

Dec. 30, 1969

J. P. L. DROUX

3,487,374

MAGNETIC-FILM INPUT-OUTPUT ELEMENT

Filed June 5, 1967

10 Sheets-Sheet 1

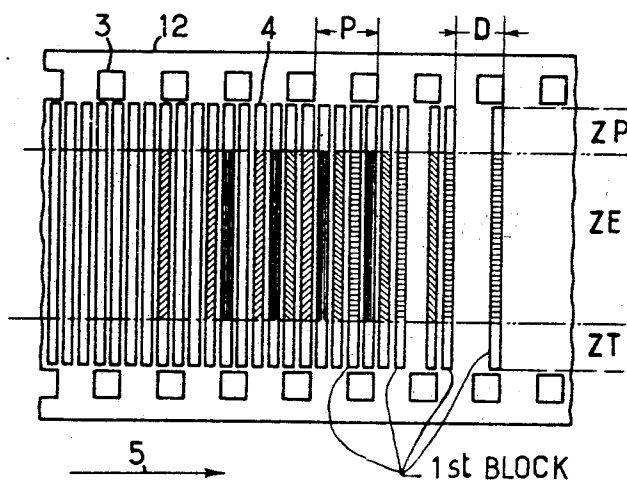


FIG. 1

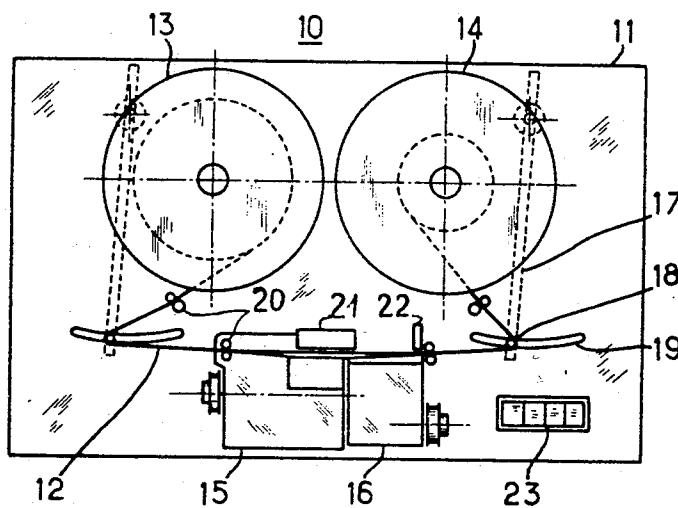


FIG. 2

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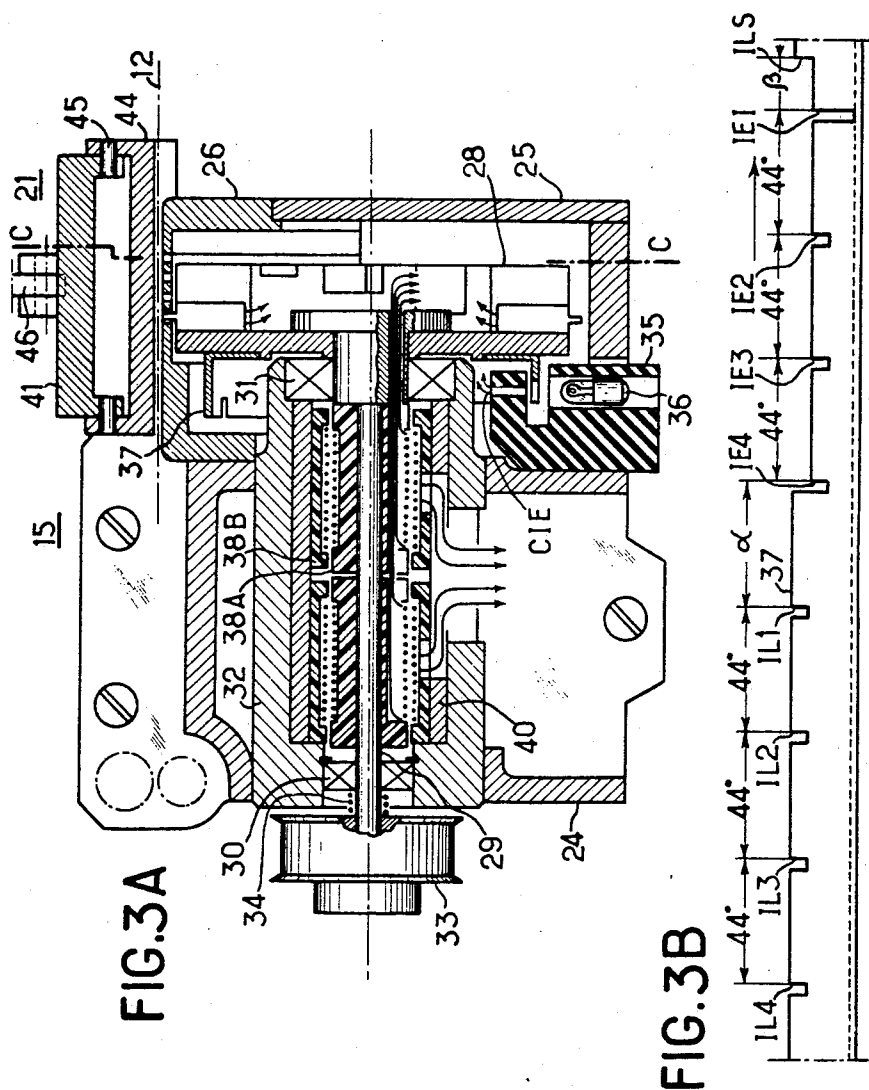
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10 Sheets-Sheet 2



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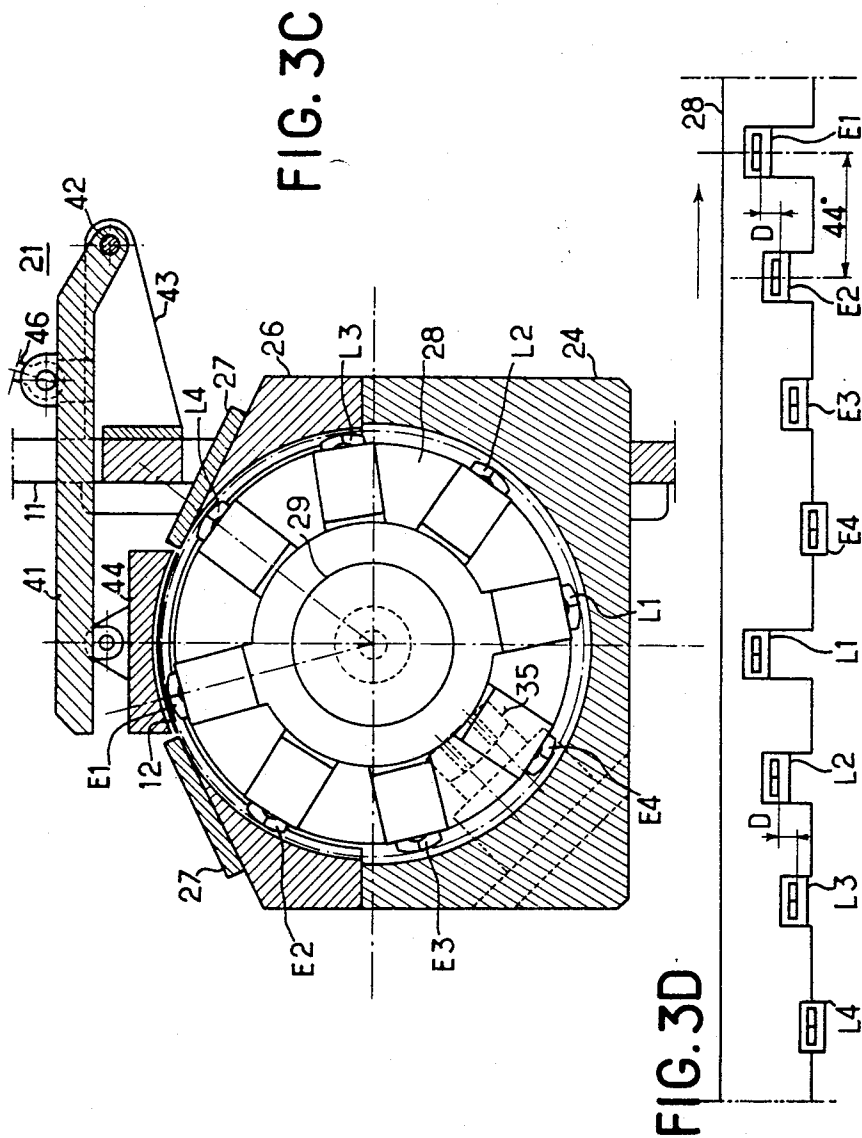
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MAGNETIC-FILM INPUT-OUTPUT ELEMENT

Filed June 8, 1967

10 Sheets-Sheet 3



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MAGNETIC-FILM INPUT-OUTPUT ELEMENT

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10 Sheets-Sheet 4

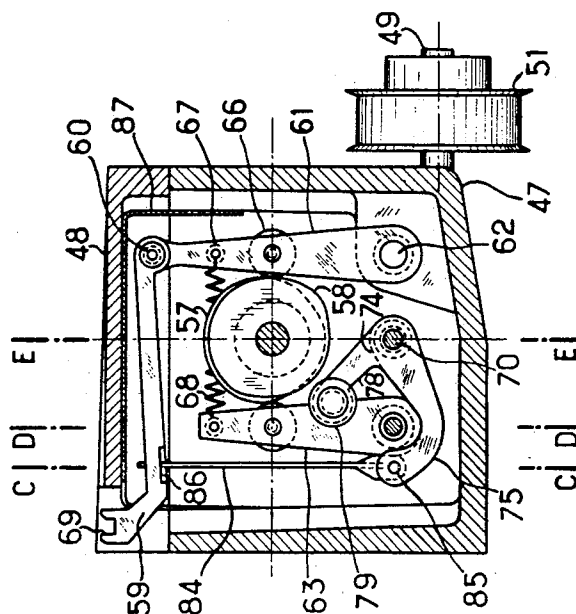


FIG. 4B

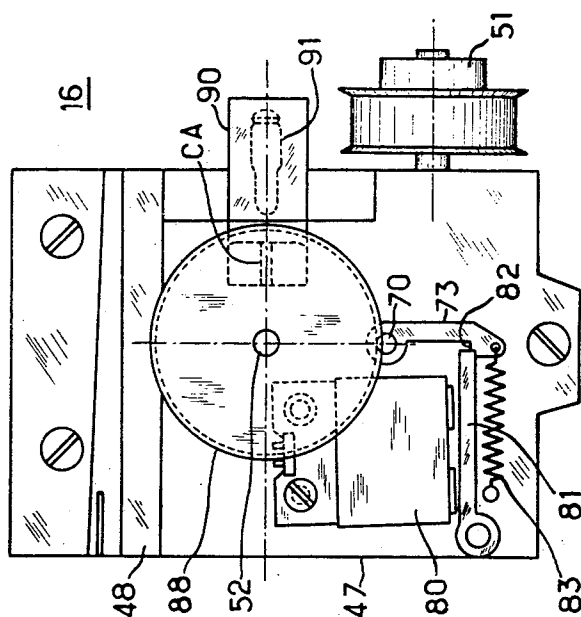


FIG. 4A

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10 Sheets-Sheet 5

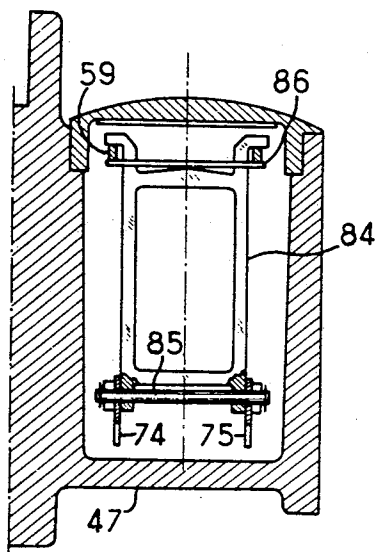


FIG. 4C

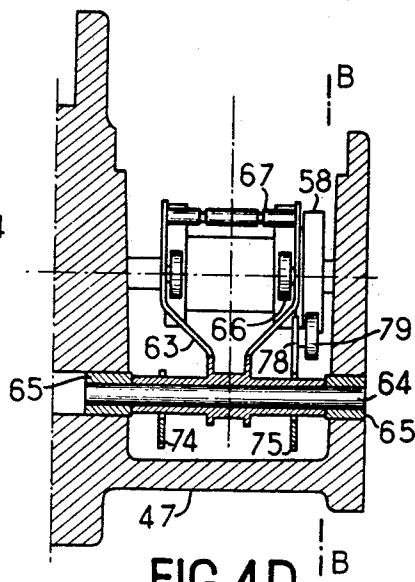


FIG. 4D

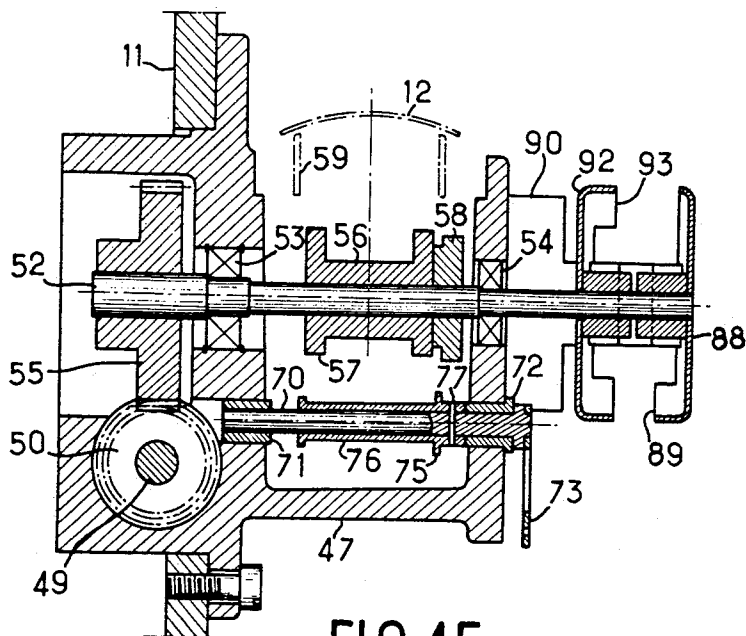


FIG. 4E

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MAGNETIC-FILM INPUT-OUTPUT ELEMENT

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10 Sheets-Sheet 6

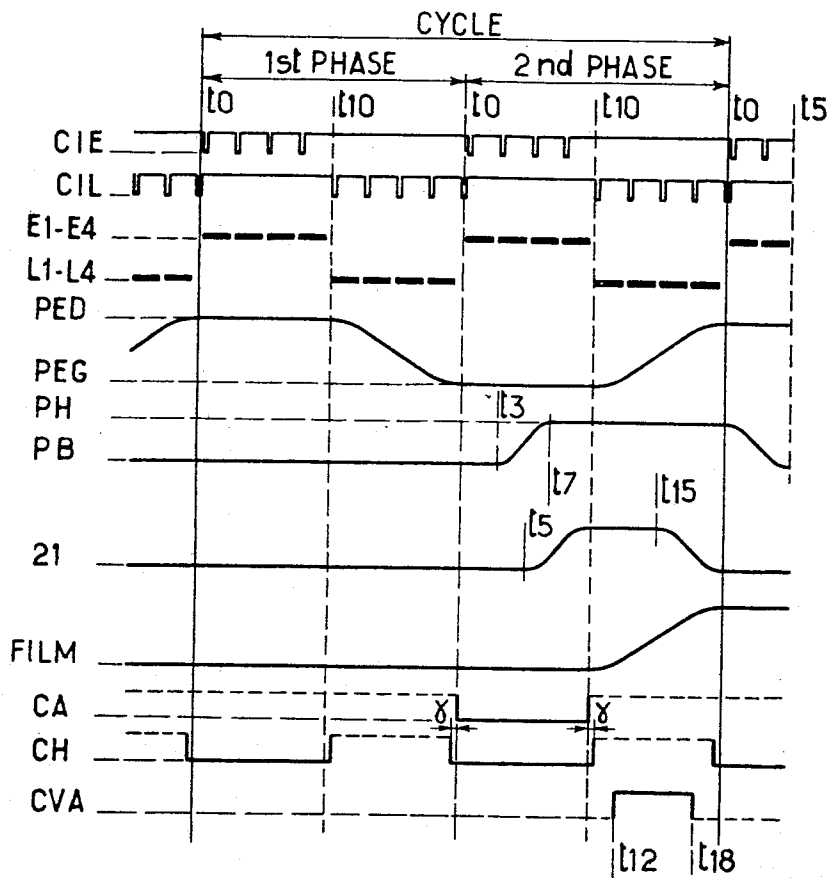


FIG. 5

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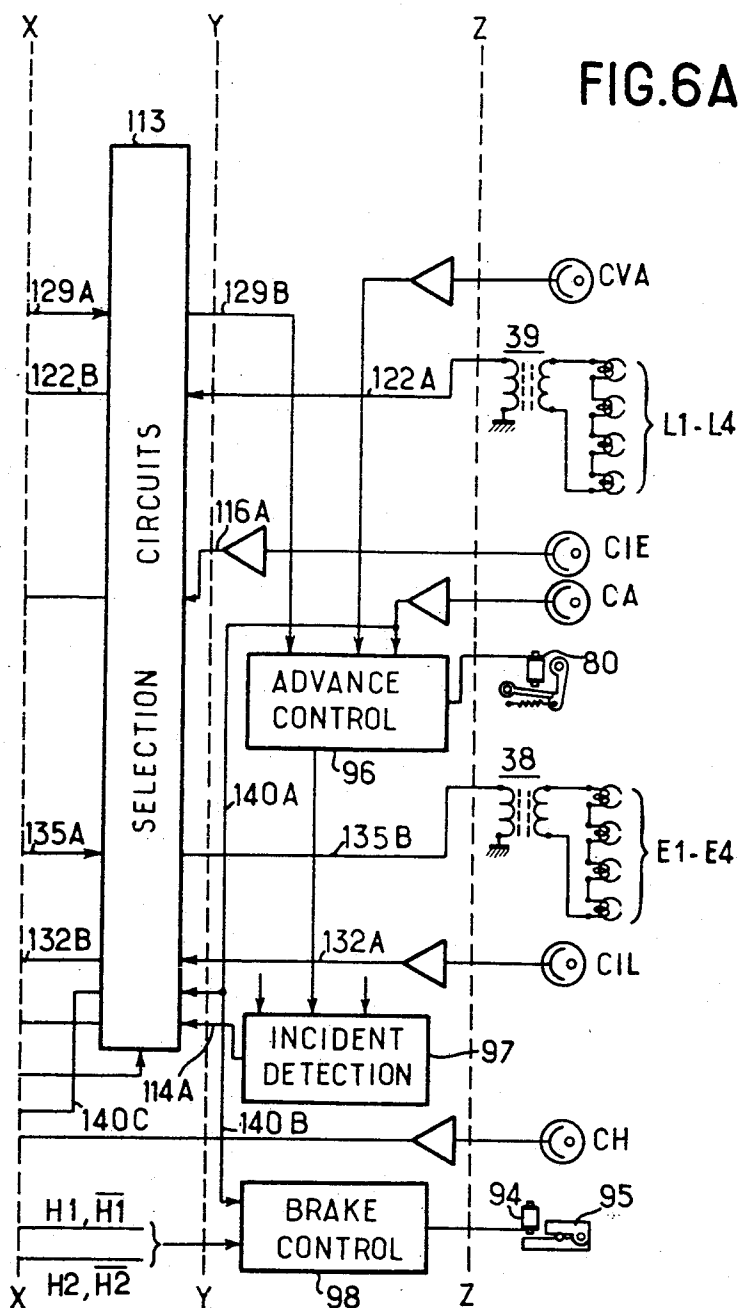
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MAGNETIC-FILM INPUT-OUTPUT ELEMENT

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10 Sheets-Sheet 7



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MAGNETIC-FILM INPUT-OUTPUT ELEMENT

Filed June 5, 1967

10 Sheets-Sheet 8

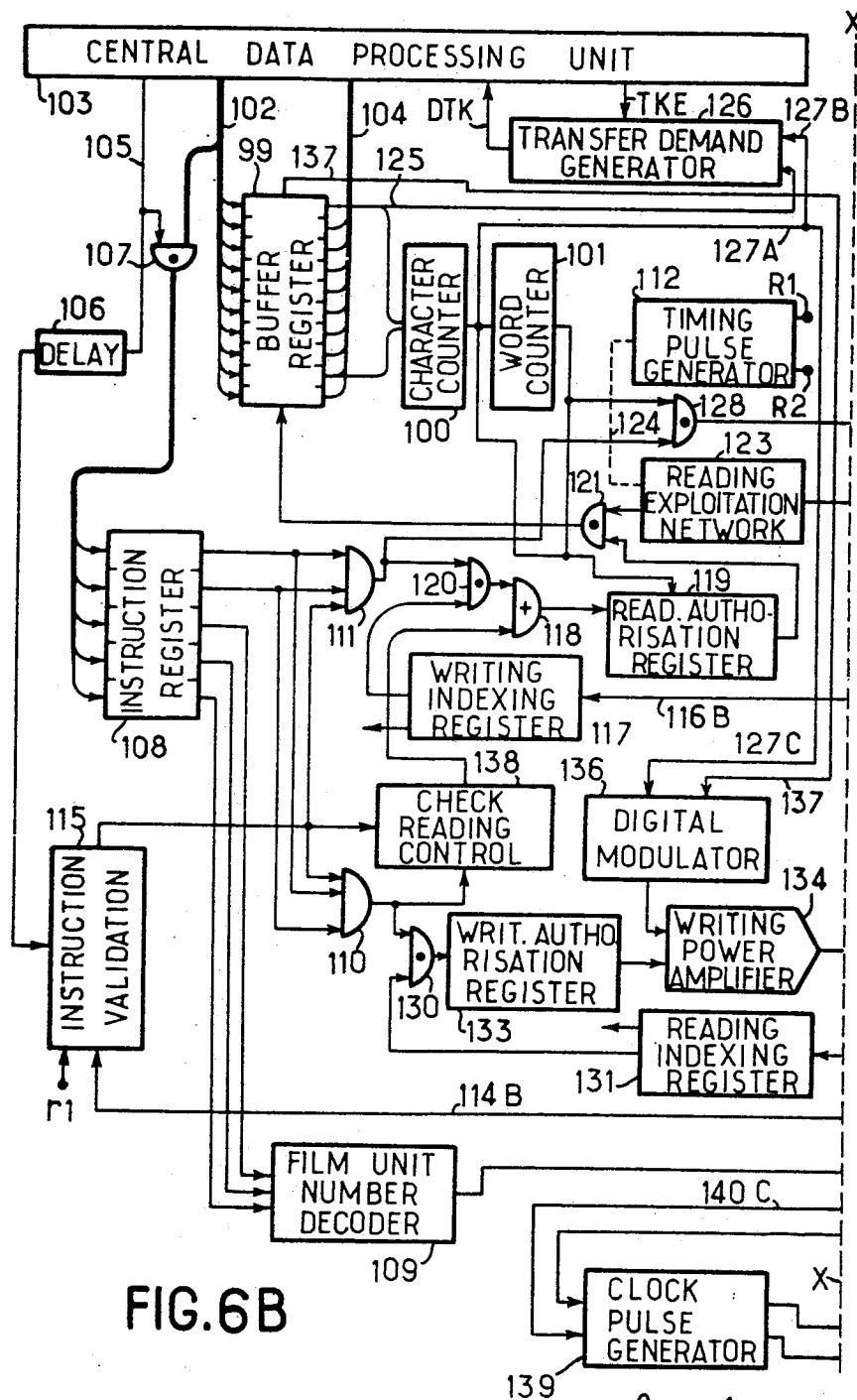


FIG. 6B

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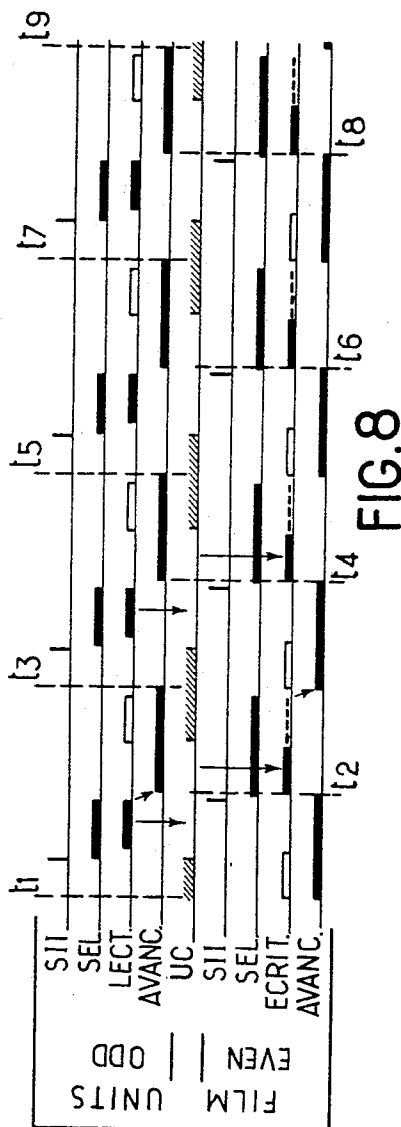
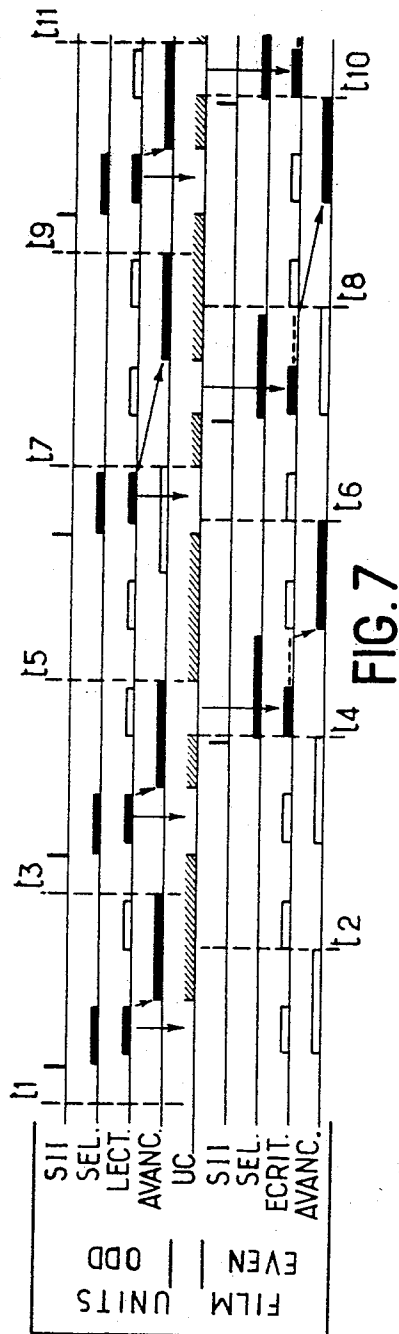
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MAGNETIC-FILM INPUT-OUTPUT ELEMENT

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10 Sheets-Sheet 9



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MAGNETIC-FILM INPUT-OUTPUT ELEMENT

Filed June 5, 1967

10 Sheets-Sheet 10

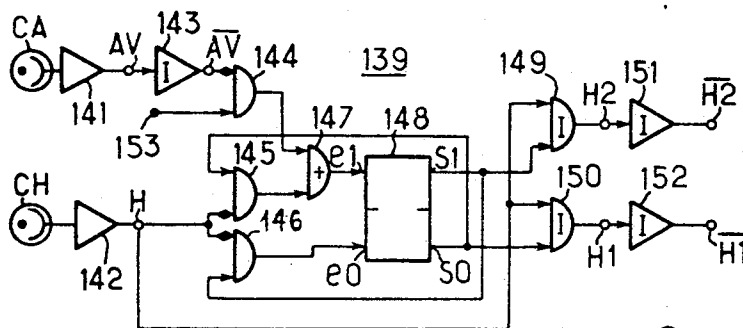


FIG. 9

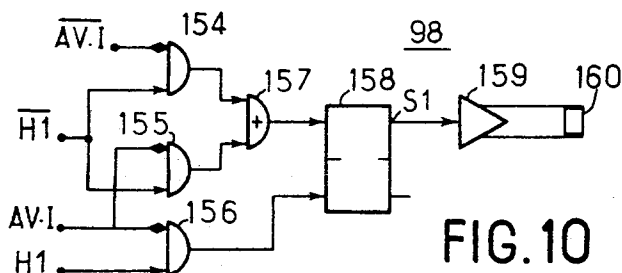


FIG. 10

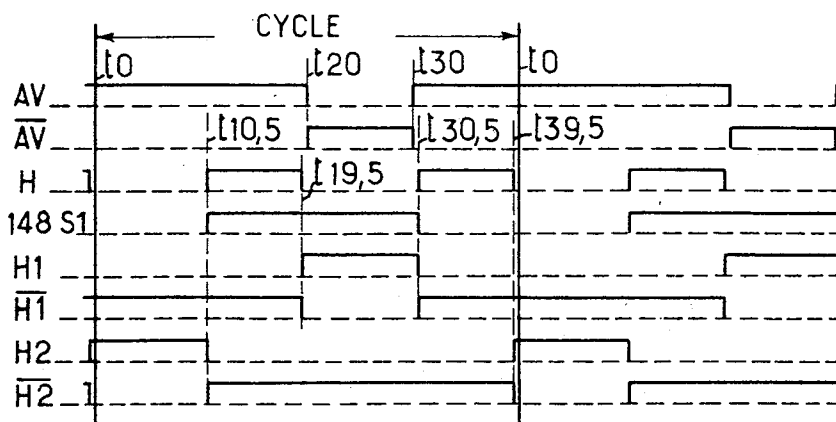


FIG. 11

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MAGNETIC-FILM INPUT-OUTPUT ELEMENT
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Claims priority, application France, June 28, 1966,

67,217

Int. Cl. G11b 13/00; G06f 1/00, 7/00

U.S. Cl. 340—172.5

13 Claims

ABSTRACT OF THE DISCLOSURE

In a magnetic film unit adapted to advance a magnetic film step-by-step and to utilise transverse recording tracks while the film is stationary, a rotative magnetic-head support performs two revolutions during a cycle defined by a cycling shaft. While the film can be advanced only during the second half of a cycle, a transducing operation can be effected during the first or second phase of a cycle, in order to reduce the dead times.

In an input-output element comprising a "master" film unit and one or more "slave" film units, phase-monitoring and braking means are provided to obtain an optimum rotative phasing and an optimum output.

The invention relates to a magnetic-film writing and reading apparatus which constitutes an input-output element adapted to be included in a data processing system.

Magnetic-tape writing and reading apparatus as hitherto employed generally operate on a tape which is continuously moved, at least during the writing or reading. Many disadvantages arise out of the necessity to stop the magnetic tape after one or more blocks of information have been read or written. More particularly, the space between two blocks constitutes an unused recording surface on the tape.

In a conventional magnetic-tape apparatus also, the data processing takes place in series for the characters and in parallel for the binary items, or bits, of the coded characters. This means that for an eight-bit character code there are provided eight longitudinal tracks on a magnetic tape, and obviously an equal number of transducer members, transmission paths, amplifiers, signal shapers, registers, etc. All this leads to some complexity and very high cost of equipment.

The present invention has for its object to provide an input-output element based on a magnetic-film apparatus which is of low cost while having an interesting performance level, due to the data processing by the purely sequential or "series" mode, which involves only one signal transmission path in said apparatus.

The invention also has for its object to provide a magnetic-film apparatus with which the losses of recording surface are obviated and with which the problems of running up to speed and of speed monitoring or synchronisation are eliminated. This all arises out of the fact that a transducing, i.e. reading or writing, operation is carried out while the film is stationary. The relative movement which is still necessary is produced by the magnetic heads being disposed on the drum of a continuously rotating support actuated by a synchronous motor. Of course, the film must be curved at the position of the transducing station in order to adapt itself to the cylindrical form of the drum carrying the heads, the axis of rotation of which drum is parallel to the direction of advance of the film. The tracks thus formed on the magnetic layer in the writing extend in a direction transverse to the length of the film.

For requirements of the invention, there is employed instead of a conventional magnetic tape a cellulose acetate support covered by a magnetisable layer of oxides and

having the same form and dimensions as the well-known photographic film. By way of example, the magnetic film employed has a width of 35 mm. and is formed with two rows of marginal perforations whose longitudinal spacing, or pitch, is 4.76 mm.

A single-step advance movement may be imparted to the magnetic film between two successive transducing operations, each affecting one block of information of fixed length. This single-step advance may be performed, when ordered, by a claw-type driving device actuated with a continuous reciprocating movement.

Since it was desirable to reduce the cost of the associated circuits, a reduced density on the tracks of the magnetic film has been chosen, by reason of which the magnetic-film apparatus has relatively modest performance.

The invention also has for its object to provide an input-output element formed of a combination of a number of magnetic-film apparatus of the above-indicated type, which will be referred to as "film units," with a control apparatus, which will be referred to as the "uniselector," and which effects the connection to the dispatching unit of a calculator, which in turn is preferably of the relatively low-performance type.

It will be appreciated that the operation of a film unit as defined above is essentially cyclic. A further object of the invention is to provide an installation comprising at least two film units having alternating operating conditions such that the input-output element thus formed has performances entirely comparable to those supplied by conventional tape or film unit assemblies, although it is of incomparably lower cost.

The construction of the rotative head support is of known type. In the present case, there is provided on the periphery of a continuously rotating cylinder a set of four angularly and axially staggered magnetic writing heads, as also a set of four angularly staggered magnetic reading heads in the same axial alignment as the writing heads. The axial spacing of staggering between two successive heads is equal to $\frac{3}{4}$ of an advanced step as previously defined. The four transverse tracks thus formed, during the scanning of the magnetic layer by the heads, correspond to one block of information. After a number of step-by-step advances of the magnetic film, the four tracks of the successive blocks are interlaced one block with another, so that there is no lost recording surface, the utilisable zone obviously being limited to the width between the marginal perforations in the film.

Consequently, in accordance with the invention, in a magnetic-film unit adapted to advance step-by-step a film formed with marginal perforations, and to utilise at least one transverse track for the recording of coded characters, by means of continuously rotating magnetic heads, while the film is stationary, there are provided: a rotative head support carrying on its periphery a number n of equidistant staggered writing heads and a number n of equidistant staggered reading heads; a cycling shaft, the said head support and the said shaft being rotated by means of a common synchronous motor in such manner that they have respectively the angular velocities ω and $\omega/2$, the support and the shaft each carrying respective position indexing members; a film-driving member associated with the cycling shaft for effecting, when ordered a single-step advance of the film; pulse generators adapted to generate position-indexing signals for the heads and for the cycling shaft; an advance control device adapted to store a control signal and to supply an actuating signal to the said driving member, the arrangement being such that, in one cycle of operation, corresponding to one revolution of the cycling shaft and divided into two equal phases, a transducing (writing or reading) operation may be carried out in the course of either one

or the other of the phases of a cycle, and may be systematically followed by a single-step advance of the film, which can be effected only in the course of the second phase of a cycle.

In accordance with another feature of the invention, it is arranged that, in an input-output element comprising at least two magnetic-film units as hereinbefore defined, one of the units is provided with an additional indexing member and with devices for generating position reference signals, the other or each one of the other magnetic-film units being associated with a phase relation monitoring device and provided with a braking device adapted to slow down the said synchronous motor, under the influence of the monitoring device, whereby the second magnetic-film unit may be caused to operate in phase opposition, and where necessary returned into phase opposition, in relation to the first magnetic-film unit.

For a better understanding of the invention, and the manner in which it may be performed, the same will now be described by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 illustrates a portion of the magnetic film employed,

FIGURE 2 illustrates the mechanism plate of a magnetic-film unit according to the invention,

FIGURES 3A to 3D are detailed views of a transducing station including the rotative head support,

FIGURES 4A to 4E are detailed views of the film advancing device,

FIGURE 5 is a time graph relating to one operating cycle,

FIGURES 6A and 6B illustrate, respectively the members and electrical circuits forming part of a film unit and, in the form of a block diagram, those included in the control unit referred to as the "uniselector,"

FIGURE 7 is a time graph relating to the least favourable phase relation between two film units,

FIGURE 8 is a time graph relating to the optimum phase relation between two film units,

FIGURE 9 is a logical diagram of a "clock" pulse generator depending upon a "master" film unit and included in the uniselector,

FIGURE 10 is a logical diagram of a braking control device associated with each of the "slave" film units, and

FIGURE 11 is a time graph explaining the operation of the devices of FIGURES 9 and 10.

GENERAL FEATURES

The magnetic-film unit according to the invention finds the same applications as a magnetic-tape unit of which a number are usually employed to form an input-output element included in a data processing system.

In a typical installation, the input-output element comprises a set of control circuits, called a "uniselector," associated with a number of magnetic-film units, which will be briefly referred to as "film units." Although only one or two film units may be employed, it is generally desirable to have available at least three film units. In fact, the uniselector is designed to control at most 3, 5 or 7 film units, that is to say, to effect the connection to the dispatching unit of a calculator, as also the selection of only one of the film units at a given instant. The circuits of the uniselector and one film unit, which will be the "master" film unit, may be disposed in a common cabinet. One or more cabinets will each receive two "slave" film units, as also their separate control circuits.

The dispatching unit of the calculator controls the activity of a film unit by sending to a uniselector a special order signal accompanied by an instruction, which is transmitted on the "parallel" mode. An instruction is comprised in a nine-bit character, since it is composed of a two-bit function code, and of the three-bit number of the film unit to be used. Four function codes are pro-

vided, namely, writing, reading, rewinding and emptying, the last two being purely mechanical functions.

After having ensured that the film unit to be used is available, the uniselector sends to the dispatching unit of the calculator a transfer-demand signal and causes the performance of the required function to be started. A writing or reading function affects in each instance a block of information of fixed length. A block comprises 48 character codes, each being composed of nine bits, one of which is a parity bit.

Although there is no reason why a series of operations in an input-output element should not involve only one film unit, it is nevertheless more common general practice for at least two film units of the installation to be employed jointly for inclusion into a data processing system. Generally, one film unit may be constantly the transmitter, i.e. the data read on its film are intended to be transferred into the calculator, which causes them to undergo the processing (comparison, bringing up to date, calculation, etc.) required by its programme. The other film unit is then constantly the receiver, i.e. the data returned by the calculator will be written on its film. It may then be decided that the transmitting film unit will preferably be chosen from the film units to which an odd number is allocated, and that consequently the receiving film unit will have an even number. It may also be decided that the master film unit will always have the higher odd number, that is to say, 3, 5 or 7, depending upon the size of the installation. This greatly simplifies the production of an optimum phase relation with a view to an alternating cyclic operation of an odd-numbered film unit and of an even-numbered film unit, as will hereinafter be explained.

MAGNETIC FILM

Reference will be made to FIGURE 1. The support of the magnetic film 12 may consist of cellulose acetate, in the same way as a cinematographic film, or of Mylar. It is coated on one side, over its entire width, of 35 mm., with a magnetisable layer suitable for magnetic recording. In any case, the magnetic film constitutes a light-opaque surface, except at the positions of the driving perforations 3, which are formed in two marginal rows, with a spacing pitch P equal to 4.76 mm. Provision is made to form four recording tracks 4 over a length equal to P. The utilisable length of the transverse tracks is that which is available between the two rows of perforations. However, the length of one track is divided into three zones: a preparatory zone ZP and a terminal zone ZT, in both of which only series of zeros are registered, and a central zone ZE, on which the recording proper of the data is effected. This central zone is designed to contain 108 recording cells corresponding to 12 characters of 9 bits each. The end of the preparatory zone may be detected in the reading because the last cell contains a binary 1, which may readily be distinguished from the preceding zeros.

A block of data is recorded on a group of four tracks, of which the pitch D is equal to $\frac{3}{4}$ of P. The four tracks of each of the first blocks have been differently hatched for distinguishing the different blocks. Taking into account the direction of advance of the film, indicated by the arrow 5, the four tracks of the first block are shown to the right, after which there come, to the left, the four tracks of the second block, and so on. The tracks of the various blocks being intercalated into one another, the whole available surface of the magnetisable layer is utilised, the loss of surface occurring at the beginning being negligible.

The mode of recording is the method known as "pulse width modulation." This method is characterized by the fact that (1) each recording cell boundary is formed by a reversal of the direction of magnetisation of the magnetic layer; (2) the writing of a binary 1 results in a reversal of the direction of magnetisation at the centre of the recording cell under consideration; (3) the writing of a

binary zero results in the absence of reversal of magnetisation in the cell under consideration. This recording method is advantageous in that it is readily possible thereby to obtain a synchronising or "timing" pulse in the reading of each cell boundary.

FILM UNIT MECHANISM PLATE

Reference will be made to FIGURE 2. The mechanism plate 10 is composed of a plate 11 on which are mounted a number of devices for effecting the feed of the magnetic film. The magnetic film 12, which is originally wound on the supply reel 13, must be shifted step-by-step from left to right in order finally to be wound on to the take-up reel 14. Each reel may be actuated by a reversible electric motor mounted on the rear face of the plate 11.

The film 12 must pass over the transducer station 15 and over the advance unit 16. It is appropriately tensioned by means of two follow-up arms 17, each of which is terminated by a tension roller 18 extending through a curved slot 19 in the plate 11. Each followup arm, which rocks on a pin fixedly mounted on the rear face of the plate, is urged by a spring to tension the film and it can actuate, depending upon its angular position, one of a number of switches, which serve to control the supply to each of the reel motors and their direction of rotation, in well-known manner. Other guide rollers, such as 20, complete the guiding of the film.

A presser device 21 is mounted above the transducer station 15. It is actuated by electromechanical means in order to force the film to take up a curvilinear form close to the rotative magnetic heads, during the transducing operation, and it must be automatically lifted during the single-step advance of the film, carried out by the advance unit 16.

There will also be seen a device 22 comprising a photo-electric cell intended to check that the film has in fact been advanced by one step. Finally, the mechanism plate supports an assembly 23 of four pushbuttons for the manual control, namely: advance, rewinding, step-by-step and incident.

The details of the transducer station 15 are illustrated in FIGURES 3A to 3D. FIGURE 3A is an axial section and FIGURE 3C corresponds to a section taken along the line C—C of FIGURE 3A. For the sake of brevity, the well-known securing means such as screws, pins, etc., will be mentioned only in exceptional cases. The casing 24 may be closed by a plate 25 and by the cover 26. Two film guides 27 are secured to the cover 26 (FIGURE 3C). The rotative head support is composed of a circular plate 28 fast with a shaft 29. The latter turns in two ball bearings 30 and 31 disposed in the sleeve 32.

The plate 28 is formed with banked recesses to receive four magnetic writing heads E1 to E4 and four magnetic reading heads L1 to L4. The magnetic heads are so disposed that the ends of their pole pieces describe a common radius, for example of 40 mm. While the eight heads could be angularly equidistant, their angular spacing is in fact 44°, an angle of 52° then remaining between the head E1 and the head L4. In FIGURE 3D, which shows the developed periphery of the plate 28, it will be seen that two neighboring writing heads, or two neighboring reading heads, are staggered by the distance, D, mentioned with reference to FIGURE 1. The alignment of the heads is such that the writing heads E1 to E4 successively sweep on the film the four tracks of a block in the course of a first half-revolution, and that the reading heads L1 to L4 successively sweep the same corresponding tracks in the course of the second half of the same revolution of the head support.

In the same axial alignment as that of the heads, the cover 26 is formed with four internal grooves or slots, and since the radius of these grooves slightly exceeds 40 mm., there exist along the axis of the cover four apertures or slits which afford passage to the ends of the pole pieces of the magnetic heads, so that the latter can

come into contact with the magnetic film. However, there may also be disposed between the cover and the film a very thin sheet of a non-magnetic material, the thickness of which is such that the distance between the head and the magnetic film is made uniform, although increased, for example at 50 microns.

A pulley 33 is secured to the end of the shaft 29. A synchronous electric motor is disposed on the rear face of the plate 11. One end of its shaft is provided with a pulley identical to the pulley 33, and owing to a serrated belt the head support rotates at a speed of 50 revolutions per second. The spring 34 serves to compensate for any play in the ball bearings 30 and 31.

Members are provided to detect the instants at which each of the heads travels past a reference position, which in the present instance is that of the recording cell reserved for the end-of-preparatory-zone signal. These members comprise a support 35 of insulating material secured to the casing 24. The said support serves to position two small incandescent lamps 36 and two photo-resistive cells CIE and CIL, only the former one being visible in the section of FIGURE 3A. An indexing disc 37 is secured against the left-hand face of the plate 28. The said disc is formed with a flange and a cylindrical rim. The latter is formed with two series of indexing notches at different levels. FIGURE 3B shows the developed rim of the disc 37. The notches IE1 to IE4 are located at a first level so as to lie in the plane of the cell CIE. The notches IL1 to IL4 are located at a second level so as to lie in the plane of the cell CIL. It is the transition from the darkening to the illumination of a cell which is utilised when the right-hand edge of a notch unmasks the associated photo-resistive cell. The step marked ILS (additional reading indexing) from the second to the first level of the rim constitutes an additional position location preceding IE1, the function of which will hereinafter be seen.

The spacing of the indexing notches is generally 44°, like that of the heads. However, it is clear that the angles α and β depend upon the angular position of the support 35 of the indexing cells, as also upon the angular spacing of the latter.

It will be seen from FIGURE 6A that the windings of the writing heads E1 to E4 are connected in series with one another and with the secondary winding of the transformer 38. Likewise, the windings of the reading heads L1 to L4 are connected in series with one another and with the primary winding of the transformer 39. Referring again to FIGURE 3A, the magnetic core of each transformer is composed of two portions of high-frequency ferrite. An inner half-core, such as 38A, is fitted on the shaft 29 and rotates therewith. It carries a cylindrical winding whose wires for connection to the writing heads extend through a longitudinal groove in the half-core and through a hole in a collar on the shaft 29. The outer half-core, such as 38B, is disposed in the bush 40. It therefore does not rotate and contains a second cylindrical winding whose connecting wires may be accessible since they pass through aperture in the outer half-core 38B, in the bush 40 and the sleeve 32. A very small air gap exists between the ends of the inner and outer half-cores, but it does not interfere too much with the output of the transformer. This known arrangement has the great advantage that it eliminates all switching by switching members which are subject to deterioration in use.

The presser device 21 (FIGURES 3A and 3C) comprises a lever 41 pivotally mounted on the pin 42, which is in turn maintained by the support 43. The latter is secured to the rear face of the plate 11. The presser block 44 is connected to the lever 41 by pins 45, on which it is adapted to oscillate. As already mentioned, the curvature of the lower face of the presser block 44 is designed to impart to the film a curvilinear form over a sufficient length. Means (not shown) are provided for lifting the

lever 41, for example from an electromagnetic plunger and a connecting rod such as 46.

The details of the advance unit 16 are visible in FIGURES 4A to 4E. In FIGURE 4A, the feed unit is shown in the same view as in FIGURE 2. The advancing members are contained in or supported by the casing 47, over which there is mounted the cover 48, these parts being mounted on the plate 11. The casing comprises bearings in which the intermediate shaft 49 turns. At the level of the axis E—E of FIGURE 4B, the shaft 49 is connected to a helically-toothed pinion 50 (FIGURE 4E). A pulley 51, which may be identical to the pulley 33 of FIGURE 3A, is mounted on the end of the intermediate shaft 49 extending from the casing. Under the action of a serrated belt and of another pulley mounted on the second end of the shaft of the previously mentioned synchronous motor, the shaft 49 constantly rotates at a speed of 50 revolutions per second.

Above and perpendicularly to the axis of the intermediate shaft 49, the cycling shaft 52 turns in two ball bearings 53 and 54. The helically toothed pinion 55 is fast with the shaft 52. Since the gear ratio of the pinions 55 and 50 is 2:1, the cycling shaft 52 rotates at a speed which is half that of the intermediate shaft 49, i.e. at 25 revolutions per second.

A two-cam sleeve 56 is mounted on the shaft 52 along the axis of travel of the magnetic film 12. Two flanges 57 are provided to form two cams of predetermined shape. A single-cam sleeve 58 is mounted beside and in front of the sleeve 56.

There are provided (FIGURES 4B, 4C and 4E) two driving claws 59 which are coupled by the pins 60 to the double driving lever 61, the latter being adapted to rock on the pin 62. A double tension lever 63 has the same general form as the double lever 61, except that it is shorter than the latter. The double lever 63 is adapted to rock on the shaft 64 held fast in the bushes 65 (FIG. 4D). Each of two lateral lugs on the levers 61 and 63 supports, level with the shaft 52, a follower roller such as 66, which may consist of a riveted pin and a small ball bearing. Each of the levers 61 and 63 is provided with a rod 67 serving as a cross-member but also for the engagement of one or two tension springs 68. It follows that the rollers 66 remain constantly in contact with the cams 57, so that the levers 61 and 63 are actuated with an oscillatory movement. In the position illustrated in FIGURE 4B, the two teeth 69 constituting the end of each claw 59 are situated below the film 12, as may be seen from FIGURE 4E. In this position, the teeth in question are actuated with a horizontal reciprocating movement whose amplitude is equal to P, but they cannot drive the film.

In order to produce a vertical movement of the ends of the claws 59, and consequently in order to effect a single-step advance of the film, vertical displacement members are driven by an electromagnet. A lever system comprises a shaft 70 turning in two bushes 71 and 72. An outer lever 73 is secured to the shaft 70 by soldering or welding. Two inner levers 74 and 75 fast with the hub 76 are coupled with the shaft 70 by means of the pin 77. The lever 74 has the same form as the lever 75. However, only the latter is provided with an upper arm 78, to the end of which the follower roller 79 is secured. Like the preceding ones, the latter consists of a riveted pin and a small ball bearing.

The feed electromagnet 80 is secured to the outside of the casing 47. When it is energised, it can attract the armature 81. Normally, the end of the armature is disposed in the catch 82 formed by the end of the lever 73. Therefore, the latter is held fast, although it is urged by the spring 83 to turn in the clockwise directions.

A flat link 84 (FIGURES 4B and 4C) is so shaped as to connect the claws 59 to a pin 85 mounted in the ends of the levers 74 and 75. This connection is completed by the plate 86 consisting of a thin split sheet of spring steel.

A guide 87 consisting of bent thin sheet metal guides the ends of the claws. The electromagnet 80 is energised just at the instant when the claws are in their extreme left-hand position. The end of the armature 81 becomes disengaged from the catch 82, so that the spring 83 turns the above-described lever device, and the teeth 69 of the claws move upwards and enter two perforations in each side of the film. The teeth thereafter drive the film to the right and advance it by one step. During this time, a follower roller 79 has come into contact with the cam 58 and the latter is shaped to rotate the lever system in the counterclockwise direction immediately when the claws are in their extreme right-hand position. This produces on the one hand the disengagement of the teeth 69 from the perforations in the film and on the other hand the resetting of the armature 81 of the electromagnet 80, which is no longer energised at this instant. The claws 59 therefore perform their return movement from right to left in the bottom position.

Each of the film units of an installation comprises members for indexing the position of its cycling shaft. The cycling shaft 52 (FIGURES 4E and 4A) supports at that end which projects from the casing a so-called "advance disc" 88. The latter is a thin flange fast with a hub and having its cylindrical rim cut away, so that there remains a masking portion 89. The latter must mask a photo-resistive cell CA (advance cell) secured in the insulating support 90, for a quarter of a revolution in each revolution of the disc, the said revolution corresponding to one cycle. During the remainder of the revolution, the cell may be illuminated by a small incandescent lamp 91 secured in the support 90, outside the advance disc.

In an installation, there is only one master film unit. On the latter only, the end of the cycling shaft 52 supports an additional disc called the "clock disc" 92, with which there are associated a photo-resistive cell CH (clock cell) and another small incandescent lamp (not shown), for which the support 90 is also adapted. The construction of the disc 92 is identical to that of the disc 88, except that its rim comprises two masking portions 93 each positioned to intercept the light in correspondence with an angle of $90^\circ + 2\gamma$, the angle γ being related to the function of monitoring the phase relation, as will hereinafter be explained.

The graphs of FIGURE 5 show how the mechanical members of the transducer station 15 and of the advance unit 16 are adjusted within the range of each cycle of a duration of 40 ms. (milliseconds), defined by the cycling shaft 52. It may be considered that each cycle has a first phase and a second phase, called the "advance phase," each phase lasting 20 ms., in correspondence with one revolution of the magnetic-head support. Thus, there will be seen on the line CIE groups of four pulses available at the output of a shaping amplifier connected to the photo-resistive cell CIE (writing indexing cell). Likewise, there will be seen on the line CIL groups of five pulses available at the output of a shaping amplifier connected to the cell CIL (reading indexing cell). There will be seen on the line E1—E4, in the course of the first half of each phase, the periods during which signals can be supplied to the writing heads E1—E4 to write the data of a block of information on four tracks of the magnetic film. There will be seen on the line L1—L4, in the course of the second half of each phase, the periods during which the reading heads L1—L4 can supply reading signals corresponding to a block of information.

With regard to the film-advancing members, the curve referenced by the levels PED, PEG relates to the horizontal movements of the teeth of the claws 59, which movements are imparted by the cams 57. Between the instants t_0 and t_{10} , first phase, the claws are stationary in the extreme right-hand position (PED). Between the instant t_{10} and the instant t_0 of the second phase, the claws are shifted to the left. Between the instants t_0 and t_{10} , the second phase, the claws are stationary in the

extreme left-hand position (PEG). Finally, between the instant *t*10 and the instant *t*0 of the succeeding cycle the claws are shifted to the right.

The curve referenced PH, PB relates to the vertical movements of the teeth of the claws 59. If an advance movement of one step is to be performed, the electromagnet 80 is energised from the instant *t*0 to the instant *t*10, second phase. By reason of the electrical and mechanical delays, the vertical movement of the teeth of the claws takes place a little later, for example between the instants *t*3 and *t*7, the teeth of the claws then being engaged in the perforations in the film. The curve marked FILM shows that the single-step advance of the film occurs between the instant *t*10, second phase, and the instant *t*0 of the succeeding cycle. Between the instant *t*0 and the instant *t*5 of this cycle, the cam 58 produces the withdrawal of the teeth of the claws.

From the curve marked 21, it may be seen that the lifting movement of the presser 21 is carried out between the instants *t*5 and *t*10, second phase, and that the return into the bottom position is effected between the instant *t*15 and the instant *t*0 of the succeeding cycle.

The succeeding lines marked CA, CH, CVA also represent signals available at the output of shaping amplifiers which are each connected to a photo-resistive cell. Thus, the pulse supplied from the advance cell CA lasts between the instants *t*0 and *t*10, second phase, and is available at each of the film units of the installation. On the other hand, the clock cell CH, only on the master film unit, supplies two equidistant pulses per cycle. For example, the second pulse CH is centered on the pulse CA, but it has a slightly longer duration, which corresponds to an angle of 90° plus twice the angle γ , which may be from 4° to 5°.

The advance checking device 22 of FIGURE 2 comprises a photo-resistive cell and a small incandescent lamp, which are disposed on either side of the film, in alignment with one of the rows of perforations in the latter. The cell is so disposed that when the film is stopped in the normal position it is situated between two perforations. Normally, the light from the lamp is therefore intercepted by the film and the cell is illuminated only during the time when a perforation is travelling past it.

There will be seen in FIGURE 5 on the line marked CVA the signal supplied from the advance checking cell CVA, the pulse being produced between the instants *t*12 and *t*18, second phase. It is obvious that if, as a result of failure of the advancing members, the film is not moved, this pulse will be suppressed. On the other hand, if the film is incompletely advanced, in which case the cell CVA remains illuminated, the signal supplied by the latter will remain at the upper level after the instant *t*18, instead of falling back to the lower level. Thus, means are available for checking whether an advance movement of the film has been correctly carried out during a second phase of a cycle in which this movement has been ordered.

There will now be considered with reference to FIGURES 6A and 6B, which are joined by the lines X—X, the basic diagram of the circuits and electric members included in an input-output element according to the invention. FIGURE 6B relates to the control apparatus called the "uniselector," while FIGURE 6A illustrates mainly the electric circuits and members forming part of a film unit or directly associated therewith.

In FIGURE 6A, the electric members whose operation influences, or is dependent upon, the mechanical members are illustrated to the right of the vertical line ZZ. The electrical control devices associated with one of the film units and mounted therewith in the same cabinet are shown between the vertical lines YY and ZZ. Finally, there is shown in a rectangle between the lines XX and YY an assembly of selection circuits which in practice forms part of the uniselector.

To the right of the line ZZ, there may be seen: the advance check cell CVA, the four reading heads L1 to

L4 and the transformer 39, the writing indexing cell CIE, the advance cell CA, the advance electromagnet 80, the four writing heads E1 to E4 and the transformer 38, the reading indexing cell CIL, and the clock cell CH, which, it will be recalled, is present only at the master film unit.

There is shown a member which has not hitherto been mentioned, namely a braking electromagnet 94 capable of actuating the brake 95. The latter is mounted on one end of the shaft of the aforesaid synchronous motor belonging to each of the film units, except the master film unit, whose motor is never braked. This brake is intended to obtain initially, or to restore, a particular phase relation either between the master film unit and a slave film unit of even number, or between two slave film units, one of which is of odd number and the other of even number.

The devices peculiar to each film unit comprise an advance control device 96, an incident detection device 97 and a brake control device 98, the latter device obviously being excluded in the case of the master film unit.

In the uniselector, FIGURE 6B, there is provided a buffer register 99, with which there are associated a character counter 100 and a word counter 101. The buffer register 99 consists of a shift register intended to effect the conversion from series to parallel for the transfer of a character to the ordinator, or the conversion from parallel to series in the case of the transfer of a character coming from the ordinator. It is mainly for the purpose of economising in equipment that this shift register has a capacity of only one character, but it could be given a larger capacity. In a practical example, it possesses 10 stages, i.e. 9 stages corresponding to 9 bits of a character, and one additional stage. In the storage of a character, a locating "1" is stored in the first stage and in the extraction, after nine successive shifts, this locating "1" must be stored in the 10th stage, by which time the transit of the character through the register may be detected, which is equivalent to a counting of the bits of each character.

When 12 characters have passed through the buffer register 99, the counter 100 supplies in each instance an end-of-word signal to the counter 101. The term "word" has here been adopted for 12 characters corresponding with the recording capacity of one of the four magnetic tracks for each block of information, but it is obvious that the real words of the data need not at all be composed of 12 characters. When the counter 101 has received four end-of-word signals, it supplies at its output an end-of-block signal, which indicates that four words have passed into the register 99.

The inputs of the stages of the register 99 may sequentially receive through the channels 102 data emanating from the dispatching unit 103 of the calculator. The outputs of the stages of the register 99 can sequentially supply to the dispatching unit, by means of the channels 104, the characters forming a block of information read on one of the film units. Before any transfer, the dispatching unit supplied an instruction along the channels 102 and, at the same time, along the channel 105, an instruction indicating signal SII, which is applied to a delay element 106 and to a group of AND circuits, symbolically illustrated at 107. From the latter, the instruction may be stored in the instruction register 108 composed of 5 stages.

Each instruction is composed of a film unit member code, having 3 binary positions, and a function code, having two binary positions. The two functions or operations which will be considered in detail are the "reading" function and the "writing" function.

The outputs of three of the stages of the register 108 are connected to supply to the decoding device 109 the number code of the film unit to be used. The outputs of the other two stages of the register 108 are connected to two inputs of each of the logical circuits 110 and 111. Each of the latter is adapted to decode the coded combination representing the function to be performed. The

writing and reading functions are decoded respectively by the logical circuits 110 and 111.

There has been represented by a single link the control exerted by the decoding device 109 (FIGURE 6B) on the set of selection circuits 113 (FIGURE 6A). The latter establish the connections between the uniselector and the electric circuits and members of the film unit to be employed, the number of which is specified by the instruction stored in the register 108.

The signal from the advance cell CA (FIGURE 6A) is applied to the advance control device 96 in order that the latter may supply, if it has received an advance order, a current pulse of like duration to the advance electromagnet 80. The advance control device 96 is in addition connected to one input of the incident detection device 97, in order to supply to the latter a signal indicating either that an advance order has been received or that an advance movement of one step is being performed. The device 97 is composed of a group of logical circuits designed to supply at the output a signal indicating whether the film unit is available or not.

In particular, owing to the fact that the device 96 also receives the signal emanating from the cell CVA, the device 97 may supply a signal indicating non-availability of the film unit if any advance movement of the film has not been correctly performed. The device 97 possesses other inputs by means of which incidents of various orders may be detected, more particularly an advance incident. For example, the non-availability signal may be supplied during the period when the motor of a film unit is being brought into phase, or if the latter is occupied in a rewinding operation, or again in the case of malfunctioning of the film presser device, etc.

The signals of the device 97 are applied by means of the links 114A, 114B (FIGURES 6A and 6B) to an instruction validation device 115. The latter receives, with a delay which may range from 60 to 120 microseconds due to the delay element 106, the previously mentioned instruction indicating signal. The output of the device 115 is connected to a third input of each of the logical circuits 110 and 111.

The device 115 also receives at an input marked R1 pulses called "timing" pulses which are supplied by a timing pulse generator 112. The latter, which is self-running as long as a reading operation has not been performed, comprises a master oscillator having a well-defined frequency, for example 133.3 kc./s., and frequency divider and timing circuits which are so adapted that the generator supplies a first pulse train R1 whose repetition frequency is 66.67 kc./s., thus determining a bit period of a duration of 15 microseconds. A second pulse train R2 is available at a second output. Their frequency is the same, but they are staggered by half a bit period in relation to the pulses R1. Although the necessary links have not been shown in the basic diagram, it will be noted that these pulses serve to synchronise the operation of the majority of the illustrated devices.

Finally, when the selected film unit is available, the output of the validation device 115 supplies an authorising voltage to the logical circuits 110 and 111. There will be denoted by IEU (utilisable writing instruction) the authorising voltage which is set up at the output of the logical circuit 110 throughout the time necessary for performing a writing operation. There will be denoted by ILU (utilisable reading instruction) the authorising voltage which is set up at the output of the logical circuit 111.

The uniselector receives the instructions from the calculator at any instants in relation to the cyclic operation of the film units. When a reading instruction has been stored in the register 108, it must have been previously authorised in order that it may be performed during the second half of the first or the second phase of a cycle. FIGURE 5 shows that for this purpose it is necessary to employ pulses from the writing indexing cell CIE. It will be seen from FIGURE 6A and from FIGURE 6B

that the cell CIE is connected through a shaping amplifier (already mentioned) and the links 116A and 116B to the writing indexing register 117. The latter controls an input of an AND circuit 120, whose other input receives the above-mentioned signal ILU. The output of the AND circuit 120 controls through the OR circuit 118 an input of the reading authorisation register 119. In addition, the reading authorisation register 119 jointly receives the "end-of-word" signal and the "end-of-block" signal, which emanate respectively from the counter 100 and the counter 101. The register 119 can supply a reading authorisation voltage AL to one input of the AND circuit 121. The arrangement is such that a time condition for the performance of the function during one of the phases is that the signal ILU should be set up before one of the pulses CIE, and in any case before the fourth one of a group, failing which it can be performed only during the succeeding phase.

The secondary winding of the transformer 39, in the selected film unit, is connected through the links 122A and 122B to a group of circuits 123, which will be called the "reading exploitation network" and which is composed in known manner of a preamplifier, of an amplifier, of a level crossing detector circuit, and of logical circuits associated with a time base, for the purpose of supplying at their output signals by which the "ones" can be distinguished from the "zeros" in the characters read on the magnetic film. This output is connected to the other input of the AND circuit 121, the output of which is connected to one input of the first stage of the buffer register 99.

When the first reading head arrives opposite the first track, it first reads the preparatory zone containing zeros. From this instant, owing to the link 124 represented by a chain line, the reading exploitation network 123 acts on the timing pulse generator 112, so that the latter is no longer self-running but is synchronised by the reading signals. Thus, the previously mentioned master oscillator is disconnected and each time a transition indicating recording cell boundary is detected a timing pulse R1 is generated. The timing pulses R2 are also emitted, but their staggering is reduced to a delay of 5.5 microseconds in relation to the pulses R1.

As already indicated, the reading of the first digit "1" marking the end of the preparatory zone results in the introduction of a locating "1" into the first stage of the buffer register 99, which marks the beginning of the effective reading of a word. Signals emanating from the cell CIL also control the application of shift pulses to the buffer register 99.

One output of the tenth stage of the buffer register 99 is connected through the link 125 to one input of a device 126, called the "transfer demand generator." Another input of this device is connected through the link 127A, 127B to the output of the character counter 100.

When the first character has been completely introduced into the buffer register, the arrival of the locating "1" in the tenth stage results in a pulse being applied to the device 126. Since the end-of-word signal is absent at this instant, the device 126 emits a pulse a pulse called DTK (character transfer demand), which is transmitted to the dispatching unit 103. The latter effects the transfer of the stored character to a buffer memory very rapidly through the channels 104, and immediately afterwards it sends a signal TKE (character transfer effected) to the device 126 in order to authorise the latter to emit the next transfer demand.

The reading of the succeeding characters of the first word continues in the same way. The reading signals are interrupted from the instant when the first reading head leaves the first track of the block until the instant when the second reading head arrives opposite the beginning of the second track. The reading of the second word commences and it is clear that the third and fourth words of a block of information will thereafter be read in the same way.

It will be seen from FIGURE 6B that the output of the word counter 101 is connected to one input of the AND circuit 128, the other input of which receives the signal ILU emanating from the logical circuit 111. The output of the AND circuit 128 may be connected through the links 129A and 129B to the advance control device 96 (FIGURE 6A) of the selected film unit. When the last character of the fourth word of a block, which has been read, has been introduced into the buffer register 99, the word counter 101 emits an "end-of-block" indicating pulse which, when it is transmitted by the AND circuit 128, constitutes an advance order.

It will be appreciated from what has already been stated that after the storage of this advance order the device 96 may produce the energization of the advance electromagnet 80 immediately it receives a signal emanating from the advance cell CA. It will also be appreciated that if the aforesaid reading has been effected in the course of the second half of the first phase (see FIGURE 5), the advance of the film by one step is performed in the course of the second phase of the same cycle. Otherwise, if the aforesaid reading has been effected in the course of the second half of the second phase of a cycle, the single-step advance of the film can be carried out only during the second phase of the succeeding cycle. It will be recalled that, during the period of time, the validation of a fresh instruction affecting the film unit under consideration is prevented.

The output of the logical circuit 110 is connected to an input of the AND circuit 130. The other input of the latter is controlled by the reading indexing register 131 which, through the links 132A and 132B, can receive the pulses emanating from the reading indexing cell CIL. The register 131 is analogous in all respects to the register 117. The output of the AND circuit 130 is connected to the input of the writing authorising register 133, which is similar to the register 119. The output of the register 133 controls an input of a group of writing power amplifiers 134. The latter can supply a writing current in one direction or the other, through the links 135A and 135B and through the transformer 38, to the writing heads E1 to E4.

A device 136 called the "digital modulator" has one input connected through the link 137 to one output of the tenth stage of the buffer register 99. Another input of the digital modulator 136 is connected through the links 127A and 127C to the output of the counter 100. The output of the digital modulator 136 controls one input of the group of two-amplifiers 134.

As soon as an instruction concerning the "writing" function and a particular film unit has been stored in the instruction register 108, the signal IEU is generated at the output of the logical circuit 110, provided that this film unit is available. When a writing instruction has been stored in the register 108, it must have been previously authorised in order that it may be performed during the first half of the first or second phase of a cycle. FIGURE 5 shows that, for this purpose, it is necessary to employ pulses from the reading indexing cell CIL. If only the four notches IL1 to IL4 (FIGURES 3A and 3B) had been employed, the instruction would have had to arrive at least before the pulse resulting from the fourth notch IL4. In order not to lose a period of time equal to the duration of one phase, the step marked ILS is employed to generate a fifth pulse CIL, a little before the end of each phase, whereby the margin of time for taking into account the writing instruction is increased.

Therefore, when the signal IEU exists, the AND circuit 130 becomes conductive as soon as one of the five pulses CIL is stored in the reading indexing register 131, and the writing authorisation register 133 supplies an authorisation voltage to the writing amplifiers 134.

The digital modulator 136 is composed essentially of a bistable multivibrator associated with logical circuits which

interconnect its two inputs and its two outputs in known manner and which receive in addition the timing pulses R1 and R2. Their arrangement is such that each pulse R1 produces a change-over of the multivibrator, and when a "1" leaves the buffer register 99 a change-over is in addition produced by a pulse R2 at the middle of a bit period, the duration of which is 15 microseconds. The directions applied by the devices 133 and 136 to the amplifiers 134 are such that the writing heads are constantly supplied with a current which is reversed at each bit period, as long as a reading operation has not been effected, or during the writing as long as the "1's" of the characters to be written are not supplied to the digital modulator 136. Thus, the zeros of the preparatory zone and of the terminal zone are written at the beginning and at the end of each track.

Control links which have been omitted from the drawings for the sake of simplicity have the effect of almost simultaneously producing, as soon as the first pulse CIE has been stored in the writing indexing register 117, the return to zero of the counters 100 and 101, and of the buffer register 99, as also the transfer into the latter of the first character to be written, which emanates from the central unit. Thereafter, the register 117 acts on the digital modulator 136 to cause it to bring about the writing of a "1" constituting the indication of the end of the preparatory zone. In the succeeding bit period, a locating "1" is introduced into the first stage of the buffer register 99, while the generator 126 emits a pulse demanding the transfer of the second character. Since shift pulses have been released and applied to the buffer register 99, the binary digits of the first character appear at the output of the latter, in order to control the digital modulator 136, so that it causes them to be written on the magnetic film.

The passage of the locating "1" into the tenth stage of the buffer register causes the evolution of the contents of the character counter 100. The successive characters of a first word are written in the same way, as also are the characters of the 2nd, 3rd and 4th words of a block of information.

The characters and the words having been counted during this process by the counters 100 and 101, the latter supplies an "end-of-block" indicating signal to the reading authorisation register 119, because any block writing operation is systematically followed by a reading of this same block in order to check that no fault has occurred during the writing. This check consists mainly in a calculation of the parity key of each character of the block.

A set of logical circuits called the "check reading control device" 138 is controlled at the same time by the output of the logical circuit 110 and by the instruction validation device 115. The output of the device 138 is connected to a second input of the OR circuit 118, whereby the latter supplies an authorisation voltage in such manner that the end-of-block signal is this time sufficient to activate the reading authorisation register 119.

At the desired instant, the check reading of the block will be performed in the same way as during a normal reading operation, except that, by virtue of particular means, the generator 126 is not authorised to emit transfer demand pulses during this operation. It will readily be appreciated that when the last character of the block thus checked has been read, the word counter 101 again emits an "end-of-block" indicating pulse, which becomes an advance order when it leaves the AND circuit 128, as previously indicated.

If the writing operation has been performed in the course of first phase, the single-step movement of the film is performed in the course of the second phase of the same cycle. On the other hand, if the writing operation has been performed in the course of a second phase of a cycle, the single-step movement of the film takes place

only during the second phase of the succeeding cycle, since no instruction affecting the same film unit can be validated almost throughout this cycle.

The construction of the devices previously considered may differ in accordance with the type of technology adopted. For example, these devices may be formed by the association of logical circuits of the NOR type, with bistable multivibrators having two input and two outputs. Each input of a multivibrator may be controlled by one or more "edge gates," with which a voltage transition, applied to a first input appears at the output only if an authorising voltage has been applied to the second input at a sufficiently early instant. Moreover, the amplifiers are generally of the polarity-reversing type. As is known, the advantage of such a technology is that the first edge and the second edge of a square-wave pulse can be successively utilised.

Thus, the advance control device 96 (FIGURE 6A) is composed of a first bistable multivibrator and of a second bistable multivibrator, associated with a number of NOR circuits. When the logical circuit 128 supplies a pulse of a duration of 15 microseconds, the latter changes the first multivibrator to the state "1" during the detection of the end of the reading of a block of information. In the succeeding second advance phase, a pulse derived from that emanating from the advance cell CA changes the second multivibrator to the state "1." The latter then controls a power amplifier which energises the advance electromagnet 80, which results in a single-step advance of the film.

If the latter is correctly accomplished, the second edge of a pulse emanating from the advance check cell CVA has the effect of returning the first and second multivibrators to the state "0." If the film has not been advanced at all, or if it has been incompletely advanced, the second edge of the aforesaid pulse does not exist, and at the end of a second phase the two multivibrators remain in the state "1." The latter condition is detected by a logical circuit controlling a third multivibrator, which changes to the state "1" at the first edge of the pulse emanating from the cell CA, at the beginning of the second phase of the succeeding cycle. The latter multivibrator has the object of activating the incident detecting device 97, as also a device which signals an advance incident.

It should be noted that each of the devices 115, 117, 119, 131 and 133 also consists of a first bistable multivibrator and a second bistable multivibrator which are associated with NOR circuits. Each arrangement is such that first multivibrator must previously be brought to the state "1" in order that the second multivibrator may also change to the state "1." In addition, the first multivibrator can change to the state "1" only after the two multivibrators have been brought to the state "0."

However, one feature of the instruction validating device 115 resides in that, when a writing instruction has just been performed, only the first multivibrator is brought to the state "0." The state "0" of the first multivibrator, the state "1" of the second multivibrator and the presence of the signal IEU at the output of the logical circuit 110 are logical conditions which enable the device 138 to initiate the check reading operation previously mentioned.

Owing to the fact that the mechanical members each of the film units are driven by an individual synchronus motor, the cycle of the film units, corresponding to one revolution of the cycling shaft, is uniform and has a duration of 40 ms. when the frequency of the alternating current of the supply line is 50 c./s.

As during the starting of the installation, a motor of a film unit may be set in phase or in phase opposition in relation to the motor of another film unit, and on the other hand by reason of the reduction effected by the pinions coupling the intermediate shaft and the cycling

shaft, there exist four possible phase relations between two magnetic-film units if no special measures are taken. Thus, two film units may be set in phase or with a phase advance or a phase lag of a quarter of a cycle, or in anti-phase, the latter relation constituting the optimum phase relation.

There will now be considered with reference to FIGURE 7 the operation of two film units in the case where one film unit having an even number is set with an advance of a quarter-cycle, i.e. a half-phase, in relation to a film unit having an odd number. The boundaries of the cycles of the odd and even numbered film units are referenced by the indications $t_1, t_3, t_5 \dots$ and $t_2, t_4, t_6 \dots$ respectively. The thin-lined rectangles correspond to periods in which operations are possible, but which are not in fact carried out. When a function is in fact carried out, its duration is represented by a block rectangle. On each of the lines marked SII there are indicated the instruction indicating signals received by the uniselector at the latest instants when each instruction can be validated. There are represented by hatching on the line marked UC the periods during which the data read on an odd-numbered film unit may be processed by the calculator. Vertical arrows indicate on the one hand the transfers of a block of information emanating from an odd-numbered film unit, from the uniselector to the dispatching unit of the calculator, and the other hand the transfers of a block from said dispatching unit to the uniselector and intended for the even-numbered film unit. On the lines marked SEL, there are indicated the periods during which the selection circuits of the uniselector are occupied in selecting either the odd-numbered film unit or the even-numbered film unit.

In the course of the first cycle t_1-t_3 shown, the transfer of a first block to the calculator is followed (line "AVANC.") by a single-step movement of the film at the odd-numbered film unit. The same is the case in the course of the second cycle t_3-t_5 for a second block. During the cycle t_4-t_6 affecting the even-numbered film unit, the first block, which may or may not have been modified by the processing carried out in the calculator, is transferred (line "ECRIT.") and written on the film of the even-numbered film unit. After check reading of this first block (chain line), a single-step advance of the film at the even-numbered film unit is carried out during the second phase of the cycle t_4-t_6 . By reason of the occupation of the selection circuits of the unit selector, the third reading instruction can be validated only during the second phase of the cycle t_5-t_7 . The single-step movement of the film at the odd-numbered film unit is carried out only during the second phase of the cycle t_7-t_9 . In the course of the succeeding cycles, the operation is self-explanatory.

By reason of the dead times, the mean rate of supply of information considered for a pair of film units is 1.333 block of information per cycle. This rate, which is the least favourable, is identical to the case where the even-numbered film unit has a time lag of a quarter of a cycle in relation to the odd-numbered film unit. The mean rate is a little better, since it amounts to 1.5 block per cycle, when the two film units are set in phase. The mean rate is optimum only when the two film units are set in "anti-phase." The mean rate then amounts to two blocks per cycle, as may be verified from the graphs of FIGURE 8. This phase relation is characterised in that the first phase of an odd-numbered film unit corresponds in time to the second phase of the even-numbered film unit, and vice versa.

Thus, during the first phase of the cycle t_1-t_3 of the odd-numbered film unit, while a block of order number n is transferred to the calculator, an advance movement is carried out on the even-numbered film unit. In the course of the second phase of the cycle t_1-t_3 of the odd-numbered film unit, the latter performs an advance movement, while a block of order number $n-1$ is transferred

in return from the calculator to the uniselector in order to be written on the film of the even-numbered film unit. It will be seen that the reading on the odd-numbered film unit, and the writing on the even-numbered film unit are always carried out in the course of the first phase of their respective cycles. It will be noted that the optimum alternate operation of two film units is possible by reason of the fact that the duration of the occupation of the selection circuits of the uniselector is only a little more than a half-phase in reading and a little less than one phase in writing. During optimum alternate operation, the calculator has available a period of 17 ms. for processing each block of information.

There will now be considered the very simple steps taken to monitor constantly the phase relation of two film units and to obtain initially, or to restore, the optimum phase relation, because various causes may have the effect of accidentally retarding the driving members of one film unit.

Reference will again be made to FIGURES 6A and 6B. It will be seen that the clock cell CH, which exists only on the master film unit, is connected to an input of a device 139, called the clock pulse generator. The latter also receives, through the links 140A and 140C, the signals emanating from the advance cell CA of the master film unit.

FIGURE 9 shows diagrammatically, but clearly, the arrangement of the circuits of the generator 139, included in the uniselector. The devices 141 and 142 are non-inverting shaping amplifiers. The devices 143, 151 and 152 are inverting amplifiers. The logical circuits 144 to 146 are edge gates, of which one input, denoted by a diamond-shaped arrow, indicates that only the positive-going edge of the signal received gives rise to the transmission of a short pulse at its output. The logical circuit 147 is an OR circuit for positive signals. The logical circuits 149 and 150 are NOR circuits. The bistable multivibrator 148 has two inputs $e1$ and $e0$, and two outputs $s1$ and $s0$.

FIGURE 11 shows the signals received or emitted by the generator 139. It will be seen that the signals H emanating from the amplifier 142 are composed, in the course of each cycle, of two positive pulses lasting between the instants $t10.5-t19.5$ and $t30.5-t39.5$ respectively. The multivibrator 148 (line 148s1) normally changes to the state "1" at the instant $t10.5$ and returns to the state "0" at the instant $t30.5$. Since the inputs of the NOR circuit 150 receive respectively the signals H and those from the output $s0$ of the multivibrator 148, the signal H1 is composed, at each cycle, of a positive pulse between the instants $t19.5$ and $t30.5$.

Since the NOR circuit 149 is controlled by the output $s1$ of the multivibrator 148, the signal H2 is composed of a positive pulse between the instant $t39.5$ of one cycle and the instant $t10.5$ of the succeeding cycle. A control signal is applied, at starting, to the input terminal 153 of the edge gate 144, so that at the instant $t20$ the first edge of the signal $\overline{AV}$ changes the multivibrator 148 to the state "1" if it is not already in this state, in order to ensure correct operation of the device.

The signal H1, and its complement $\overline{H1}$ are intended to be applied to a coincidence detector included in the braking control device 98, in each of the film units having an odd number, of course except the master film unit. Likewise, the signal H2 and its complement $\overline{H2}$ are intended to be applied to a coincidence detector included in the braking control device, in each of the film units having an even number.

FIGURE 10 shows the construction details of a braking control device 98, which is assumed to be associated with an odd-numbered film unit. The logical circuits 154 and 156 are edge gates. An OR circuit is shown at 157. The bistable multivibrator 158 is of the same type as the multivibrator 148 of FIGURE 9. A relay 160 may

be energised through the power amplifier 159, which is controlled by the output $s1$ of the multivibrator 158.

The signals AVI and $\overline{AVI}$ which are applied respectively to the upper inputs of the edge gates 156, 155, 154, are the same in principle as the signals AV and $\overline{AV}$ shown in FIGURE 11, but it is to be noted that they emanate from the cell CA of the odd-numbered film unit under consideration, and that the latter must normally be exactly in phase with the master film unit. The signal H1 is applied to the lower input of the gate 156, while the signal $\overline{H1}$ is applied to the lower input of each of the gates 154 and 155. Normally, the multivibrator 158 must constantly remain in the state "0." As long as the phase relation is correct between the cycling shaft of the master film unit and that of the odd-numbered film unit, a short pulse emanating either from the first edge of AVI or from the second edge of AVI cannot be transmitted to the input $e1$ of the multivibrator 158, since the signal $\overline{H1}$ is negative.

If it happens that the odd-numbered film unit acquires a time lag greater than about 5% of the duration of the signal AV (10 milliseconds), a short pulse emanating from the second positive edge of the signal AVI is produced while the signal $\overline{H1}$ is positive, i.e. after the instant $t30.5$. It causes the multivibrator 158 to change to the state "1." This results in energisation of the relay 160, which forms part of a group of relays adapted to produce the energisation of the braking electromagnet 94 (FIGURE 6A) of the film unit under consideration. It follows that the motor of the latter will be braked until it has been restored to a correct phase relation. The said group of relays is also designed to limit the braking time to a certain period of time, for example 4 seconds, and to notify the incident detecting device 97 if the correct phase relation is not restored at the end of this period of time.

It will readily be appreciated that the same results will be obtained if by chance the odd-number film unit acquires an excessive lead. In this case, however, it is a brief pulse emanating from the first edge of the signal $\overline{AVI}$ which changes the multivibrator 158 to "1" before the instant $t19.5$, which results in the braking. Since the correct phase relation can be more rapidly restored in this case, the multivibrator 158 may be returned to the state "0" at the instant $t30$ of the same cycle, under the action of the gate 156.

The operation of a braking control device associated with an even-numbered film unit is similar in all respects to that just described. The only difference resides in that the lower inputs of the edge gates 154 to 156 receive from the uniselector the signals H2 and $\overline{H2}$, which are out of phase by 180° in relation to the signals H1 and $\overline{H1}$. The optimum phase relation is obtained when the signal emanating from the advance cell CA of the even-numbered film unit coincides with the signal H2. It therefore follows that each even-numbered slave film unit is set in anti-phase in relation to the master film unit and in relation to any one of the odd-numbered slave film units. Thus, the optimum alternate operating conditions illustrated in FIGURE 8 are obtained.

It is to be noted that even if the optimum phase relation cannot be restored after the previously indicated period of time, the pair of film units can nevertheless continue to be used, while a phase incident indicating lamp will remain lit. The operator will then have to choose between two solutions: either to allow the operation to continue at a reduced rate or to stop the installation for the purpose of repairing any defects which may have caused the disturbance.

It will also be noted that even when the optimum phase relation between two film units is not aimed at, a particular feature of the design of the film unit affords a certain advantage. This feature resides in the possibility of a reading or writing operation being performed during the first or second phase of a cycle. It is apparent that if,

in the case illustrated in FIGURE 7, this possibility had not existed, the dead times would have been even greater and the mean rate of operation per cycle thereof would have been considerably lowered.

It will be obvious that constructional details have been given purely by way of illustration and have no limiting character, both in regard to certain mechanical parts and in regard to the electric circuits. Modifications and adaptations could be made thereto without departing from the scope of the invention.

What is claimed is:

1. Magnetic film unit adapted to advance step-by-step a film fitted with marginal perforations and to exploit transverse tracks for the recording of coded characters, by means of continuously rotating magnetic heads, while the film is stationary, comprising in combination:

a rotative head support carrying on its periphery a number n of equidistant angularly and axially staggered writing heads, an equal number of equidistant angularly and axially corresponding staggered reading heads and position indexing members,

a cycling shaft supporting position indexing members, a synchronous electric motor,

coupling means so arranged that said motor continuously rotates said head support and said cycling shaft at angular velocities ω and $\omega/2$ respectively,

a film driving member arranged and adapted to be actuated in relation with said cycling shaft to effect, when ordered, a single-step advance of the film,

pulse generators coupled to said indexing members to generate reference signals indicative of the angular position of said magnetic heads and of the angular position of the cycling shaft,

an electric advance control device adapted to store a control signal and to supply an actuating signal to said driving member, and

logical memory and reciprocal control circuits co-operating, in dependence upon said pulse generators, with said writing and reading heads and with said advance control device, in such a manner that in an operating cycle corresponding to one revolution of the cycling shaft and divided into two phases of equal duration, a transducing (writing or reading) operation can be performed in the course of either one or the other of the phases of a cycle, and is systematically followed by a single-step movement of the film, which can be performed only in the course of the second phase, either of the same cycle or of the succeeding cycle.

2. Magnetic film unit according to claim 1, wherein said rotative head support comprises head recesses disposed to determine between two successive writing heads and between two successive reading heads an axial stagger equal to $(n-1)P/n$, P being the longitudinal spacing pitch of the perforations of said magnetic film, such that, in the course of one revolution of said head support, or phase, n transverse tracks of said films are successively scanned by said n writing heads and by said n reading heads.

3. Magnetic film unit according to claim 2, wherein there is mounted on said head support an indexing disc formed with a first series of notches and a second series of notches situated along its periphery, the unit comprising a first photoelectric cell and a second photoelectric cell, which cells are each disposed in operative relation with one of said series of notches, such that said first cell produces n indexing pulses relative to said writing heads and said second cell produces n indexing pulses relative to said reading heads.

4. Magnetic film unit according to claim 3, comprising one further cell and wherein said film driving member is adapted to be actuated by an electromagnet and in which said cycling shaft supports a masking disc arranged in operative relationship with said further cell to determine from the latter, a so-called "advance" pulse which defines the second phase of each cycle, said advance control

device being adapted to receive and store an advance order signal and connecting means being provided to transmit in such case said advance pulse to said electro-magnet.

5. An input-output element connected to the dispatching unit of a calculator and consisting of the combination of a number of magnetic film units with a control and selection unit, each film unit being adapted to advance step-by-step a film fitted with marginal perforations and to exploit transverse tracks of the film for recording coded characters by means of continuously rotating magnetic heads, while the film is stationary, each film unit comprising in combination:

a rotative head support carrying on its periphery a number n of equidistant angularly and axially staggered writing heads, an equal number of equidistant angularly and axially corresponding staggered reading heads and position indexing members,

a cycling shaft carrying position indexing members,

a synchronous electric motor,

a coupling means arranged in such manner that said motor continuously rotates said head support and said cycling shaft at angular velocities ω and $\omega/2$ respectively,

a film driving member situated and adapted to be actuated in relation with said cycling shaft to effect when ordered, a single-step advance of the film,

pulse generators coupled to said indexing members to generate reference signals indicative of the angular position of said magnetic heads and of the angular position of the cycling shaft,

an electric advance control device adapted to store a control signal and to supply an actuating signal to said driving member, and

logical memory and reciprocal control circuits co-operating in dependence upon said pulse generators, with said writing and reading heads and with said advance control device, in such manner that in an operating cycle corresponding to one revolution of the cycling shaft and divided into two phases of equal duration, a transducing (writing or reading) operation may be carried out in the course of either one or the other of the phases of a cycle, and is systematically followed by a single-step movement of the film which can be performed only in the course of the second phase, either of the same cycle or of the succeeding cycle.

6. An input-output element according to claim 5, wherein, for each film unit, said rotative head support comprises head recesses disposed to determine between two successive writing heads and two successive reading heads an axial stagger equal to $(n-1)P/n$, P being the longitudinal spacing pitch between the perforations of said magnetic film, such that in the course of one revolution of said head support, or phase, n transverse tracks of said film are successively scanned by said n writing heads and by said n reading heads.

7. An input-output element according to claim 6, wherein, for each film unit, said head support carries an indexing disc formed with a first series of notches and a second series of notches situated along its periphery, the unit comprising a first photoelectric cell and a second photoelectric cell, said cells being each disposed in operative relation with one of said series of notches, such that said first cell produces n indexing pulses relative to said writing heads and said second cell produces n indexing pulses relative to said reading heads.

8. An input-output element according to claim 7, wherein, in each of said film units, there is provided one further photoelectric cell, said film driving member is adapted to be actuated by an electro-magnet and said cycling shaft carries a masking disc arranged in operative relationship with said further cell to determine, from the latter, a so-called "advance" pulse (CA), which defines the second phase of each cycle, the said advance control

device being adapted to receive and store an advance order signal and connecting means being provided to transmit in such case said advance pulse to said electromagnet.

9. An input-output element according to claim 8 comprising:

selection circuits for establishing all the connections between one of said film units and said selection unit, a buffer register adapted for effecting the conversion from series to parallel and vice versa of the coded data received,

first transfer means adapted to convert and transmit the data read by said reading heads of a selected film unit to an input of said buffer register,

second transfer means adapted to transmit and convert data from an output of said buffer register to the writing heads of the selected film unit, and

control means, including an instruction validation register, connected to render operative said first transfer means or said second transfer means when an instruction has been received by said control unit.

10. An input-output element according to claim 9, wherein the film units are numbered, for example with even and odd numbers, and wherein at least one of these units, called the "master" unit, comprises a second further photoelectric cell and has its cycling shaft on which is mounted a second masking disc which determines, from said second further photoelectric cell two equally time spaced clock pulses per cycle, said master unit including another pulse generator which is adapted to process these pulses and to supply at two separate outputs a first clock pulse (H1) and a second clock pulse (H2) respectively.

11. An input-output element according to claim 10, wherein each of a number of "slave" film units, i.e. other than said "master" unit, is provided with a braking device controlled by an electromagnet and adapted to slow down by braking the shaft of its synchronous motor, as also with a braking control device which is adapted to energize said braking electromagnet and including a pulse coinci-

dence detector, which receives the aforesaid advance pulse (CA) indicating the angular position of its cycling shaft and which is connected to one of the outputs of said other pulse generator.

12. An input-output element according to claim 11, wherein at least one "slave" film unit, for example of even number, has its coincidence detector connected to receive said second clock pulse (H2) with the result that its motor is braked as long as the said advance pulse (CA) does not exactly coincide with said second clock pulse, until there is a difference of one phase between the cycle of the slave unit and the cycle of the master unit.

13. An input-output element according to claim 11, wherein at least one "slave" film unit, for example of odd number, has its coincidence detector connected to receive said first clock pulse (H1) with the result that its motor is braked as long as said advance pulse (CA) does not exactly coincide with said first clock pulse, until the cycles of the slave unit and of the master unit are in phase.

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