means according to claim 8 in which said stop means includes a control signal detector connected between said transducing head means and said tape drive control means, and means responsive to detection of said control signal by said control signal detector to deenergize said play relay and thereby automatically predetermine said restart position at said control signal.

11. In reproducing apparatus for a magnetic tape having a plurality of said sets of recorded program signals and a control signal between successive sets of program signals, automatic sequence control means according to claim 8 including:

a play switch controlling energization of said play relay by said electrical power source;

a control signal detector connected between said transducing head means and said tape drive control means;

means responsive to detection of each of said control signals by said control signal detector to deenergize said play relay and stop said tape and thereby establish a start position for each successive set of program signals;

whereby upon successive actuations of said play switch said apparatus automatically stops said tape at a start position established by a control signal preceding each successive set of program signals.

12. In reproducing apparatus for a magnetic tape, automatic sequence control means according to claim 11 having means responsive to initiation of a play mode by said play switch for delaying deenergization of said play relay, and consequent stopping of said tape, for a sufficient time to enable said tape to move beyond a residual control signal at which said play mode was initiated.

13. In reproducing apparatus for a magnetic tape, automatic sequence control means according to claim 8 having:

a capacitor;

means for storing an electrical charge in said capacitor during energization of said rewind relay;

means responsive to said activation of said light sensor at said beginning clear leader for applying the charge stored in said capacitor to energize said play relay.

14. In reproducing apparatus for a magnetic tape, automatic sequence control means according to claim 8 in which said tape has an end clear leader and said means for initiating energization of said rewind relay to place said apparatus in rewind mode in responsive to activation of said sensor by light transmitted through said end clear leader.

15. In reproducing apparatus for a magnetic tape, automatic sequence control means according to claim 14 having:

a play capacitor, and means for storing an electrical charge in said play capacitor in response to energization of the play relay, and means to apply such stored charge to energize the rewind relay in response to activation of said sensor by light transmitted through said end clear leader.

16. In reproducing apparatus for a magnetic tape having an end-of-tape control signal thereon, automatic sequence control means according to claim 8 in which said means for initiating energization of said rewind relay to place said apparatus in rewind mode includes an end-of-tape control signal detector connected between said head means and said tape drive control means and effective to energize said rewind relay to place said apparatus in rewind mode in response to detection of said end-of-tape control signal.

17. In reproducing apparatus for a magnetic tape having a plurality of recorded program signals and an end-of-program control signal recorded following each program signal, automatic sequence control means according to claim 8 in which said means for initiating energization of said rewind relay to place said apparatus in rewind mode includes an end-of-program control signal detector connected between said head means and said tape drive control means and effective to energize said rewind relay to place said apparatus in rewind mode in response to detection of an end-of-program control signal.

18. In reproducing apparatus for a magnetic tape, automatic sequence control means according to claim 17 having:

an end-to-program capacitor, and means for storing an electrical charge in the end-of-program capacitor in response to detection of an end-of-program control signal on the tape; and

means to apply such charge stored in said end-of-program capacitor to energize the rewind relay in response to termination of said end-of-program control signal.

19. In reproducing apparatus for a magnetic tape having at least one end clear leader and tape drive means for moving said tape in opposite directions between a light source and a light sensor, automatic sequence control means comprising:

tape drive control means;

means for initiating movement of said tape in one direction to move said clear leader toward said light source and sensor;

a capacitor, and means for storing an electrical charge in said capacitor while said tape is driven in said one direction;

means responsive to activation of said light sensor on movement of said clear leader thereto, to deener-

gize said tape drive means and stop movement of said tape in said one direction; and

means responsive to so deenergizing said tape drive means to apply the stored electrical charge from said capacitor to said tape drive control means to thereby energize said tape drive means to move said tape in the opposite direction.

20. In reproducing apparatus for a magnetic tape having beginning and end clear leaders and an opaque intermediate portion, tape drive means for moving said tape at selected forward and rewind speeds past transducing head means, between a pinch roller and a rotatably driven capstan, and between a light source and a light sensor, automatic sequence control means comprising:

tape drive control means including play and rewind relays effective when energized to activate said tape drive means to move said tape in opposite directions respectively;

a first capacitor, and means for storing an electrical charge therein while said play relay is energized to move the end clear leader toward said light source and sensor;

means responsive to activation of said light sensor, on movement of said end clear leader thereto, to deenergize said play relay and stop the forward movement of the tape;

means responsive to so deenergizing and play relay to apply the stored electrical charge from said first capacitor to said rewind relay to thereby energize said tape drive means to move said tape in rewind direction;

a second capacitor, and means for storing an electrical charge therein while said rewind relay is energized to move the beginning clear leader toward said light source and sensor;

means responsive to activation of said light sensor, on movement of said beginning clear leader thereto, to deenergize said rewind relay and stop the rewind movement of the tape;

means responsive so deenergizing said rewind relay to apply the stored electrical charge from said second capacitor to said play relay to thereby reenergize said tape drive means to move said tape in forward direction; and

stop means for deenergizing the play relay to deenergize the tape drive means and stop the tape at a predetermined beginning position.

21. In reproducing apparatus for a magnetic tape having discrete program-identifying control signals at intervals therealong, tape drive means selectively energizable in fast forward mode or forward play mode to move said tape past a transducing head at constant forward speed or at fast forward speed respectively, automatic sequence control means comprising:

control signal detector means connected to said head;

means for activating said detector means in response to initiation of fast forward movement of said tape;

control means for said tape drive means effective in response to detection of said control signals by said detector means to change tape speed from fast forward speed to constant forward speed and then stop the tape.

22. In reproducing apparatus, automatic sequence control means according to claim 21 in which said control means is effective to bring tape movement to a

complete stop before changing to constant forward speed.

23. In reproducing apparatus for a magnetic tape having discrete program-identifying control signals recorded thereon, tape drive means for moving said tape past a transducing head, and control signal detector means connected to said head, automatic sequence control means comprising:

a scanning mode circuit having a fast forward switch controlling electrical energization of a fast forward relay including means responsive to continuous closure of the fast forward switch to energize the fast forward relay and thereby place the apparatus in scanning mode in which said tape drive means moves said tape at fast forward speed continuously through successive control signals; play monitoring means responsive to said continuous closure of the fast forward switch to monitor said control signals to locate programs associated therewith; and means to deenergize said fast forward relay and terminate said scanning mode in response to opening said fast forward switch.

24. In reproducing apparatus, automatic sequence control means according to claim 23 in which said monitoring means is an indicator lamp and means for illuminating same in response to said control signals to enable visual monitoring of said signals.

25. In reproducing apparatus, automatic sequence control means according to claim 23 in which said monitoring means is an audible indicator and means for actuating same in response to said control signals to enable sound monitoring of said signals.

26. In reproducing apparatus for a magnetic tape having opposite terminal portions wound on reels driven by torque motor means, motor control means for connecting said torque motor means to an electrical power source actuatable to move said tape past a transducing head and between a pinch roller and a rotatably driven capstan, said tape having spaced, discrete program-identifying control signals, and control signal detector means for generating output signals in response to said control signals, automatic sequence control means comprising:

a scanning mode circuit having a fast forward switch controlling electrical energization of a fast forward relay; means responsive to continuous closure of said fast forward switch to hold said fast forward relay energized and said apparatus in a scanning mode to thereby energize said torque motor means to move the tape at fast forward speed past said head while said fast forward switch is held closed; and means for monitoring said output signals to locate programs on said tape; and means responsive to opening said fast forward switch to thereby deenergize said torque motor means and stop said tape on detection of the next said output signal.

27. In reproducing apparatus, automatic sequence control means according to claim 26 having:

a fast forward mode circuit including a holding circuit for said fast forward relay; and means responsive to momentarily closing said fast forward switch to hold said fast forward relay energized through said holding circuit and hold said apparatus in a fast forward mode to thereby energize said torque motor means to move the tape at a fast forward speed and activates said control signal detector

means to automatically render said fast forward relay holding circuit non-conductive and deenergize said fast forward relay and terminate said fast forward mode in response to detection of a next succeeding control signal.

28. In reproducing apparatus, automatic sequence control means according to claim 27 having:

a play mode circuit including a play relay effective when energized to move said tape at forward play speed less than said fast forward speed;

means responsive to momentarily closing said fast forward switch to activate said control signal detector means to generate a first output signal in response to detection of a control signal during fast forward movement of the tape;

means responsive to said first output signal to deenergize said fast forward relay and said torque motor means for a predetermined time period sufficient to enable said tape to come to a complete stop;

and other means responsive to said first output signal to energize said play relay subsequent to said predetermined time period to restart said tape at forward play speed;

said control signal detector means including means for generating a second output signal in response to detection of a control signal during forward play movement of the tape; and

means responsive to said second output signal to deenergize said play relay and thereby deenergize said torque motor means and stop said tape.

29. In reproducing apparatus for a magnetic tape having discrete program-identifying control signals including primary and end-of-message control signals respectively preceding and following at least one recorded program, automatic sequence control means according to claim 28 in which:

said control signal detector means includes a broad band detector and a relatively narrow band detector;

said broad band detector when activated generating said first output signal in response to detection of either of said primary and end-of-message control signals at any operating tape speed; and

said narrow band detector when activated generating said second output signal in response to detection of a primary control signal when the tape is driven at forward play speed.

30. In reproducing apparatus for a magnetic tape having a series of recorded programs respectively followed and preceded by end-of-program and primary control signals, tape drive means for moving said tape past a transducing head, means for actuating said tape drive means to move said tape selectively at constant forward speed and fast forward speed in response to energization of play and fast forward relays respectively, automatic sequence control means comprising:

means including a holding circuit for selectively connecting said play and fast forward relay through a normally-open gate to an electrical power source; broad band and narrow band detectors connected to said head;

means responsive to detection of an end-of-program control signal by said broad band detector during movement of the tape at fast forward speed to generate a first output control signal having first and second time-spaced output signal components;

means responsive to said first output signal component to block said gate and open said holding circuit to deenergize said fast forward relay and stop the tape;

a run-to-cue relay;

means for connecting said play relay to the output terminal of said gate through said holding circuit in response to energizing said run-to-cue relay to thereby energize said play relay from said electrical source under control of said gate;

means responsive to said second output signal component to energize said run-to-cue relay to thereby energize said play relay to restart said tape at constant forward speed; and

means responsive to detection of a primary control signal by said narrow band detector during movement of the tape at constant forward speed to block said gate and open said holding circuit to deenergize said play relay and restop the tape.

31. In reproducing apparatus for a magnetic tape having at least a beginning clear leader and at least one central signal beyond the clear leader, tape drive means for moving the tape past a transducing head between a light source and a light sensor, means for activating said tape drive means to move said tape selectively in forward and rewind directions in response to energization of play and rewind relays respectively, automatic sequence control means comprising:

a main holding circuit for connecting said play and rewind relays to an electrical power source through a normally-open gate;

means for initiating energization of said rewind relay; means for storing an electrical charge in a capacitor during energization of said rewind relay;

a run-to-cue relay effective when energized to energize said play relay through an auxiliary circuit connected to said electrical power source through said gate;

means responsive to rewind movement of said clear leader to said light sensor to: open said main holding circuit thereby deenergizing said rewind relay and stopping said tape; apply the charge in said capacitor to said run-to-cue relay thereby initiating energization of said play relay through said auxiliary circuit; and connect said run-to-cue relay directly to said electrical power source through said run-to-cue holding circuit;

means responsive to forward movement of the end of said clear leader to said light sensor to disconnect said capacitor from said run-to-cue relay, and to energize said play relay through said main holding circuit controlled by said gate; and

means responsive to detection of said control signal during forward movement beyond the end of said clear leader to block said gate, deenergize and play relay, and stop said tape.

32. In reproducing apparatus for a magnetic tape having beginning and end clear leaders and an opaque intermediate magnetic portion for at least one recorded program preceded and followed by primary and end-of-program control signals respectively, tape drive means for driving said tape at selected forward and rewind speeds past transducing head means, and between a light source and a light sensor, automatic sequence control means comprising:

a play relay, and means for energizing the play relay to energize the tape drive means to move the tape

at forward play speed thereby placing the apparatus in play mode;

a fast forward relay, and means including a fast forward switch connected to an electrical power source for energizing the fast forward relay to energize the tape drive means to move the tape at fast forward speed;

a rewind relay, and means for energizing the rewind relay to energize the tape drive means to move the tape at rewind speed, thereby placing the apparatus in rewind mode;

a run-to-cue relay which, when energized, is effective to energize said play relay, thereby placing the apparatus in run-to-cue mode;

an end-of-program control signal detector connected between an end-of-program relay and said transducing head means, means for energizing said end-of-program relay in response to detection of an end-of-program control signal on said tape, and means for energizing said play relay in response to energizing said end-of-program relay;

a holding circuit for said play, fast forward and rewind relays connected through a normally-open gate to an electrical power source;

a primary control signal detector connected between said gate and said transducing head means, means for blocking said gate to deactivate said holding circuit in response to detection of a primary control signal on said tape to automatically deenergize any relay energized by said holding circuit;

means responsive to momentary actuation of said fast forward switch to hold said fast forward relay energized by said holding circuit thereby placing said apparatus in fast forward mode until tape movement is stopped at the next primary control signal by blocking said gate and deactivating said holding circuit;

means responsive to holding said fast forward switch actuated to override the blocking of said gate by primary control signals and maintain movement of said tape at fast forward speed, and means to monitor said control signals on the tape, thereby placing the apparatus in scanning mode while said fast forward switch is held actuated;

means for automatically placing said apparatus in rewind mode in response to movement of the end clear leader between said light source and light sensor while in play mode;

alternate means, effective when activated, to place said apparatus in rewind mode in response to detection of an end-of-program signal during play mode;

means for automatically placing said apparatus in run-to-cue mode in response to movement of the beginning clear leader between said light source and light sensor while in rewind mode;

means for automatically terminating said run-to-cue mode and stopping said tape at the first primary control signal on the tape, by blocking said gate; and

alternate means effective when activated, for automatically terminating said run-to-cue mode and stopping said tape at the edge of the beginning clear leader, in response to deactivating said light sensor by shielding said light sensor from said light source by the beginning opaque portion of the tape.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,869,719

DATED : March 4, 1975

Page 1 of 2

INVENTOR(S) : John P. Jenkins

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Specification:

- Col. 7, line 47 - "by" should be -- be -- ;
- Col. 9, line 55 - "CR208" should be -- 208 -- ;
- Col. 14, line 13 - "play" should be -- plays -- ;
- Col. 14, line 48 - "sourrce" should be -- source -- ;
- Col. 15, line 7 - "4228" should be -- 428 -- ;
- Col. 16, line 45 - "by" should be -- of -- ;
- Col. 17, line 25 - delete the semicolon;
- Col. 17, line 53 - after "fast" delete "16" and
insert -- forward -- ;
- Col. 17, line 58 - "durig" should be -- during -- ;
- Col. 18, line 6 - "connector" should be -- connection -- ;
- Col. 18, line 10-11 - "control 422 signal" should be
-- control signal 422 -- ;
- Col. 18, line 53 -- "forwad" should be -- forward -- ;

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,869,719

DATED : March 4, 1975

Page 2 of 2

INVENTOR(S) : John P. Jenkins

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Claims:

Col. 19, line 43 - after "means for" insert -- a -- ;

Col. 25, line 16 - delete "play";

Col. 26, line 56 - "plaly" should be -- play -- .

This certificate supersedes Certificate of Correction issued Aug. 12, 1975 and Sept. 23, 1975.

Signed and Sealed this

second Day of March 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,869,719

DATED March 4, 1975

INVENTOR(S) : John P. Jenkins

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

- Col. 7, line 47 - "by" should be -- be -- ;
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- Col. 14, line 47 - "sourrce" should be -- source -- ;
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- Col. 17, line 58 - "durig" should be -- during -- ;
- Col. 18, line 6 - "connector" should be -- connection -- ;
- Col. 18, line 10-11 - "control 422 signal"
should be -- control signal 422 -- ;
- Col. 18, line 1 - "forwad" should be -- forward -- ;
- Claim 1, Col. 19, line 1 - after "means for" insert
-- a -- ;

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,869,719 Dated March 4, 1975
Inventor(s) John P. Jenkins Page - 2

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 14, Col. 23, line 9 - "in" (second occurrence)
should be -- is -- ;

Claim 23, Col. 25, line 1 - delete "play" ;

Claim 30, Col. 26, line 56 - ";laly" should be -- play -- .

Signed and Sealed this

twenty-third Day of September 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks