PATENT SPECIFICATION (11) 1 592 349

1 592 349

(21) Application No. 44608/76 (22) Filed 27 Oct. 1976 (19)
(31) Convention Application No's. 50/131534 (32) Filed 4 Nov. 1975
51/017487 21 Feb. 1976 in
(33) Japan (JP)
(44) Complete Specification Published 8 Jul. 1981
(51) INT. CL.^{3} D04B 7/26
(52) Index at Acceptance
D1C 1C2
G3N 1 282A 402

(54) A PROGRAM READING APPARATUS FOR A KNITTING MACHINE

(71) We, SILVER SEIKO CO., LIMITED, a Japanese Joint Stock Company of 51 Suzuki-cho 1-chome, Kodaira-shi, Tokyo, Japan 187, do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to a patterning system for a knitting machine, especially a hand-operated home knitting machine, and more particularly to a program reading apparatus for use in such patterning system for reading a patterning program on a program carrier to provide electric signals generally representing such patterning program to the system.

An electronically controlled patterning system for a knitting machine has been already proposed and is described in the specification of British Patent 1536745, in which an electromechanical needle selection means is controlled to select knitting needles in the needle bed of the machine in accordance with patterning instructions in the form of electric signals applied thereto. In such system, it is conventional that patterning instructions, which generally specify a patterning or needle selection program representative of a design pattern to be obtained on a knitted fabric, are originally prepared on a program carrier such as a design card on which the patterning program is represented as a design configuration marked out or drawn in continuous contour lines or by coloured areas. Conventionally, the patterning program on the program carrier is read by a suitable program reading apparatus and converted into electric signals representative of the patterning instructions and then recorded by a suitable data recording machine such as paper tape perforator or a magnetic tape or disc recorder on an appropriate record medium. Prior to a design knitting on the machine, the patterning program is read out from the record medium and is stored in a temporary electronic storage memory in the form of electrical digital signals representative of the patterning instructions. The signals stored in memory are recalled therefrom in response to movement of the machine carriage relative to knitting needles in the needle bed and then applied to the needle selection means to cause the needles to be selected in accordance with the original patterning or needle selection program.

When the electronically controlled patterning system is to be applied to a hand-operated home knitting machine, however, special regard must be paid to the fact that an ordinary machine operator is willing at any time whilst knitting to visually confirm that portion of the design pattern which is currently being knitted and that the one patterning program is realized normally on a single or a very small number of fabrics knitted on the machine while a patterning program is realized on a great number of fabrics on an industrial knitting machine for use in an industrial factory. Accordingly, the patterning system for a hand-operated home knitting machine is preferably constituted such that the program reading apparatus is mounted alongside the needle bed and the program carrier is fed on in the reading apparatus, an increment upon each directional movement of the carriage relative to the needle bed to enable the patterning program thereon to be subsequently read along a predetermined fixed line so as to obtain electric signals representative of a row of patterning instructions of the program to be stored in memory and that the signals thus stored are then recalled from memory during a subsequent course of knitting for needle selection in accordance therewith, thereby eliminating an intermediate storage or record means such as a tape perforator as mentioned above.

An object of the present invention is thus to provide an improved program reading apparatus for reading a patterning program on a program carrier to provide electric signals generally representing the patterning program, which is designed with an electronically controlled patterning system in a knitting machine and is most appropriate for use with such system in a hand-operated home knitting machine.

According to the present invention there is provided a program, reading apparatus for reading a patterning program on a program carrier to provide electric signals in accordance with the readings and to provide strobe pulses which are used to sample the serial signals to provide patterning instruction signals which generally represent the patterning program and are adapted to control patterning mechanisms of a knitting machine, comprising a frame, a holder supported on said frame for rotation about an axis and adapted to movably carry a program carrier thereon, first bidirectional drive means including an electromagnetic means for rotating said holder a predetermined angle about said axis to incrementally feed the program carrier thereon in one or the other direction, a guide bar mounted on said frame and extending parallel with said axis, a slidable member slidably mounted on said guide bar, a scanning sensor mounted on said slidable member, second bidirectional drive means including an electric motor for driving said slidable member from one to the other stroke end and vice versa thereby to effect the reading of the program on said program carrier along a predetermined scanning line to provide serial electric signals in accordance with the reading, pulse generator means for generating an interval pulse upon every incremental movement of said slidable member thereby to provide a predetermined number of strobe pulses which are used to sample said serial signals during a directional movement of said slidable member from one to the other stroke end or vice versa, and control means including a control circuit for controlling said first and second drive means to effect feeding of the program carrier in a selected direction and scanning by said scanning sensor.

Preferably, a simple linear motor is employed as the electric motor in the second bidirectional drive means in order to attain an exceedingly high speed of scanning by the scanning sensor and also a very high responsiveness in such scanning. The linear motor includes a coil wound on a bobbin mounted on the slidable member and a permanent magnet placed on the frame parallel with a guide bar for co-operation with the coil on the slidable member. Upon energization of the coil, the slidable member is moved in one or the other direction in accordance with the direction of the electric current through the coil.

The first drive means may include as the electromagnetic means a pair of electromagnets each adapted to operate a pawl engageable with a ratchet wheel connected to the holder. More preferably, the electromagnetic means in the first drive means may be a bidirectional stepping motor having its output shaft connected to the holder in order to attain a relatively high speed of repetitive feeding of the program carrier over a multiple of increments.

Where the program reading apparatus is provided with a cover member to shield the appropriate components of the apparatus in order to prevent them from being unfavourably influenced by environmental conditions such as might cause incorrect readings by the scanning sensor, such cover member would prevent the machine operator visually observing the portion of the program carrier along the scanning line. In order to facilitate such visual confirmation of the portion of the program carrier on the reading apparatus one example of the program reading apparatus according to the present invention is arranged such that upon a first depression of a key provided on the apparatus the program carrier on the holder is automatically fed in a predetermined fixed direction a predetermined fixed distance to bring that portion of the program carrier which has been coincident with the scanning line into coincidence with a reference or inspection line outside the cover member for visual observation by the machine operator, and upon a subsequent second depression of the key the program carrier is fed in the reverse direction the predetermined distance to bring that portion of the program carrier again into coincidence with the scanning line to enable a subsequent scanning of the program carrier along the scanning line.

In order to facilitate handling of a program carrier on the holder, the program reading apparatus may be arranged so that the feeding of the program carrier is specified in response to the readings of an instruction mark represented thereon. With a pair of instruction marks appropriately represented on the program carrier for specifying the direction in which the program carrier is to be fed, the feeding direction of the program carrier will be automatically reversed at either horizontal stroke end of a unit design, i.e. a patterning program so that a vertical image of the unit design can be easily obtained on a knitted fabric being produced on the knitting machine associated with the program reading apparatus.

Where it is intended to apply the program reading apparatus to a hand-operated home knitting machine, the apparatus may be incorporated in the machine and disposed alongside the needle bed of the machine such that it is activated in a synchronized relation with the movement of the carriage on the needle bed.

Fig. 1 is a schematic perspective view of a hand knitting machine including a program reading apparatus in accordance with the invention,

Fig. 2 is a front view of one example of a feeding device and a knitting program card to be loaded thereon;

Fig. 3 is a vertical cross section of the knitting machine including the feeding device, a scanner, and a carriage;

Fig. 4 is a plan view of the feeding device of Fig. 2;

Fig. 5 is a side elevation view of the feeding device, particularly a driving mechanism, of Fig. 2;

Fig. 6 and 7 are cross sections taken on line VI-VI and VII-VII in Fig. 2, respectively;

Fig. 8 is a plan view of part of a needle bed and a carriage mounted thereon, the right half of the carriage showing mechanisms on the upper portion of a base member, and the left half showing a cam mechanism under the base member;

Fig. 9 is an enlarged cross section of a switch taken on the center line CL in Fig. 8;

Fig. 10 is a block diagram illustrating an input function part of a control means for processing data resulting from the scanning of the program card and storing the data in a memory;

Fig. 11 is a circuit configuration illustrating an information processing part of the input function part of Fig. 10, including an effective scanning data forming circuit, an effective sampling pulse forming circuit, a pulse separation circuit, a unit number setting circuit, and a function discriminator circuit;

Fig. 12 is a time chart illustrating operations of the respective components of Fig. 11, in connection with information marks on the program carrier;

Fig. 13 is a circuit configuration illustrating a control part of the input function part of Fig. 10, including an instruction circuit and a control circuit;

Figs. 14 and 15 are time charts illustrating operations of the respective components of Fig. 13;

Fig. 16 is a block diagram illustrating an output function part of the control means for reading the stored data and sending needle selection signals;

Fig. 17 is a time chart illustrating operations of the respective components of Fig. 16;

Figs. 18 and 19 are plan views of lower parts of a second and a third program card different from the first program card of Fig. 2, respectively;

Fig. 20 is a schematic perspective view of a modified control panel;

Fig. 21 is a front view, similar to Fig. 2, of a modified feeding device and a scanner utilized with the control panel of Figure 20;

Fig. 22 is a vertical cross section of the feeding device and scanner of Fig. 21;

Fig. 23 is a block diagram illustrating an electrical construction of the scanner; and

Fig. 24 is a time chart illustrating operations of the respective components of Fig. 23.

Referring to the drawings, Fig. 1 shows a schematic perspective view of a hand knitting machine to which a first embodiment of a program reading apparatus according to the invention is applied. In this specification, the side of the knitting machine facing the operator is called the front side and the opposing side, the rear side.

A body of the knitting machine generally designated by character X has a needle bed x. Behind the needle bed x, the body X is provided with a reading device A which comprises feeding means capable of carrying and feeding an information record carrier in the form of a knitting program card 1 and scanning means for optically scanning the information recorded on the card (not shown in Fig. 1) and a control box B which comprises various manually operable buttons arranged on a control panel 2 for manually operating the corresponding mechanisms (to be described hereinafter) and various electric and electronic circuits built in under the panel. On the needle bed x is positioned a pair of boundary members 3ℓ and 3r which are shiftable in the longitudinal direction of the needle bed x. A range in which needle selection is effective (needle selection range) can be defined by setting the boundary members 3ℓl and 3r at desired positions on the needle bed x.

A carriage Y is mounted for lateral sliding movement on the needle bed x. The carriage Y has a base member 4 and includes a cam mechanism known per se and provided on the underside of the base member and a pair of (left and right) needle selection mechanisms (not shown) also provided on the underside of the base member with a predetermined spacing therebetween along the longitudinal direction. Both of the left and right needle selection mechanisms are adapted to select necessary needles from the needles aligned in the needle bed x by the action of electromagnetic force in response to electric signals obtained by scanning a knitting pattern on the program card 1.

The reading device A is adapted to scan the card 1 automatically by means of the scanning means immediately after the direction of movement of the carriage has been reversed and to generate the corresponding electric output signals. The output of the reading device A is connected to a suitable electronic component built in the body X, in which the electric signals are processed in a suitable form. Further, the electrical connection between the electronic component in the body X and other electronic components of the left and right needle selection mechanisms is provided by a cord 6 suspended from a tension member 5 for giving proper tension to a yarn. Accordingly, signals which are obtained by scanning the card 1 are processed and transmitted to the needle selection mechanisms through the associated electronic components and the cord 6. The boundary members 3ℓ and 3r, and the needle selection mechanisms are operatively connected so that even when the carriage Y is traversed to the left or the right beyond either of the boundary members 3ℓ and 3r, only the needles present between the boundary members may be subjected to needle selection (except for the needles at rest positions).

A significant construction of the reading device A will be described below, referring to Figs. 2 through 6.

The reading device A as a whole is mounted on a frame 7 (this frame consists of a plurality of members in practice, but is herein regarded as an integral assembly) behind a standing wall x_1 disposed at the rear end of the needle bed *x* (see Fig. 3). As described above, the reading device A comprises the feeding means and the scanning means. First of all, the program carrier feeding mechanism, that is, the feeding means for carrying and feeding the knitting program card 1 will be explained.

Between lateral side walls 7′ of the frame 7 are supported for rotation a lower shaft 12 and an upper shaft 13 disposed parallel thereto. The upper and lower shafts 12 and 13 are provided with geared pulleys 10 and 11 at either end thereof, respectively. Timing belts 8 are installed on the respective adjoining pulleys 10 and 11 so as to enclose the outer opposing peripheries of the pulleys. The inner surface of each belt 8 is provided with teeth which ensure the engagement with the pulleys so that the rotation of the shaft 12 is synchronously transmitted to the belts 8. Further, each belt 8 is provided at the outer surface with protrusions 8′ which will engage with perforations 1′ aligned at the left and right sides of the card 1. This means that the belts 8 are sprocket belts and serve as feeding members to feed the card 1 in the direction of the perforation alignments upon the rotation of the lower shaft 12.

In order to guide the program card 1, a card-guiding plate 9 is longitudinally extended between the side walls 7′ of the frame 7 and is transversely curved in a circular shape concentric with the large pulleys 10 in the lower half thereof. Thus, it is nearly U-shaped as shown in the cross sectional view of Fig. 3. To the same end, a card-supporting plate 24 which is laterally extended between the side pulleys 11 and card-supporting sub-plates 24′ which are positioned outside the pulleys 11 and are flush with the plate 24, but have only a small length in the lateral direction, are pivotally mounted on the upper shaft 13. As shown in Fig. 3, the surface of the supporting plate 24 presents a slant plane circumscribing the front peripheries of the pulleys 10 and 11. In addition, card-restraining members 25 adapted to lightly restrain the left and right side edges of the card 1 against the sub-plates 24′, respectively, are pivotally mounted on the shaft 12. The right restraining member 25 is shown in Fig. 6 which is a cross section taken on line VI-VI of Fig. 2. Each restraining member 25 can be pivotally moved or opened and closed with respect to a pivot point on the axis of the shaft 12 and is usually biased toward the rear side or in the closing direction by a spring 26 bridged between the shaft 13 and a jaw of the restraining member.

The loading of the knitting program card 1 on the above-described feeding means is achieved by placing the card 1 from hehind the body X on the supporting plate 24 and the sprocket belt 8 and inserting both sides of the card between the supporting sub-plates 24′ and the restraining members 25. It is necessary to ensure the correct engagement of the left and right perforations 1′ of the card 1 with the protrusions 8′ of the sprocket belts 8. Thereafter, the card 1 is transferred by the sprocket belts 8 along the curved inner or upper surface of the guiding plate 9, moved upwardly along the flat surface of the guiding plate 9 and then released. In the course of card transfer, the card 1 is lightly pressed against the sub-plates 24′ by the restraining members on both sides so that the card is moved along the slant plane of the supporting plate 24 in close contact therewith. When viewed from the direction of Fig. 3, the card 1 is held and fed in an oblique, nearly U-shaped manner.

A mechanism *a* for driving the feeding means is shown in Figs. 2, 4 and 5.

The lower shaft 12 is extended over the side wall 7′ at the right end in Figs. 2 and 4. To this extension of the shaft 12 is fixed a ratchet wheel 14 which is one of components of the driving mechanism *a*. On the front and rear sides of the ratchet wheel 14 there are positioned a forward feeding member 15 and a backward feeding member 15′ which are connected to plungers 17 and 17′ of electromagnets 16 and 16′ by pivots 18 and 18′, respectively. The feeding members 15 and 15′ are upwardly biased by springs 19 and 19′ which are bridged between the pivots 18 and 18′ and pins fixed to the frame, respectively, and also biased to each other by a spring 20 which are bridged between jaws of the members, so that the feeding members are normally lifted to an upper retracted position where extreme ends or pawls 21 and 21′ of the members may not engage with the ratchet wheel 14.

The ratchet wheel 14 may be driven forward or backward by alternatively actuating the electromagnet 16 or 16′. Upon actuation of one of the electromagnets through the application of an electric pulse signal, the corresponding plunger 17 or 17′ is lowered. Accordingly, the corresponding feeding member 15 or 15′ is lowered along guide members 22, 23 or 22′, 23′ and is eventually engaged with the ratchet wheel 14. As a result, the ratchet wheel is advanced by one tooth. Accordingly, if the electromagnet 16 is actuated, the shaft 12 is rotated counterclockwise in Fig. 3 so that the card 1 is fed forward by an increment corresponding to a one-tooth advance of the ratchet wheel 14. On the other hand, if the electromagnet 16′ is actuated, the card is fed backward by the same increment.

Instead of the above-described electromagnets 16 and 16′ and the associated linkages, a bi-directional pulse or step motor may be employed or rather be preferable for driving the shaft 12. (This embodiment will be described hereinafter).

Now, the scanning means for scanning the card 1 supported in the above-described manner will be explained.

Between the front edges of the side walls 7′ are extended a pair of guide bars 27 and 28 which are positioned one above the other and parallel with the shafts 12 and 13. A scanner *b* is mounted for sliding movement on these guide bars 27 and 28.

The scanner b comprises a body in the form of a runner 29 having a through hole 29_1 which is slidably fitted on the upper guide bar 27 and a bobbin 30 which is integrally connected to the lower portion of the runner 29 and is also slidably fitted on the lower guide bar 28.

The bobbin 30 has a coil 31 wound thereon. Further, an elongated permanent magnet 32 is placed just below the lower guide bar 28 in parallel relation therewith and is attached to the horizontal part of the frame 7 so as to extend between the side walls 7′.

This permanent magnet 32 has its north pole at the upper side and its south pole at the lower side along the entire length thereof. The lower guide bar 28 and the horizontal part of frame 7 underlying the magnet 32 are made of ferro magnetic material. Upon supplying electric current to the coil 31, this current traverses the constant magnetic field generated by the permanent magnet 32. The electromagnetic force resulting from the interaction between the coil and the magnet has the function of moving the runner 29 and hence the scanner b to the left or the right along the guide bars 27 and 28, depending upon the direction of the current flow in the coil 31.

In other words, the coil 31 and the permanent magnet 32 constitute a kind of linear motor in which the magnet 32 serves as a stator.

At the positions corresponding to the left and right ends of the permanent magnets 32, respectively, a left and a right limit switch 33ℓ and 33r for switching the direction of current flow to be supplied to the coil 31 are provided as shown in Fig. 7 which is a cross section taken on the line VII-VII of Fig. 2.

The left limit switch 33ℓ is turned on when the scanner *b* runs to the left and collides with this switch, while the right limit switch 33r is turned on when the scanner *b* runs to the right and collides with this switch. The scanner *b* is automatically moved in a reciprocating manner between the left and right limit switches 33ℓ and 33r. Accordingly, the left and right limit switches serve to define the ends of the stroke of the scanner. As will be described in detail hereinafter, the scanner *b* is normally positioned at the left stroke end as its starting position. Upon the arrival of an actuating signal in response to the reversal of the carriage Y, electric current is supplied to the coil 31. At this instant, the scanner *b* starts to move and runs at high speed from the starting position to the right stroke end, instantaneously reverses its moving direction at this stroke end and returns to the starting position at the same speed. In this manner, the left and right limit switches 33ℓ and 33r also serve as detecting means to detect whether the scanner *b* is in the starting position or in the reverse position (right stroke end).

The runner body 29 of the scanner *b* has an upper extension 29′ which is extended obliquely to the rear, first upward and then downward, as shown in Figs. 2 and 3. The extreme portion of the extension 29′ is placed in close relation to the slant plane of the card-supporting plate 24. A photoelectric sensor *c* is built in this facing portion of the extension 29′, which sensor comprises a light emitting element capable of illuminating the surface of the card 1 and a sensing element capable of receiving the reflected light from the surface and converting it into an electrical signal (these elements are not shown in the drawings because they are well known in the art).

While the scanner *b* runs along the guide bars 27 and 28, the photoelectric sensor *c* scans the card 1 supported on the plate 24 along a straight path or scanning line. In this specification, the photoelectric sensor *c* is referred to as a scanning sensor, hereinafter.

In this embodiment the reading device is of an open construction. A transparent hood 200 of a suitable synthetic resin is placed on the reading device A, as shown in Fig. 1, so that the operator can visually confirm the part of the card 1 which is in the scanning position.

The knitting program card 1 which can be employed as the knitting information record carrier according to the invention will be described with reference to Fig. 2. The card 1 may be a sheet of ordinary white paper or a semi transparent film of synthetic resin such as polyester. This card 1 is provided with a number of perforations 1′ aligned at the both sides thereof. The white surface portion of the card between the left and right perforations 1′ includes a knitting pattern region 1p where a desired knitting pattern representing knitting pattern information is recorded and a function mark region 1f where desired function marks representing knitting function informations are recorded. Both regions are divided into sections. In a preferred example, and as shown, horizontal and vertical lines are printed in a color which the light sensing element cannot discriminate. The surface portion of the card also includes a feed control mark region 1c positioned at the left end of the knitting pattern region 1p, on which region a plurality of feed control marks 34 representing information for controlling the feeding of the card through reading by the scanning sensor *c* have been printed. For example, these marks may take the form of comparatively thick, black elongated lines which are arrayed in parallel at a constant interval in the direction of alignment of the perforations 1′. Spaces between the regions 1p and 1f and the regions 1p and 1c are blank.

The knitting pattern region 1p is so divided that the vertical lines divide the adjoining stitches and the horizontal lines divide the adjoining knitting rows, the vertical and horizontal lines defining unit sections. Below the region 1p, numerals representing the number of stitches are printed in the non-sensitive color.

More illustratively, each section in the knitting pattern region 1p corresponds to one stitch. Each column of sections aligned in the vertical direction corresponds to a wale, while each row of sections aligned in the horizontal direction corresponds to a course (knitting row). For example, it is assumed that the so-called unit pattern including *n* stitches or wales as a unit group is knit. In this case, the leftmost vertical line or refernece line and the n'th vertical line spaced apart rightward therefrom are regarded as boundary lines. A desired picture (knitting pattern) corresponding to the unit pattern can be drawn on an area defined between the boundary lines by means of a suitable drawing tool such as a pencil. In the drawing, such a picture is inked in black all over.

For example, when an operation for knitting the unit pattern consisting of twelve stitches in a horizontal row is intended by selecting twelve needles as a unit group, the corresponding picture can be drawn on an area defined between the reference line and the twelfth vertical line spaced apart therefrom. Of course, the profile of the picture should be within the predetermined area.

When drawing the picture, it is not necessary to ink in the unit sections enclosed within the profile of the picture one by one. It may be preferable to ink in the unit sections all together, because each unit section will be accurately sampled out during the scanning of the pattern, which will be explained hereinafter.

The function mark region 1f is also divided by horizontal lines in line with the corresponding horizontal lines in the knitting pattern region 1p and vertical lines parallel with the vertical lines in the region 1p. The number of rows or number of unit sections in a column in the function mark region 1f is equal to that in the knitting pattern region 1p, while the number of columns or number of unit sections in a row is less than that in the region 1p. In this example, the knitting pattern region 1p has 36 unit sections in a row, while the function mark region 1f has only 4 unit sections in a row.

In Fig. 2, the region 1f has four columns of unit sections in which the leftmost column is assigned for programing the forward feed of the card 1, the adjoining column is assigned for programming the backward feed of the card and the remaining two right-hand columns are assigned for programming other desired functions, for example, switching on a buzzer to inform the need to change the yarn or the initiation or completion of needle selection. If a certain function is desired, an appropriate unit section in the function mark region 1f may be marked or inked in black.

As described above, the region 1c contains feed control marks 34 which are aligned on the extensions of the horizontal lines passing the centers of sections in the respective rows of the knitting pattern region 1p. The card is automatically fed row by row in accordance with the marks 34.

In addition to the above three record regions, there is another region in the card 1. This is a unit number region 1s for programming the unit number of needles to be selected, which is printed below the knitting pattern region 1p in the non-sensitive color.

The region 1s includes a required number of squares 35 aligned horizontally at a certain interval. Each square is appointed to a different predetermined unit number of needles. The unit number is increased by a predetermined number from left to right one after the other. Numerals representing the unit are printed below the respective squares 35 in the non-sensitive color. In this case, the region 1s has six squares 35 in total. The leftmost square is appointed to a unit number of needles to be selected of "6", and the remaining squares from left to right are appointed to unit numbers of "12", "18", "24", "30" and "36", respectively, by an increment of 6.

This unit number region 1s is also scanned by the scanning sensor *c* of the scanner *b* so that the unit number of needles is determined by the marked square. For example, when the square appointed to a unit number of "12" is inked in black as shown in Fig. 2, pattern knitting is worked according to a unit pattern consisting of 12 needles.

The card 1 further includes an instruction mark 36 which is positioned at the left hand end of the unit number region 1s. This instruction mark 36 is intended to send a preparatory signal for changing the associated electronic circuit into a state ready to set the unit number.

The instruction mark 36 may be, for example, an elongated black strip which is positioned in the extension of the squares 35 of the unit number region 1s in the horizontal direction and straight below the feed control marks 34 of the region 1c in the vertical direction. The strip 36 has a width equal to that of the squares of the unit number region 1s and a length which is longer than that of the feed control marks 34 at the right side by the distance between the regions 1c and 1p.

The card 1 involving all the necessary instructions and informations has been explained. As described in the foregoing, the card 1 is inserted in the holding means so as to engage with the sprocket belts 8ℓ and 8r. When the scanner *b* automatically travels between the starting position and the reverse position, the instruction mark 36 and the inked square in the unit number region 1s, or the feed control marks 34 in the region 1c and informations in the region 1p and 1f are be read. In this connection, it should be ensured that the scanning sensor *c* moving along its straight scanning line scans the card 1 between vertical lines Pℓ and Pr shown in Fig. 12.

It is necessary to sample the electric output signals from the scanning sensor *c* to obtain desired signals. The mechanical construction of a sampling mechanism which is used to sample the above-described output signals will now be described with reference to Figs. 2 and 3.

Behind the runner 29 of the scanner *b*, a linear encoder in the form of an elongated plate 37 having a mirror-like (reflective) front surface is mounted on the frame 7, the plate 37 being parallel with the guide bars 27 and 28.

The linear encoder 37 is perforated with three kinds of slits 38s, 38p and 38f in alignment. One slit 38s for obtaining a signal for sampling only the instruction mark 36 on the card 1 is provided at a position corresponding to the blank space between the feed control mark region 1c and the knitting pattern region 1p. A predetermined number (in this case, 120) of slits 38p for obtaining signals for sampling the knitting pattern inked in the region 1p are successively provided from a position corresponding to the leftmost column of sections in the region 1p to a predetermined position extending beyond the rightmost line in the region 1p, the leftmost slit 38p being adjacent to the slit 38s and the subsequent parallel slits 38p being aligned in a straight line at a predetermined interval. Further, a predetermined number (in this case, 4) of slits 38f for obtaining signals for sampling the function marks inked in the region 1f are successively provided in parallel with the preceding slits 38p, the leftmost slit 38f being adjacent to the rightmost slit 38p and each slit 38f corresponding to a column of sections in the function mark region 1f.

The runner 29 of the scanner *b* is provided with a sampling sensor *d* at the rear side thereof. This sampling sensor *d* is a photoelectric sensor for optically reading the above-described three kinds of slits 38s, 38p and 38f and consists of an emitting element capable of emitting light onto the reflective surface of the linear encoder 37 and a sensing element capable of receiving the reflected light from the surface and converting it into an electric signal (these elements are not shown in the drawings because they are well known in the art).

The sampling sensor *d* is so designed that it can produce output signals or sampling pulses corresponding to the slits 38s, 38p and 38f when the scanner *b* travels along the guide bars 27 and 28.

The number of the slits 38p for obtaining signals for sampling the knitting pattern is 120 so as to obtain 120 sampling pulses in this example, because even a card including "60" or "120" columns of sections in the knitting pattern region 1p (see, Figs. 18 and 19) as well as the above-described card 1 including "36" columns may be used.

The reading device according to the invention is mechanically constructed in the above-described manner. The reading device is electrically so constructed that the driving mechanism *a* and the scanner *b* in the reading device A may be started in response to the movement of the carriage Y. More illustratively, the scanner *b* is started when the forward one of the needle selecting mechanisms Fℓ and Fr built in the carriage Y (and adapted to select needles during the after-reversal movement of the carriage Y) reaches a needle selection range after the carriage Y has reversed its direction of movement. Immediately after the scanner *b* has completed its scanning operation the driving mechanism *a* is started.

Fig. 8 is a plan view of the carriage Y, in which the right half shows mechanisms on the upper surface of the base plate 4 (a cover has been taken away) and the left half shows mechanisms under the base plate (the base plate has further been taken away). Fig. 9 is an enlarged cross section taken on the center line CL of Fig. 8.

The carriage Y is provided with a switching mechanism E at the rear center thereof. This switching mechanism E responds to the reversal of the carriage Y and has the following constructioin.

To the rear center of the base plate 4 of the carriage Y is secured a rectangular box-like frame 39. A switch starter 40 is loosely fitted to the top of the frame 39 so that the starter may reciprocably slide along the lateral walls of the frame 39 within a predetermined range. The switch starter 40 comprises a T-shaped connecting member 41 adapted to slide along the top surfaces of the frame 39 and a magnet piece 42 securely interposed between a pair of magnetic plates 43_1 and 43_2. The connecting member 41, the magnet piece 42 and the magnetic plates 43 are firmly secured to form an integral body. The lower ends of the two magnetic plates 43_1 and 43_2 are extended downwardly through an elongated opening 4′ formed in the base plate 4 and another elongated opening 44′ formed in a slide pipe 44 which has a known structure and is secured to the base plate 4, and terminated at the position adjacent to a carriage guide rail 45 which has a known structure and is longitudinally placed on the needle bed *x*. The extreme lower ends of the magnetic plates 43 are always in contact with the rail 45 by magnetic attraction because the plates 43 are magnetized under the influence of the magnet 42 and the rail 45 is made of magnetic material.

On the other hand, a micro-switch *e* consisting of three switch parts e_1, e_2 and e_3 is secured to the rear side of the frame 39. A lever *e*′ of the switch *e* is extended through a window 39′ formed in the rear wall of the frame 39 and is inserted into an opening 43′ formed in the rear magnetic plate 43_2.

As described above, the switch starter 40 is permitted to freely slide along the side walls of the frame 39 within the predetermined lateral range and is attracted to the carriage guide rail 45. The starter 40 is first relatively moved in a sliding manner up to the right sliding limit in the frame 39 (more accurately, the starter is stationary and the frame is moved to the left) and is then carried to the left together with the frame by the carriage Y when the carriage Y is moved to the left. Alternatively, the starter 40 is first relatively moved in a sliding manner up to the left sliding limit in the frame 39 and is then carried to the right together with the frame by the carriage Y when the carriage Y is moved to the right. The movement of the switch starter 40 in relation to the frame 39 turns the lever *e*′ to the right or the left to actuate the switch *e*.

The first switch part e_1 of the switch *e* serves to detect the moving direction of the carriage Y. As shown in Figs. 15 [I] and 17 [II], this switch part e_1 produces a two-value electric signal which represents the moving direction of the carriage Y and changes from "H" to "L" or conversely in response to the reversal of the moving direction of the carriage Y. It is obvious that, if the carriage Y is once stopped and then moved in an opposite direction, the signal will be changed after the carriage has started to move.

The second switch part e_2 of the switch *e* serves to selectively supply needle selection signals in the form of electric current, which has been transmitted from the scanner *b* to the carriage Y through the cord 6, to work one of the needle selecting mechanisms Fℓ and Fr. Each of the needle selecting mechanisms Fℓ and Fr comprises an electro-magnet 46, a pair of magnetic members 47 and 48 which form a magnetic system with the electromagnet 46 and a butt N′ of a needle and are magnetically excited in response to the excitation of the electromagnet 46 to selectively retract the associated needle by a short distance, and a permanent magnet 52 for subsequently retracting the needle by an additional distance. The structure of the needle selecting mechanism is substantially the same as that disclosed in the specification of the above-described Patent, except that some modifications are made to several members including magnetic members 47 and 48. Besides this, a cam mechanism installed in the carriage Y including side cams 50 is substantially the same as that disclosed in the above-described Patent Application.

The third switch part e_3 is provided to selectively transmit electric output signals from a pair of mechanisms for detecting the needle selection range Gℓ and Gr (to be described in detail hereinafter) to the associated circuit through the cord 6 according to the direction of movement of the carriage Y. The needle selection range detecting mechanisms Gℓ and Gr are symmetrical in construction with respect to the center line CL of the carriage Y as well as the other mechanisms mounted on the carriage Y. In Fig. 8, only the right detecting mechanism Gr is illustrated in detail.

Each of the mechanisms Gℓ and Gr comprises a crank arm 53 which is mounted for movement in a horizontal plane about a pivot 54 on the base plate 4. One end of the crank arm 53 is connected to a lever of a microswitch 56 attached to the base plate 4 so that the switch 56 is turned on or off depending upon the pivotal movement of the crank arm

53. To the other end of the crank arm 53 is anchored a pin 55. This pin 55 is extended from the underside of the arm 53 downward through an opening 4″ formed in the base plate 4 so as to engage with the boundary members 3ℓ and 3r shiftably positioned on the needle bed x (see Fig. 9).

The boundary members 3ℓ and 3r serve to define the range in which a desired pattern is to be realized in a knitted fabric. Needles N are fitted in side-by-side relation on the needle bed x. Either of the boundary members 3ℓ and 3r is positioned on the needle bed x so that a given mark 3_6 on the member may coincide with a boundary between the outermost one of the working needles within the portion where the pattern should be knitted or the range where the needle selection should be effected and the adjacent one of the remaining needles. In this condition, a desired number of needles N present between the marks 3_6 on the boundary members 3ℓ and 3r are subjected to selection.

The boundary members 3ℓ and 3r not only serve to define the pattern knitting range, but also function as switch starters in combination with the mechanisms Gℓ and Gr.

Each of the boundary members or switch starters 3ℓ and 3r comprises a body which has a cam groove 3_1 extending laterally from one end to the other on the upper surface, a plurality of projections 3_2 extending downward from the front underside so as to tightly fit into needle paths x_2 from about, and a plurality of butt-receiving grooves 3_3 formed in the front side so as to receive butts N′ of needles N in a snug fit manner, respectively. The starters 3ℓ and 3r can be fixed at desired positions on the needle bed x by fitting the projections 3_2 into the needle paths x_2. Of course, the cam grooves 3_1 of the two starter bodies are symmetrical with each other in this case. That is, in the left switch starter 3ℓ, a front and a rear cam portion 3_4 and 3_5 which form a front and a rear side wall of the cam groove 3_1 are situated at the left and the right, respectively, while vice versa in the right switch starter 3r.

When the carriage Y is moved to the left or right, the pins 55 of the micro-switches 56 of the switch mechanisms Gℓ and Gr are engaged with the cam grooves 3_1 of the switch starters 3ℓ and 3r and are guided along the cam portions 3_4 and 3_5. The micro-switches 56 are so set that the switches are turned on when they are within the range defined between the switch starters 3ℓ and 3r and turned off when they are out of the range.

It is to be noted that the left and right pins 55 are positioned in the rear extension of the needle selection performing points F′ of the left and right needle selecting mechanisms Fℓ and Fr. Accordingly, the left and right switch mechanisms Gℓ and Gr perform their switching action when the selection performing points F′ of the needle selecting mechanism Fℓ and Fr reach the positions on the needle bed x which correspond to the switch starters 3ℓ and 3r, respectively. As shown in Fig. 17 [III] and [IV], the left and right switch mechanisms Gℓ and Gr produce electric output signals which are changed from "H" to "L" or vice versa. By the selective action of the third switch part e_3 of the micro-switch e, only the effective signals which correspond to the working one of the needle selecting mechanisms Fℓ and Fr are derived among the entire output signals from the left and right switch mechanisms Gℓ and Gr.

As shown in Fig. 17 [V], the third switch part e_3 for instructing the effective needle selection range is so designed that it produces an output signal "H" representing the effective needle selection range when the needle selection performing point F′ of working one of the needle selecting mechanisms Fℓ and Fr which is ahead of the other in the moving direction of the carriage Y is within the range defined between the left and right switch starters 3ℓ and 3r, or produces an output signal of "L" when the needle selection performing point F′ is out of said range. Only when the output signal "H" is given, it is possible to selectively control the excitation and non-excitation of the electromagnet 46.

The micro-switch e further comprises a fourth switch part, not shown. This fourth switch part is adapted to selectively derive outputs from a pair of timing pulse generators Hℓ and Hr for producing timing pulses representing the movement of the carriage Y. The timing pulse generators Hℓ and Hr may comprise the same types of photoelectric sensor as the above-described photoelectric sensors c and d. The photoelectric sensors Hℓ and Hr are attached to the rear side of the base member 4 of the carriage Y at positions corresponding to the respective left and right needle selecting mechanisms Fℓ and Fr (see Figs. 3 and 8). In relation to the sensors Hℓ and Hr projecting rearwardly from the base member 4, the opposing standing wall x_1 disposed at the rear side of the needle bed x is provided with a number of slits x_3 corresponding to needle paths x_2 respectively. The photoelectric sensors Hℓ and Hr moving together with the carriage Y can scan and read the slits x_3 as a linear encoder and produce timing pulses corresponding to the movement of the carriage Y as shown in Fig. 17 [I].

Among the timing pulses generated from the left and right timing pulse generators Hℓ and Hr, only the timing pulses which correspond to the working one of the needle selecting mechanisms Fℓ and Fr are derived as an effective output by means of the fourth switch part of the switching mechanism E.

Now, the operation of the knitting

machine will be described.

It is assumed that preparatory knitting operations including loose course knitting have been made by operating the carriage Y in the conventional manner and the knitting machine is just ready for knitting pattern stitches. The carriage Y is in a stationary state on the needle bed *x* at the left or right thereof outside a group of operative or working needles. Further, the left and right boundary members 3ℓ and 3r are put in desired positions on the needle bed *x*, respectively.

Under these conditions, first of all, the operator manually positions in the feeding means the pattern program card 1 on which the necessary information and patterns have been drawn or inked in. By manually rotating the ratchet wheel 14 counterclockwise, the card 1 is forwarded until the lateral center line of the instruction mark 36, that is line P_1-P_1 on the card shown in Fig. 12, reaches a position located substantially opposite to the scanning sensor *c* of the scanner *b* in the starting position.

Thereafter, the operator turns on a power switch (not shown) and pushes predetermined buttons arranged on the control panel 2 and then a start button CB. An electric circuit associated with these switches will be explained hereinafter. Necessary instructions are sent so that the driving mechanism *a* and the scanner *b* automatically perform predetermined operations in a predetermined order. As a result, the relevant circuit is ready for the operation of selecting the needles which are required for the carriage Y to knit the first row of the pattern. The subsequent operations of the program providing system are as follows;

1. The card 1 is fed by an increment in either direction.

2. The scanner *b* moves to the right, reverses its moving direction and returns to its starting position. In accordance with this reciprocal movement, the sensor *c* scans the unit number region 1s and reads the information in the form of an inked square, and hence, the unit number of needles to be selected is set or stored in the relevant circuit (memory).

3. The card 1 is fed forwardly until the sensor *c* can scan and read the control mark 34 in the first row.

4. The scanner *b* reciprocates again. In accordance with this, the sensor *c* scans the first row sections in the knitting pattern region 1p and the function mark region 1f and hence, signals including information concerning the needles selected during the knitting of the first row are sent and stored in an erasable temporary storage or memory in the relevant circuit.

Next, the conventional operations necessary prior to the pattern knitting are to be performed. For example, a desired combination yarn is threaded into a known combination yarn-feeder or a second yarn feeder fixed to the carriage Y. Thereafter, the operator can traverse the carriage Y along the needle bed x including the operative needles beyond the left and right boundary members 3ℓ and 3r, in a reciprocating manner. In the left to right and right to left movement of the carriage Y, only when the needle selection performing point F′ of the working one of the needle selecting mechanisms Fℓ and Fr in the carriage Y is between the boundary members 3ℓ and 3r, will a needle selection signal which has been stored in the memory as described above be read out from the memory in a predetermined order each time the carriage Y is moved by the spacing between the two adjoining needles (see the specification of the above-described Patent.). The thus derived signals are sent to the working one of the needle selecting mechanisms Fℓ and Fr, which performs the instructed needle selection. On the other hand, when the carriage Y reaches the boundary member 3ℓ or 3r, or a first one if plural pairs of boundary members are set on the needle bed, the driving mechanism *a* is actuated to move the card 1 forward by an increment of one row. As a result, the scanner *b* reads a new feed control mark 34 in the second row and starts to scan the second row in the regions 1p and 1f on the card 1 and the corresponding information is stored in the memory. It is assumed that the memory used herein comprises two portions which can store and read informations independently so that storing in one and reading from the other, or vice versa, can be effected. These newly stored signals are to be read when the direction of movement of the carriage Y is reversed and the carriage is moved in the opposite direction.

It is obvious that the subsequent operations are carried out in a similar manner as described above. Accordingly, each time the carriage Y is traversed to the left or the right, the corresponding storing and reading of information is effected in the memory and as a result, the needle selection and hence the pattern knitting according to the information on the card 1 is carried out in the range between the left and right boundary members 3ℓ and 3r.

The above-described information processing required to apply the information on the knitting program card 1 to the effective needles is handled by a single control circuit, which will be described hereinafter.

To meet the convenience of illustration, the control circuit is divided into two, i.e., an input function part and an output function part, which are illustrated as in the form of a block diagram in Figs. 10 and 16, respectively.

Fig. 10 diagrammatically shows the input function part of the control circuit which comprises an information processing part for reading information on the card 1 and storing the information in a memory MEM and a control part which can control the feeding of the card 1 and the movement of the scanner *b* (which operations are both necessary to perform the above reading operation) because this control part is controlled or influenced by the feeding of the card, the scanning of the scanner and the information which is read. Fig. 16 diagrammatically shows the output function part of the control circuit which has an information processing function for reading the signals stored in the memory and applying them to the associated needles to actually select needles.

As shown in Fig. 10, the information processing part of the input function part comprises an effective scanning data forming circuit C and an effective sampling pulse forming circuit D for deriving read signals of the scanning sensor *c* and the sampling sensor *d* as effective only when the scanner *b* is in the forward (moving to the right in Fig. 2) state including the starting point; a separation circuit Ps for separating output pulses from said circuit D according to their application (refer to the description concerning the slits 38s, 38p and 38f of the linear encoder 37); a circuit NS for setting the unit number of needles to be selected in response to the instruction mark 36 and a mark representing the unit number in the region 1s on the card 1; a circuit WA for addressing the memory MEM during writing output data of said data forming circuit C; a control circuit MC for controlling the writing and reading of the memory MEM; and a discriminator FS for discriminating function marks inked in the region 1f according to their function.

The control part of the input function part comprises an instruction circuit CS for instructing the commencement of the feeding and/or the subsequent scanning of the card; a control circuit SC for controlling so as to perform the feed and/or scan in a predetermined order according to different conditions at a given instant after said commencement instruction is made; and drivers CD and SD adapted to be controlled by said control circuit SC for exciting the electromagnet 16 (or 16′) and the coil 31 to perform the feeding and scanning, respectively.

Another driver FD for actuating a buzzer is added to the input function part in Fig. 10.

The above-described input function part is operated as follows.

As apparent from Fig. 10, the information processing part has influence upon the control part of the input function part and accordingly, the feeding and scanning are controlled in terms of the results obtained by reading the card 1. In light of this fact, the information processing part is first explained. Reference is also made to Figs. 11 and 12.

As shown in the block diagram of Fig. 11, the effective scanning data forming circuit C and the effective sampling pulse forming circuit D have a similar construction and comprise the scanning sensor *c* and the sampling sensor *d*, gates 61c and 61d connected to the respective sensors, and a common flip flop 60 connected to limit switches 33ℓ and 33r for controlling said gates 61c and 61d, respectively. The output of the gate 61d is connected to gates 63 and 64 of the separation circuit PS which separates output pulses of the gate 61d into two groups of pulses. One group contains a first pulse associated with the slit 38s of the linear encoder 37, while the other group contains 124 pulses consisting of 120 successive pulses associated with the slits 38p and further 4 successive pulses associated with the slits 38f of the linear encoder 37. The outputs of the switch 33ℓ and the gate 61d are connected to a flip-flop 62, the outputs of which are in turn connected to said gates 63 and 64 to control the latter. The above-described 124 pulses which have passed the gate 63 proceed to gates 71_1 and 71_2 where they are separated into two groups containing 120 and 4 pulses, respectively. In order to control the gates 71_1 and 71_2, a counter 67 for counting output pulses of the gate 63 and a gate network 70 for discriminating whether the counted value of the counter 67 is less than 120 or not are connected to the outputs of the gates 71_1 and 71_2.

Output pulses of said gate 71_1 are appropriately processed by suitable means (to be explained hereinafter) and sent to the memory control circuit MC and the writing address instruction circuit WA in order to sample outputs of the effective scanning data forming circuit C and store the sampled data in the memory. On the other hand, output pulses of the gate 71_2 are sent to the function discriminator FS.

In the foregoing explanation concerning the separation circuit PS, the gate 64 is described as a gate for taking out the first output pulse from output pulses of the gate 61d. In practice, the gate 64 also receives output signals of the effective scanning data forming circuit C and thereby detects the instruction mark 36 on the card 1. This means that the gate 64 also constitutes a part of the unit number setting circuit NS. This circuit NS comprises, in addition to the gate 64; a gate 66 adapted to sample outputs of the effective scanning data forming circuit C in terms of the output pulses of the effective sampling data forming circuit D except the first pulse and as a result, to detect a mark representing the unit number in the region 1s; a flip-flop 65 connected to said gates 64 and 66; a memory 69 connected to said gate 66 and the counter 67; and a code converter 76 connected to said memory 69.

The circuit NS having the above-described components serves to set the unit number of needles to be selected. This operation will be explained herein by referring to the reading of the card 1 along the line P_1-P_1 of Fig. 12 by the scanning sensor *c*. While scanning the card along the line P_1-P_1, first the gate 64 detects the instruction mark 36 as shown in Fig. 12 [VI] and sets the flip-flop 65. Subsequently, the gate 66 detects a mark representing the unit number in the region 1s as shown in Fig. 12 [VIII] and resets the flip-flop 65. Electrical connections are so made that the output of the flip-flop 65 is fed back to the gate 66 as a further input in order to effect the latter detection only at a necessary instant, that is, according to the instruction mark 36. At the same time, the counter 67 counts output pulses of the gate 63. The value of the counter 67 which is counted at the time of the latter detection is written in and stored in the memory 69. Hereafter, this value stored in the memory 69 substantially represents the set unit number.

In this example, the unit number of needles to be selected is chosen among multiples of "6", ie., 6, 12, ---, and 36, as shown in Fig. 12. In accordance with this the counter 67 comprises a seximmal counter part which counts pulses from the gate 63 and a 5-bit binary counter part which counts the obtained values of the former. The output of the latter counter part is, of course, the output of the counter 67. Therefore, the counter 67 counts by 6's and produces the corresponding output. The output of the counter will be 1, 2, 3, ---, or 6 (represented in the decimal code), when the number of the input pulses is 1-6, 7-12, 13-18, --- or 31-36. The unit number of needles which is set according to the above output will be a product of the output by 6, ie., 6, 12, 18, --- or 36.

In light of the above regulation, since the number of input pulses to the counter 67 is 8 in this example as shown in Fig. 12 [IV], a value of "2" (2 x 6 = 12) is stored in the memory 69. In this manner, the unit number of needles has been set and stored. This stored value is then converted to a binary value by the code converter 76 and offered to the reading address instruction circuit RA as the actual set unit number.

The counter 67 receives more than 120 pulses and can count them as described in the foregoing. Therefore, the unit number may be increased by 6 to 42, 48, ---, and 120. Accordingly, in addition to the card (first card) shown in Fig. 2 in which the number of columns of sections in the knitting pattern region 1p is 36 and the unit number may be set to 6-36, a second card shown in Fig. 18 in which the number of columns in the region 1p is 60 and the unit number may be set to 42-60 and a third card shown in Fig. 19 in which the number of columns in the region 1p is 120 and the unit number may be set to 66-120, may also be used in the program-providing system according to the invention. Depending on a desired unit number of needles to be selected, any one of the above three cards may be used in the system.

These three cards are so related that the dimensions of a unit section in the knitting pattern region 1p, that is, the width in the laterial direction (the direction of the scanning line P_1 - P_1) and the length in the vertical direction of a unit section of the first and second cards (Figs. 2 and 18) are 3 and 2 times larger than those of the third card (Fig. 19). Further, the spacing between the two adjoining knitting pattern sampling slits 38p in the linear encoder 37 and the increment of the feed of the ratchet wheel 14 are equal to the width and length of the unit section of the third card. Accordingly, the respective sections of the first, second and third cards correspond to 3, 2 and 1 slit 38p. The respective sections also correspond to 3, 2 and 1 time excitation of the electromagnet 16 (or 16′).

Under these conditions, however, sections should be read one by one as independent sections each representing one information. To this end, the separating circuit PS is provided with means for discriminating which card is used among the three and based on the result of this discrimination, producing sampling pulses each corresponding to one section of the relevant card.

The pulse selection circuit 72 connected to the gate 71_1 can produce the three pulse groups which have been processed so as to match with the three cards, respectively. That is, the pulse selection circuit 72 is so designed that its output 72-3 may pass the above-described 120 pulses in an intact manner for the third card, as shown in Fig. 12 [XIII]. Its output 72-2 may pass 60 pulses left after eliminating the even-numbered pulses from the 120 pulses for the second card, as shown in Fig. 12 [XIV]. Its output 72-1 may pass 40 pulses left after eliminating the 3n'th and (3n - 2)th pulses from the 120 pulses for the first card (*n* is a positive integer), as shown in Fig. 12 [XV]. Such a circuit 72 may be composed of counters and gates. The pulse selection circuit 72 is connected to gates 74_1, 74_2 and 74_3 in order to selectively use the outputs 72-1, 72-2 and 72-3.

On the other hand, the memory 69 of the unit number setting circuit NS is connected to a gate network 73 for determining which group among the (6 - 36), (42 - 60), and (66 - 120) groups the set unit number belongs to, in other words, discriminating which card is used among the three. This gate network 73 selectively opens one of the gates 74_1, 74_2

and 74_3 according to the result of this discrimination. In this manner, pulses matched with the card used appear as the output of the circuit PS at the output of the gate 75 connected to the gates 74_1, 74_2 and 74_3. It is obvious that the feeding amount of the card 1 at one time, i.e., the number of excitation of the electromagnet 16 (or 16′) may be controlled by using the output of the gate network 73, and not using the feed control mark 34 on the card.

Still remaining among the components of the information processing part shown in Fig. 11 is the function discriminator FS. The output of the gate 71_2 is connected to the discriminator FS which comprises a well-known combination of a counter 78, a decoder 79 and a gate group 77. The above-described 4 pulses coming from the gate 71_2 are separated from each other in the discriminator FS and then successively forwarded from the outputs 77-1 to 77-4 of the gate group 77, as shown in Fig. 12 [XX] and [XXI].

The four pulses discriminated by the gate group 77 are sent to a function storage circuit 80 which comprises D-type flip-flops and other components. In this circuit 80, the output (Fig. 12 [IX] coming from the effective scanning data forming circuit C is subjected to sampling for each section (column) in the function mark region 1f. The sampled data are independently stored for each column as shown in Fig. 12 [XXII]. The storage circuit 80 has four outputs 80-1 to 80-4. Signals appearing at the outputs 80-1 and 80-2 are sent to the input of the controlling circuit SC for controlling the feeding and scanning of the card 1. The signal from the output 80-1 functions to feed the card forward and the signal from the output 80-2 functions to feed the card backward. Further, signals from the outputs 80-3 and 80-4 are sent to the input of the function driver FD to achieve other functions such as the actuation of a buzzer.

The information processing part having the above-described configuration also serves to read the knitting pattern and function mark regions 1p and 1f on the card 1. This operation will be explained below, referring to the reading of informations by the scanning sensor c along the line P_2-P_2 in Fig. 1.

First of all, the sensor c reads the feed control mark 34 (Fig. 12 [IX]). However, the reading of this mark causes no operation, due to the absence of a sampling pulse. Next, though the first pulse (above-mentioned) is applied, the sensor c reads that there is no mark. Accordingly, the above-mentioned operation to set the unit number of needles to be selected is not initiated. Thereafter, the sensor c reads the information in the knitting pattern region 1p. This data is sampled according to the sampling pulses matched with the card used, in this case, the sampling pulses shown in Fig. 12 [XV]. The sampled data is stored in addressed portions of the memory MFM according to the address instruction by the writing address instruction circuit WA as shown in Fig. 12 [XVI] and [XVII]. Finally, the sensor c reads the information in the function mark region 1f. Since the leftmost section in the function mark region 1f on the card 1 has been marked in this case, the sensor c scanning along the line P_2-P_2 reads the information of the first column. This signal executes the predetermined function to set the feeding direction of the card 1 to the forward. In connection with this operation, it is to be noted that the feeding direction of the card has been determined to be forward during the preceding scanning along the line P_1-P_1, which will be described hereinafter. However, the above mark in the region 1f can be used to reverse the feeding direction when the card has been fed backward. This means that the function mark representing forward feeding can be used to obtain a certical mirror repeat of the pattern.

The other part of the input function part, that is, the control part will be described below, referring to Fig. 13.

As described in the foregoing, the control part comprises the instruction circuit CS, the control circuit SC and the drivers CD and SD. The feed/scan instruction circuit CS is designed so that the feed/scan start instruction may be ordered in three different states. The feed/scan instruction circuit CS comprises: (1) an inverter 81 connected to the start button CB, so that the instruction circuit may respond to the pressing of the button CB; (2) a gate 99 connected to the effective scanning data forming circuit C and the left limit switch 33ℓ and a flip-flop 96 connected to the gate 64 of the unit number setting circuit NS and said gate 99, so that the instruction circuit may respond to the setting of the unit number of needles to be selected; and (3) a carriage reversal detecting circuit 100 connected to the switch part e_1 for detecting the moving direction of the carriage, a flip-flop 101 connected to said circuit 100 and a gate 102 connected to the switch part e_3 for instructing the effective needle selection range and said flip-flop 101, so that the instruction circuit may respond to the arrival of the carriage Y at a first boundary member 3ℓ (or 3r) after the moving direction of the carriage is reversed. The instruction circuit CS further comprises an OR gate 82 connected to the inverter 81, the flip-flop 96 and the gate 102 and another inverter 82′ connected to said gate 82. The output of the inverter 82′ is sent to the control circuit SC as the start instruction from the instruction circuit CS and at the same time, is applied to the flip-flop 101 to reset the latter.

The control circuit SC essentially comprises a first part for controlling the feed driver CD and a second part for controlling the scan driver SD. The first part consists of a flip-flop 83 for storing the instruction from the instruction circuit CS; a pulse generator 87 for generating feed pulses; a circuit having flip-flops 89 and 91 and a pair of exclusive OR gates 90 for determining the feeding direction; a control circuit 86 for supplying the feed pulses of said pulse generator 87 from the output 86-1 or 86-2 connected to the feed driver CD, the feed pulses being controlled in terms of the setting of the flip-flop 83, the output condition (ON or OFF) of the left limit switch 33ℓ and the output condition of the feeding direction determining circuit; and a flip-flop 88 for resetting said flip-flop 83. The second part consists of a flip-flop 84 for storing the instruction from the instruction circuit CS and sending an instruction of the forward movement of the scanner *b*; a flip-flop 94 connected to the right limit switch 33r for sending an instruction of the backward movement of the scanner *b*; and a delay circuit 95 connected between the left limit switch 33ℓ and said flip-flop 94 for cancelling the instruction of said flip-flop 94 after the scanner *b* has returned to its starting position and resumed the substantially stationary condition. The control circuit SC further comprises a gate 92 which is connected between the flip-flop 84 and the scan driver SD and is also connected to the flip-flop 83. This gate 92 serves to initiate the scanning in a correct order after the completion of feeding.

The control part shown in Fig. 13 has the above-described configuration. In a similar manner to the above, the operation of this control part will be explained with respect to the operation to perform the feeding and scanning in response to the movement of the carriage Y, by referring to Fig. 15.

In response to the movement of the carriage Y, the circuit portion used in case (3) described above in relation to the instruction circuit CS is operated. The instruction circuit CS supplies a feed/scan start instruction to the control circuit SC as shown in Fig. 15 [V]. As a result, the flip-flops 83 and 84 are set and thus the pulse generator is actuated. The actuated generator 87 first produces a pulse which is transmitted to the control circuit 86, which in turn supplies said pulse to the feeding driver CD from its outputs 86-1 or 86-2 associated with the direction determined by said feeding direction determining circuit. In accordance with this output, the card 1 is fed by an increment in a selected or predetermined direction. An operation following this feeding is dependent upon the result from the reading of the scanning sensor *c* at the end of said feeding. The flip-flop 88 samples the output of the effective scanning data forming circuit C and stores the sampled output in response to the fall of said pulse. In this sampling, if the sensor *c* does not read a control mark 34, the content of the flip-flop 83 is maintained. Accordingly, the pulse of the pulse generator 87 provides another feed of the card by a further increment. This feeding operation is continued until the sensor *c* reads a control mark 34 during said sampling. As a result, the flip-flop 83 is reset. In Fig. 15, the first card shown in Fig. 12 is used. Therefore, one feeding consists of 3 increments as shown Fig. 15 [VIII].

The resetting of the flip-flop 83 opens the gate 92, which permits the flip-flop 84 to supply the instruction for forward movement of the scanner *b* to the scanner driver SD. Accordingly, the scanner *b* starts moving forward and then reaches the right stroke end to turn on the limit switch 33r. The switching of the limit switch 33r resets the flip-flop 84 and at the same time, the flip-flop 94. The latter flip-flop 94 produces the instruction for backward movement. The scanner *b* thus starts moving backward. Even after the scanner *b* reaches the left stroke end to turn on the limit switch 33ℓ (Fig. 15 [X]), this backward movement instruction of the flip-flop 94 is continued for a predetermined period of time due to the delay circuit 95, and is then cancelled (Fig. 15 [XVI] and [XVII]). Said delay circuit 95 serves to prevent the incomplete return of the scanner *b* to the starting position because of a rebound. At this time the control circuit SC resumes its original state and is ready for the next start instruction given by the instruction circuit CS.

In the above-described operation, the start button CB may be pressed when it is desired to start the pattern knitting. The operation of the circuit resulting from this pressing of the button will be explained below with reference to Fig. 14.

Upon pressing the start button CB, the flip-flop 89 is set and the instruction circuit CS produces a feed/scan start instruction (Fig. 14 [II]). The start instruction permits the control circuit SC to operate in the above-described manner, so that the card 1 is fed by an increment. The moving direction of the card 1 is opposite to the direction instructed by the flip-flop 91 because the flip-flop 89 is set, but is forward because the instruction direction of the flip-flop 91 has been reversed. A flip-flop which is resetable when the power switch is turned ON is used as the flip-flop 91. Since the scanning sensor *c* reads the instruction mark 36 at the end of the feeding of the card 1, the feeding operation is continued no longer. Immediately, the scanner *b* reciprocates in the same manner as above. As a result of this reading by the scanner along the line P_1-P_1 in Fig. 12, the unit number of needles to be selected is set. During the reading, the gate 64 (Fig. 11) produces a signal representing the detection of the mark 36 (Fig. 14 [VIII]). This signal sets not only the flip-flop 91 of the control circuit SC to change the instruction direction thereof to the forward, but also the flip-flop 96 of the instruction circuit CS to cause the circuit portion of the instruction circuit SC used in case (2) to operate. The output of the set flip-flop 96 is again given from the instruction circuit CS to the control circuit SC as said feed/scan start instruction. As a result, the control circuit SC is actuated again and the card 1 is fed by an increment. The feeding direction is forward in this case because the flip-flop 91 is set and the flip-flop 89 is reset when the right limit switch 33r is turned on during the reciprocation of the scanner *b*. At the end of this feeding, the circuit 88 produces an instruction to reset the flip-flop 83 as a result of the reading of the mark 36 by the sensor *c* as described above. However, irrespective of this instruction, the setting of the flip-flop 83 based on the start instruction coming from the flip-flop 96 is maintained because the flip-flop 83 is so constructed that the setting signal is preferential in this case. Therefore, irrespective of the detection of the mark 36 by the sensor *c*, the card 1 is successively fed forward. The sensor *c* deviates from the area of the mark 36 at last. The flip-flop 96 is reset and the start instruction is cancelled at this time. However, the card 1 is further fed forward because the reset instruction coming from the circuit 88 is also cancelled. This feeding operation is also cancelled. This feeding operation is continued until the sensor *c* detects the control mark 34 in the first row, as obvious from the above-described circuit operation. In the subsequent step, one reciprocation of the scanner *b* is made again. A series of operations resulting from the pressing of the start button CB are completed in this manner.

The start button CB is used as input means to start pattern knitting in relation to the mark 36 on the card 1 as described above. In addition, the start button CB may be used as a correction button when incorrect knitting should be corrected. For example, incorrect knitting requires the loosening of a certain number of rows (courses) of an incorrectly knitted portion and then the correct knitting of these same rows. In this case, it is also necessary to return the card 1 by the same number of rows and start scanning again from this replaced position. The necessary operation may be simplified by using the start button CB. That is, the pressing of the start button CB leads to the opposite or backward movement of the card 1. Accurately, the card 1 is fed in the backward direction by an increment each time the button is pressed. The same number of pressings can bring the card 1 back to the required position. Scanning is carried out in this condition. Therefore, the machine is ready for pattern knitting a first row of correction after the same number of pressings.

The above-described input function part further comprises a stop button SB. This button is also mounted on the control panel 2 and is connected to the input of the gate 85 (Fig. 13). When the button SB is pressed, the gate 85 is closed so that the output of the set flip-flop 83 is cut off from the control circuit 86. As a result, the feeding of the card 1 is stopped. If the instruction circuit CS gives a start instruction to the control circuit SC under the condition that the button SB is effective, the flip-flop 83 is set. While the feeding operation is not carried out due to the above cut-off, the pulse generator 87 is actuated. Thus, the flip-flop 83 is reset at a rise edge of a first output pulse, since the scanning sensor *c* remains opposite to the same control mark 34. Subsequently, the scanner *b* moves. In summary, the card 1 is repeatedly scanned for the same row in response to the movement of the carriage Y when the stop button SB is being pressed. As a result, the relevant row in a given knitting pattern is repeatedly reproduced as successive, identical courses.

As explained in the foregoing, a bi-direction step motor may be used instead of the combination of electro-magnets 16 and 16'. In this case, the control circuit SC (Fig. 13) is modified as follows: In order to supply a signal to instruct the rotation direction of the motor and a pulse to drive the motor to a driver circuit for driving the motor, the output of the circuit 90 is directly connected to said driver circuit and the control circuit 86 to be connected to said driver circuit is composed of a 3-input AND gate.

Next, the output function part will be described with reference to Fig. 16. The configuration of this part is similar to that disclosed in the specification of the above-described Patent.

A circuit RA has a function of addressing required when data stored in the memory MEM are to be read. The addressing circuit RA including an up-down counter is connected to the switch e_3 for instructing the effective needle selection range, the timing pulse generators Hℓ and Hr, the unit number setting circuit NS of the above-described input function part and a comparator CO, so that only when the carriage Y is positioned between the boundary members 3ℓ and 3r or within the effective needle selection range, the addressing circuit RA may count interval pulses associated with the movement of the carriage Y in an additive or substractive manner up to a limit having a predetermined value. The comparator CO is connected to manually operable input means RL for determining the relation of the moving direction of the carriage Y to the additionsubstraction direction in the counter of said circuit RA and as a result, determining whether a pattern to be formed on the resulting knitted fabric should be identical or inversely symmetrical with the knitting pattern on the card 1 in the lateral direction and the switch e_1 for detecting the actual moving direction of the carriage Y. This comparator CO compares the output of the means RL with that of the switch part e_1 to select alternatively the addition or subtraction in said counter. The output of the switch part e_1 representing the moving direction of the carriage Y is sent to the memory control circuit MC to control the writing and reading in the above two memory parts of the memory MEM. The memory control circuit MC supplies the data read from the memory MEM to a shaping circuit WP. The shaping circuit WP is connected to the said switch part e_3 so that one of the electromagnets 46 can be excited only when the carriage Y is present between the boundary members 3ℓ and 3r, and also is connected to manually operable input means or mode selecting means MS so that the data read from the memory MEM and hence a pattern to be formed on the resulting knitted fabric can be reversed (color reversal). The output of the shaping circuit WP is amplified by an electromagnet driver MD and then supplied to the electromagnet 46 of working one of the needle selection mechanism Fℓand Fr (which is effective with respect to the moving direction of the carriage Y) through the switch part e_2. Needle selection is performed in response to the excitation of the electromagnet 46.

The correct button CB which is described with reference to the input function part is connected to the memory control circuit MC so that the data which is read from the knitting pattern information (1p) on the card 1 upon pressing the button CB, may be stored in the above two memory parts of the memory MEM.

A second embodiment of the program providing system according to the invention will now be described referring to Figs. 20 to 22.

If the program providing system A is not covered, ambient light will enter the program providing system, particularly a space where the scanning sensor *c* and sampling sensor *d* of the scanner *b* are mounted, and especially a space between the scanning sensor *c* and the surface portion of the card 1 to be scanned. This light may influence the sensors so that the sensors are likely to misread. To prevent the occurrence of such a misreading, a special precaution is taken for the present situation. This is, the control panel 2 is mounted on the machine body X to cover the program providing system A.

In the embodiment shown in Figs. 20 to 22, the control panel 2 comprises a cover plate 110 which is mounted between the top of the rear wall of the frame 7 and the standing wall x_3. At the left of the cover plate 110 are longitudinally preformed a protruding portion 114 and an elongated slot 115. The cover plate 110 is also preformed with another elongated slot 116 which is an exit for the card. The width of the protruding portion 114 and slots 115 and 116 is somewhat larger than that of the card 1. In front of the slot 115, a transparent member 117 is placed on the cover plate 110. The transparent member 117 has an oblique rear portion 117′ which forms a path with the front surface of the protruding portion 114. This path is communicated to the slot 115 to define an entrance through which the card 1 can be passed to the interior. The oblique rear portion 117′ is marked with a reference line 118 which is used to align the card 1.

The card 1 used in the second embodiment is the same as in the first embodiment except that the control marks 34, instruction mark 36 and unit number region 1s are omitted. In addition to the knitting pattern region 1p and the function mark region 1f, the card further includes means for setting the unit number of needles to be selected in combination with a dial 129 on the control panel 2, which means is not shown in the drawings because it is not essentially related to the scope of the invention.

The feeding means has the following construction which must be regarded as essentially identical with that of the first embodiment. Between the left and right side walls 7′ of a frame 7 is a shaft 12 rotatably supported and which is provided with a pair of sprocket wheels 8. The sprocket wheels 8 are provided with protrusions 8′ which will be engaged with the perforations 1′ of the card 1 when the card 1 is loaded and fed forward or backward. A guide plate 9 having a nearly U-shaped cross section (Fig. 22) is attached to the side walls 7′, which plate guides the card 1 inserted from the entrance 115 to the outer periphery of the sprockets 8 and then to the exit 116. The front portion of the guide plate 9 is successively perforated with a plurality of slits 9p and 9f for exposing the information on the card to the sensor *c* one by one, each slit corresponding to a section in the knitting pattern region 1p and function mark region 1f. In a similar manner, a linear encoder 37 is perforated with a plurality of slits 38p for sampling purpose.

As shown in Fig. 21, the shaft 12 is extended beyond the right side wall 7′. This extension mounts and is coupled to a gear 111 which is engaged with a gear 112, which is, in turn fitted on a drive shaft of a bi-directional pulse or step motor *m*, whereby an incremental feeding operation of the card 1 is effected by a rotational stepping movement of the drive shaft of the step motor. The extension is also firmly provided with an adjusting wheel 113 adjacent the gear 111, the upper portion of which is exposed from a window formed in the cover plate 110 (see Fig. 20). An operator can turn the adjusting wheel by hand to feed the card 1.

A pair of parallel guide bars 27 and 28 are supported between the side walls 7′. On the guide bars 27 and 28 is slidably fitted a runner 29 which is a component of the scanner *b*. The scanner further comprises a bobbin 30 of ferromagnetic material on which a coil 31 is wound. The bobbin 30 encloses the lower guide bar 28 with a clearance. Further, a permanent magnet 32 which forms a linear motor with the coil 31 is placed below the lower guide bar 28 over the moving range of the runner 29.

The right side wall 7′ is provided with a damping stopper 123 which defines the right stroke-end against the scanner *b*. On the other hand, a stopper 124 is firmly secured on the left end of the guide bar 27 which is mounted to the side walls 7′ for sliding movement within a given distance. A plate spring 125 secured to the left side wall 7′ is extended downwardly so as to abut with the end of the bar 27. Therefore, the stopper 124 defines the left stroke-end against the scanner *b*. When the scanner *b* runs backward (to the left), it will collide with the stopper 124. The impact is, however, dampened by the spring 125. Consequently, the reaction which otherwise will occur each time the scanner reaches the left stroke-end can be effectively prevented.

Further, it is preferable to reduce the frictional force resulting from the inter-action between the runner 29 and the guide bars 27 and 28. It is to be noted that the frictional force depends on the total weight of the scanner *b*. The runner 29 is provided with permanent magnets 126 which are so oriented that the magnets 32 and 126 exert repulsive forces on each other. When the magnet 32 has a north pole at the top, the north poles of the magnets 126 face the former. As a result, an upward force acts on the runner 29.

To establish the electrical connection between the coil 31 of the scanner *b* and a circuit built in the control box B, a flexible cord 130 is connected to the runner 29 at one end and to any desired position of the frame 7 at the other end. (The cord 130 is drawn in broken lines in Fig. 21). As the flexible cord 130, use may be made of a known flexible cord, for example, a sheet-like cord in which a plurality of parallel conductive strips are enveloped in an insulating material. Such a flexible cord can follow the reciprocal movement without any trouble.

The circuit configuration for controlling the above-described mechanism may be obtained by modifying the circuit configuration shown in Fig. 10. The following modifications should be made on the circuit configuration of Fig. 10.

1. The unit number setting circuit NS is eliminated.
2. In relation to 1), the pulse separation circuit PS and the feed/scan instruction circuit CS are modified.
3. The start button CB and the feed/scan control circuit SC associated therewith are modified.
4. The last-mentioned control circuit SC is modified so that the pulse motor may be operated.
5. The control circuit SC is accommodated to the absence of the control marks 34 on the card 1.

For example, the modification 2) may be achieved by eliminating the flip-flop 62 in Fig. 11 and the gate 99 and flip-flop 96 in Fig. 13. Modification 4) is already described. Modification 5) may be achieved by using a counter and a gate network instead of the flip-flop 88 in Fig. 13 so that the flip-flop 83 may be reset to a desired number of pulses. However, modification 3) is somewhat complicated which will be explained below.

According to the second embodiment of the invention, the scanning sensor *c* for scanning the card 1 is shielded by the cover plate 110. As a result, an operator cannot inspect which row is scanned and therefore cannot foresee what needle selection is to be performed in the following operation of the carriage. This leads to the fact that, as a result of undesired feeding operation of the card 1, a part outside the essential region 1p containing the desired knitting pattern information is scanned in vain or mirror repeat of a pattern in the vertical direction is undesirably worked. Similar inconvenient operations will result when correction knitting is performed after a wrong knitting is loosened.

In order to eliminate the above-described inconvenience, the program providing system according to the second embodiment of the invention is provided with an appropriate electrical circuit including manually operable input means in the form of a confirmation button 135 (Fig. 20). This circuit makes it possible that a part of the card 1 which is actually positioned in the scanning line of the scanning sensor *c* may be automatically pulled back to a predetermined confirmation position where an operator can inspect the relevant part with the nakes eye and then return the card to the scanning position. The button 135 is, for example, of so-called a double-action structure and is combined with a switch which can be turned on or off in response to the pressing of the button 135, for example, turned ON at a first pressing of the button and resumed OFF at a second pressing as shown in Fig. 24 [I].

The configuration of said circuit is shown in Fig. 23, which is obtained by partially modifying the feed/scan control circuit SC of the circuit configuration in Fig. 13 A part necessary to explain such modification is only illustrated in Fig. 23.

The circuit comprises a pulse generator 139 for generating a predetermined number of pulses each time the output of the said switch (135) is reversed, the pulse generator being connected to a driver 132 for driving the pulse motor *m* to give said pulses thereto; a detection circuit 140 for obtaining a detection signal representing that the pulse motor *m* is working on the card 1 after the second pressing of the button 135, the circuit being consisting of a counter, gate circuits and a flip-flop; and a feeding direction control circuit 137 for supplying to the driver 132 an output signal to render the feeding direction of the card 1 backward when the switch (135) is ON, or another output signal to render the feeding direction forward when the detection circuit 140 is producing the detection signal, independently of the output of the flip-flop 91 (Fig. 13) for instructing the feeding direction.

This circuit is operated as follows: When the button 135 is pressed a first time, the switch is turned ON to energize the pulse generator 139, which supplies a predetermined plural number of pulses to the driver 132 as shown in Fig. 24 [III]. The card 1 is thus transferred backward by a predetermined number of rows. This feed amount is set to be equal to the distance between the reference line 118 and the scanning line along a curved path. The part of the card 1 which has been positioned in the scanning line of the scanning sensor *c* is pulled back to the position of the reference line so that an operator can inspect the relevant part of the card 1 through the oblique rear portion 117′ of the transparent member 117. As obvious from the above explanation, the number of pulses that the pulse generator 139 produces each time depends upon the feed amount and is set to 10 in this case.

After confirming the relevant part, the operator again presses the button 135. The pulse generator 139 again produces 10 pulses in response to this second pressing. The switching of the switch (135) from ON to OFF resulting from the second pressing actuates the detection circuit 140 which starts to produce its output. The detection circuit 140 stops producing its output when the pulse generator 139 has produced 10 pulses. Accordingly, the feeding direction of the card 1 as a result of the second pressing of the button 135 is forward. According to the 10 pulses from the pulse generator 139, the card 1 is automatically returned or fed forward by the predetermined distance (feed amount). The part of the card 1 which had been positioned in the scanning line of the scanning sensor *c* before the first pressing is again positioned in the scanning line.

To add to the button 135 a function similar to that of the correction button CB in the first embodiment, the detection circuit 140 is associated with a scanning instruction circuit 133. Upon extinction of the detection signal from the detection circuit 140, the scanning instruction circuit 133 is actuated. As a result, the scanner *b* automatically reciprocates in the same manner as in the first embodiment.

The button 135 can also be used as a start button similar to the start button CB in the first embodiment. The button 135 is, of course, operated after the power switch is turned on. In this condition, the operator inserts the card 1 into the entrance and then turns the adjusting wheel 113 by finger to set the first row of sections on the card 1 to the reference line 118. Then the operator presses the button again. According to this second pressing, the card 1 is automatically fed forward and stopped at the position where the first row coincides with the scanning line of scanning sensor *c*, as explained at above. Thereafter, the scanner *b* starts to reciprocate in the same manner as described as above. Scanning of the first row will transmit the information concerning the first row of the knitting pattern to the circuit.

The outputs of the detection circuit 140 and the switch combined with the button 135 are also supplied to a display element 141 mounted on the control panel 2 such as an electro-luminescent element. The display element 141 is turned on after the part of the card 1 in the scanning line starts the above-described displacement and until said part resumes the starting position. The lit display element permits the operator to confirm that the card 1 is displaced and the carriage should not be operated.

In Fig. 20, the control panel 2 also includes a feeding direction reverse button 143 connected to the feeding direction instruction flip-flop 91 to reverse the output thereof each time the button 143 is pressed, and display elements 144 and 145 connected to said flip-flop 91 to display the feeding direction.

WHAT WE CLAIM IS:-

1. A program reading apparatus for reading a patterning program on a program carrier to provide serial electric signals in accordance with the readings and to provide strobe pulses which are used to sample the serial signals to provide patterning instruction signals which generally represent the patterning program and are adapted to control patterning mechanisms of a knitting machine, comprising a frame, a holder supported on said frame for rotation about an axis and adapted to movably carry a program carrier thereon, first bidirectional drive

means including an electromagnetic means for driving said holder to rotate a predetermined angle about said axis to incrementally feed the program carrier thereon in one or the other direction, a guide bar mounted on the frame and extending parallel with said axis, a slidable member slidably mounted on said slidable member, second bidirectional drive means including an electric motor for driving said slidable member from one to the other stroke end and vice versa thereby to effect the reading of the program on the program carrier along a predetermined scanning line to provide serial electric signals in accordance with the reading, pulse generator means for generating an interval pulse upon every incremental movement of the slidable member thereby to provide a predetermined number of stroke pulses adapted to sample said serial signals during a directional movement of the slidable member from one to the other stroke end or vice versa, and control means including a control circuit for controlling said first and second drive means to effect feeding of the program carrier in a selected direction and scanning by said scanning sensor.

2. A program reading apparatus as claimed in Claim 1 wherein said electric motor of the second drive means is a linear motor which includes a bobbin mounted on the slidable member, a coil wound on said bobbin and electrically connected to said control circuit, and a permanent magnet placed on the frame parallel with said guide bar and in close relation to the coil and co-operable with the coil to drive the slidable member when said coil is energised.

3. A program reading apparatus as claimed in Claim 2 wherein said guide bar is made of a ferromagnetic material and said bobbin is slidable on the guide bar.

4. A program reading apparatus as claimed in Claims 2 or 3 further comprising a magnet piece attached to said slidable member to cooperate with said permanent magnet to urge the slidable member upwardly.

5. A program reading apparatus as claimed in any one of the preceding claims wherein said electromagnetic means of the first drive means is a pair of electromagnets, and said first drive means further includes a ratchet wheel operatively connected to the holder, and a pair of pawls linked to the respective electromagnets whereby said ratchet wheel is incrementally rotated in one or the other direction by exciting the corresponding one of said electromagnets.

6. A program reading apparatus as claimed in any one of the Claims 1 through 4 wherein said electromagnetic means of the first drive means is a bidirectional stepping motor having an output shaft operatively connected to the holder.

7. A program reading apparatus as claimed in Claim 6 wherein said first drive means further includes a manually operable member operatively connected to the holder for feeding the program carrier on the holder independently of said stepping motor.

8. A program reading apparatus as claimed in any one of the preceding claims wherein said control means further includes a manually operable input means electrically connected to the control circuit and manually operable to specify the future operation of the first and/or second drive means controlled by the control circuit.

9. A program reading apparatus as claimed in Claim 8 further comprising a guide member fixed to the frame and a cover member mounted on the frame and disposed to shield all the components of the apparatus, said cover member having formed therein a pair of elongated openings disposed parallel to the axis of the holder for permitting the program carrier to pass therethrough, said guide member co-operating with the holder to define a path for guiding the program carrier on the holder from one to the other of said openings, the guide member having a slit formed therein along said scanning line for exposing the program carrier to the scanning sensor.

10. A program reading apparatus as claimed in claim 9 further comprising reference means positioned outside the cover member and adjacent to one of the openings in the cover member, said reference means being spaced apart from the scanning line by a predetermined distance, the control circuit being operable in response to manual operation of the input means to control the first drive means such that the program carrier is fed said predetermined distance in a predetermined fixed direction whereby that part of the program carrier which was coincident with the reference means is moved so that it coincides with the scanning line.

11. A program reading apparatus as claimed in Claim 10 wherein said control circuit is further operable in response to the end of the feeding of the program carrier by the predetermined distance to control the second drive means to move the slidable member from one to the other stroke end or vice versa to effect scanning by said scanning sensor.

12, A program reading apparatus as claimed in Claim 10 or 11 wherein said control circuit is further operable in response to another manual operation of the input means to control the first drive means such that the program carrier is fed that predetermined distance in the reverse direction whereby that part of the program carrier which was aligned with the scanning line is moved so that it coincides with the reference means.

13. A program reading apparatus as

claimed in Claim 8 wherein the apparatus is of open construction so that a machine operator can visuslly observe the program carrier along the scanning line, said control circuit being operable in response to a manual operation of the input means to control the first and second drive means such that the program carrier is first fed a predetermined distance in the direction opposite to the preselected feeding direction whereafter the slidable member is moved from one to the other stroke end or vice versa to effect scanning by said scanning sensor.

14. A program reading apparatus as claimed in Claim 8 wherein said control circuit is operable in response to manual operation of the input means to disable the operation of the first drive means.

15. A program reading apparatus as claimed in Claim 8 wherein the control circuit is operable in response to manual operation of the input means to reverse the direction of the program carrier.

16. A program reading apparatus as claimed in any one of the preceding claims wherein said control circuit is adapted to control the second drive means such that the slidable member is moved first in one direction to one stroke end and subsequently in the other direction to the other stroke end, and the control means further includes circuit means for cancelling that portion of the output of the scanning sensor which is associated with the movement of the slidable member in the other direction.

17. A program reading apparatus as claimed in Claim 16 wherein said circuit means includes a switch adapted to be actuated by the slidable member and operable when the slidable member reaches said one stroke end.

18. A program reading apparatus as claimed in any one of the preceding claims wherein the program carrier carries data concerning the feeding thereof, and the scanning sensor is electrically connected to the control circuit whereby as a result of the reading of the data by the scanning sensor the control circuit controls the first drive means to operate the latter in accordance with the data read.

19. A program reading apparatus as claimed in Claim 18 wherein the program carrier carries data representative of its feeding direction whereby after the reading of the data by the scanning sensor the program carrier is fed in the direction specified by the data.

20. A program reading apparatus as claimed in Claim 18 or 19 wherein the program carrier carries stop data for stopping the feeding operation of the program carrier by the first drive means whereby once the feeding operation is started the program carrier is atuomatically fed until the scanning sensor reads said stop.

21. A program reading apparatus as claimed in any one of the Claims 18 through 20 wherein the program carrier further carries data representative of the unit number of needles to be selected or the width of one repeat of a pattern carried on the program carrier, and the control means further includes circuit means electrically connected to the scanning sensor whereby the circuit means produces electric signals representative of the unit number when the scanning sensor reads said data.

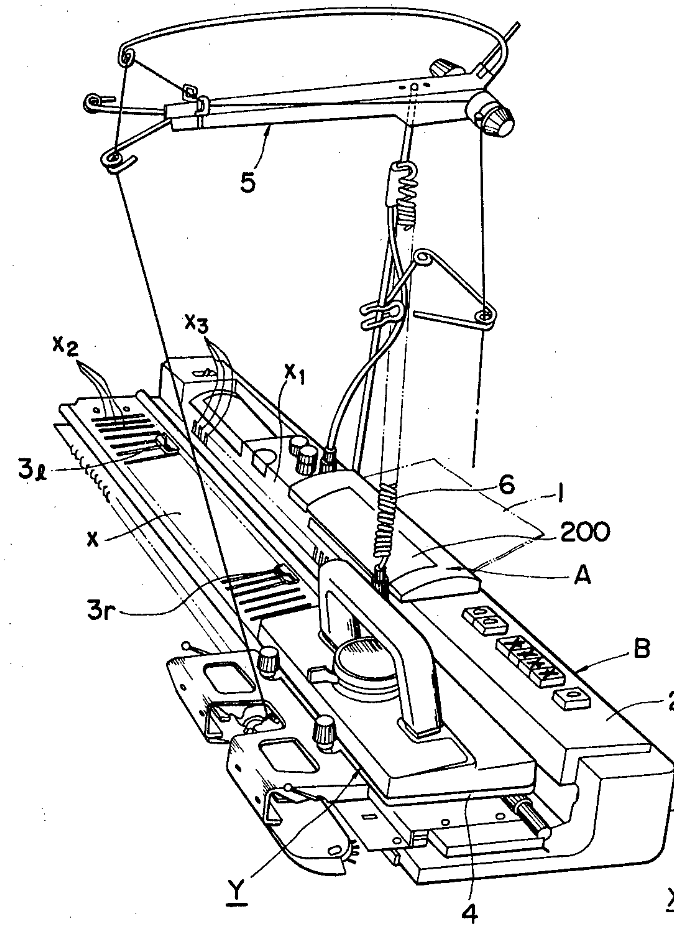
22. A program reading apparatus comprising the combination and arrangement of parts substantially as hereinbefore described with reference to Figures 1-17 of the accompanying drawings.

23. A program reading apparatus comprising the combination and arrangement of parts substantially as hereinbefore described with reference to Figures 20-24 of the accompanying drawings.

MARKS & CLERK,
Alpha Tower,
ATV Centre,
Birmingham B1 1TT.
Agents for the Applicants:-

Printed for Her Majesty's Stationery Office,
by Croydon Printing Company Limited, Croydon, Surrey, 1981.
Published by The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.

FIG. 1

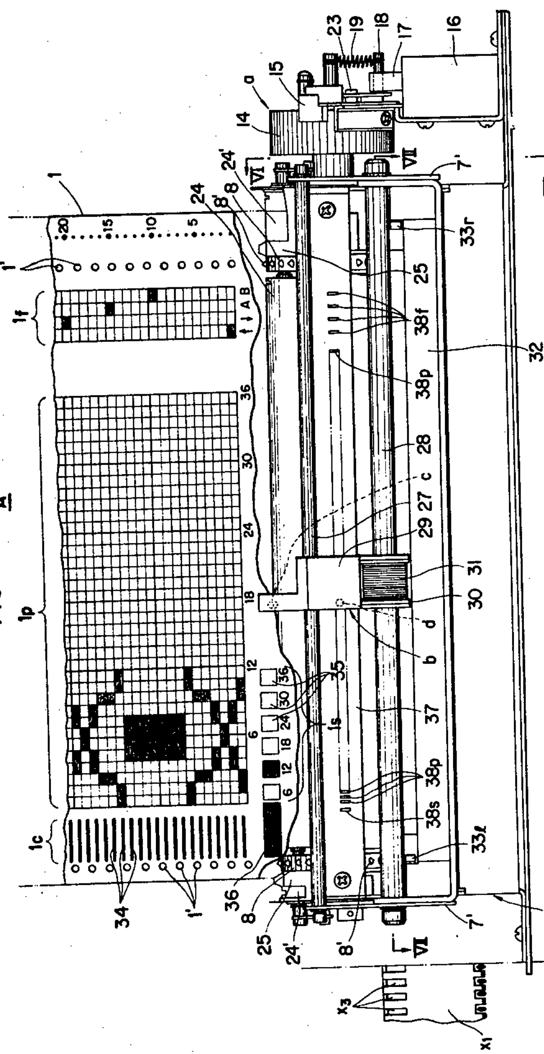


1592349 COMPLETE SPECIFICATION

20 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG. 2 A



1592349 COMPLETE SPECIFICATION

20 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

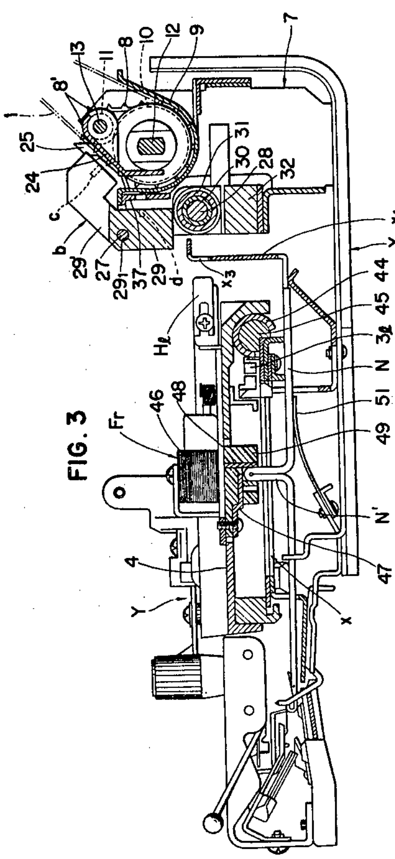


FIG. 3

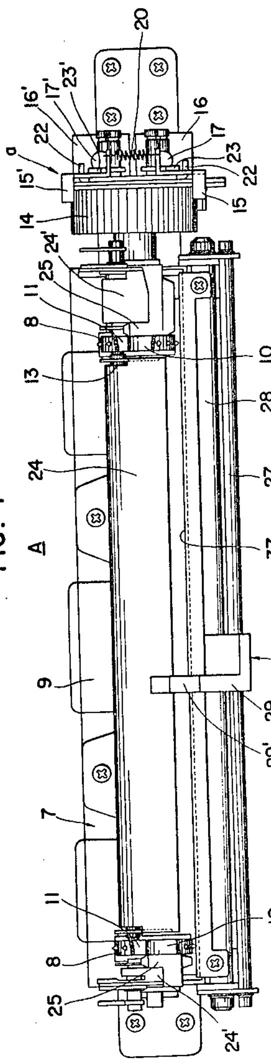


FIG. 4

FIG. 5

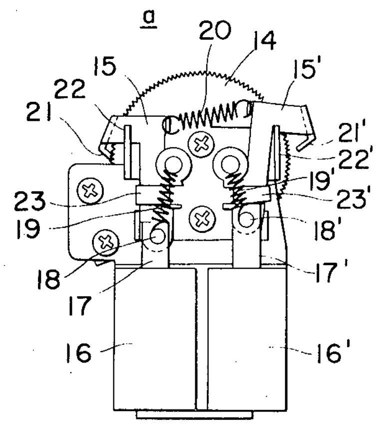
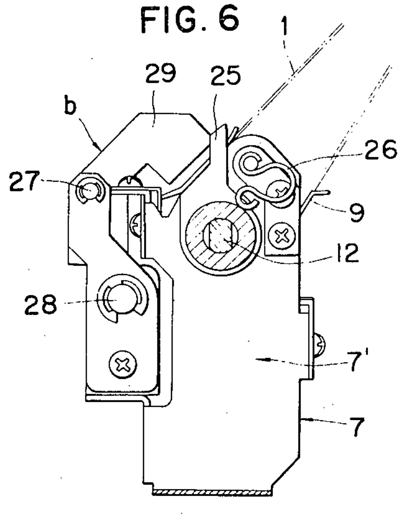

a
20
14
15
15'
22
21
21'
22'
19'
23
23'
19
18'
18
17'
17
16
16'

FIG. 6


1
29
25
b
26
27
9
12
28
7'
7

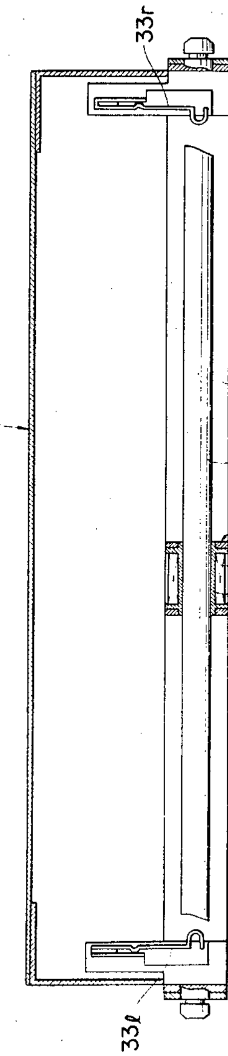


FIG. 7

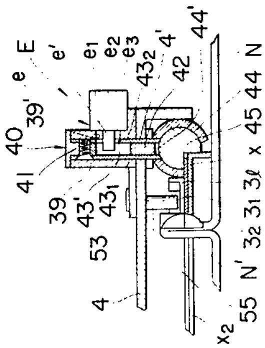


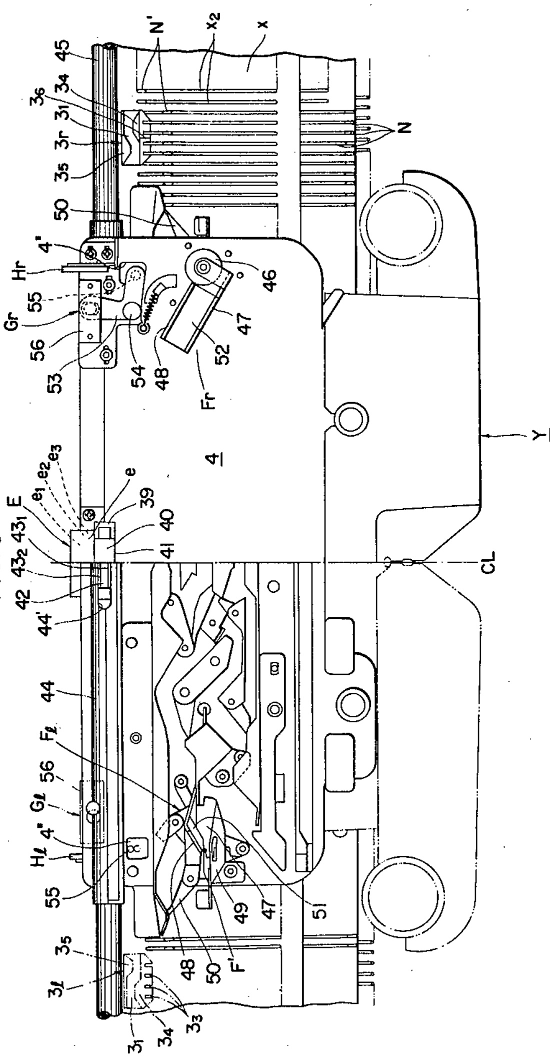
FIG. 9

1592349 COMPLETE SPECIFICATION

20 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 6

FIG. 8



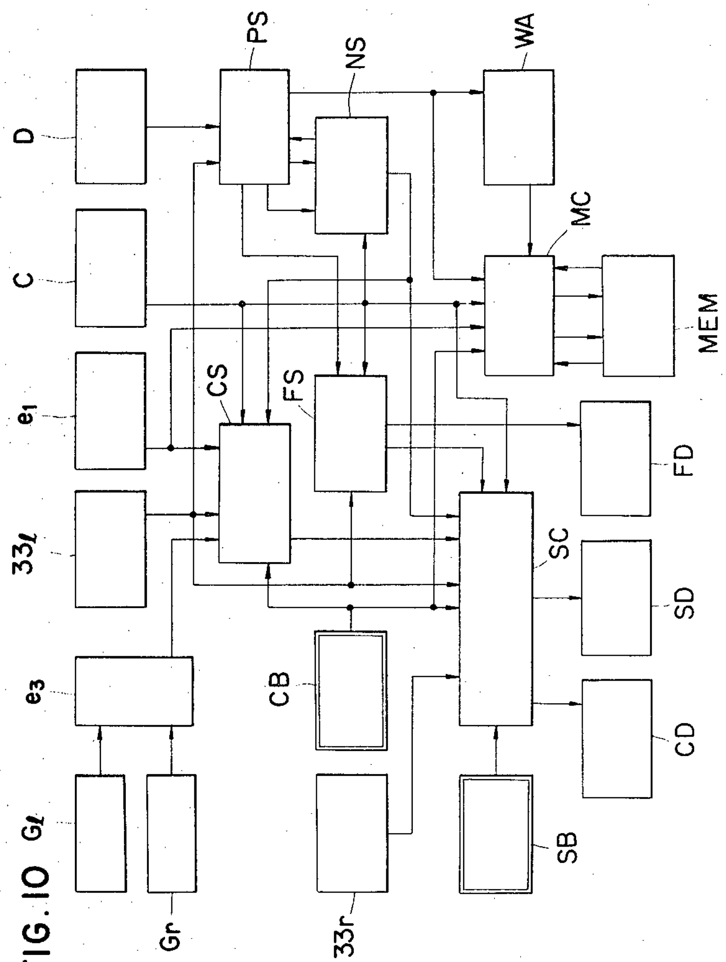


FIG. 10

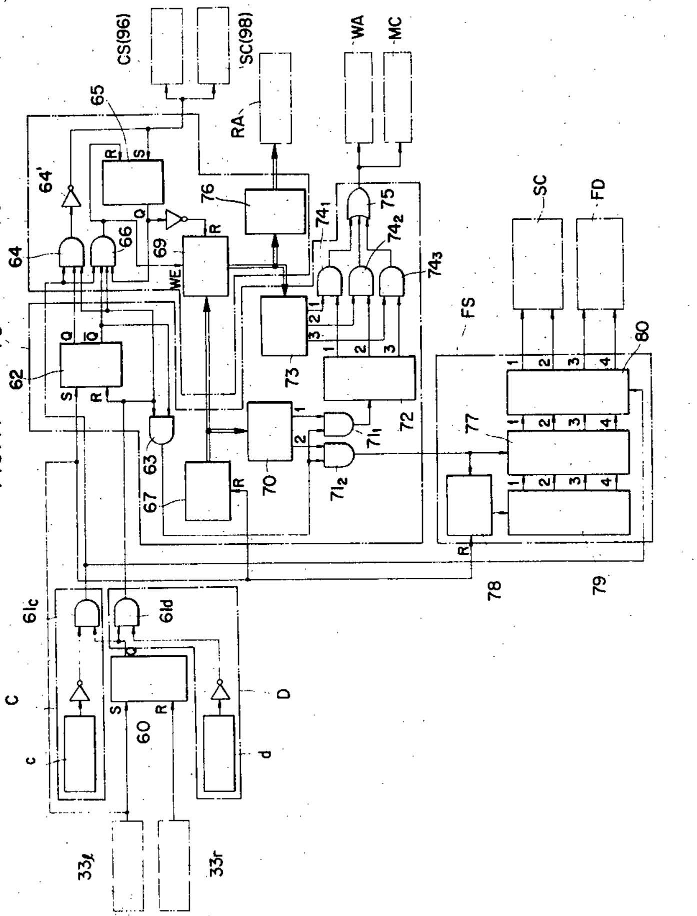

CS(96)
SC(98)
RA
WA
MC
NS
PS
FS
SC
FD
33ℓ
33r
60
61c
61d
62
63
64
64'
65
66
67
69
70
72
73
75
76
77
78
79
80

FIG. 11

FIG. 12

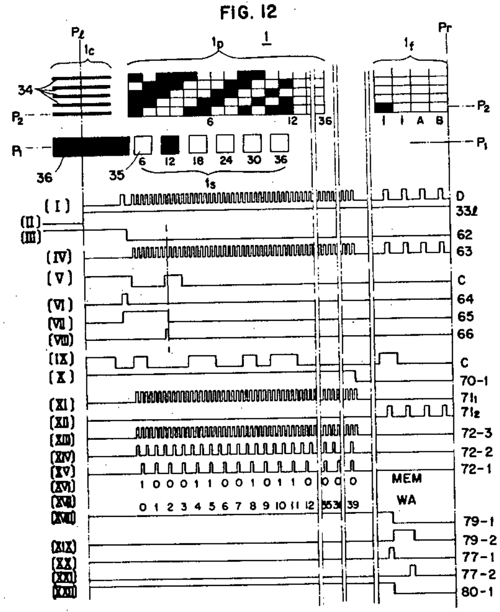
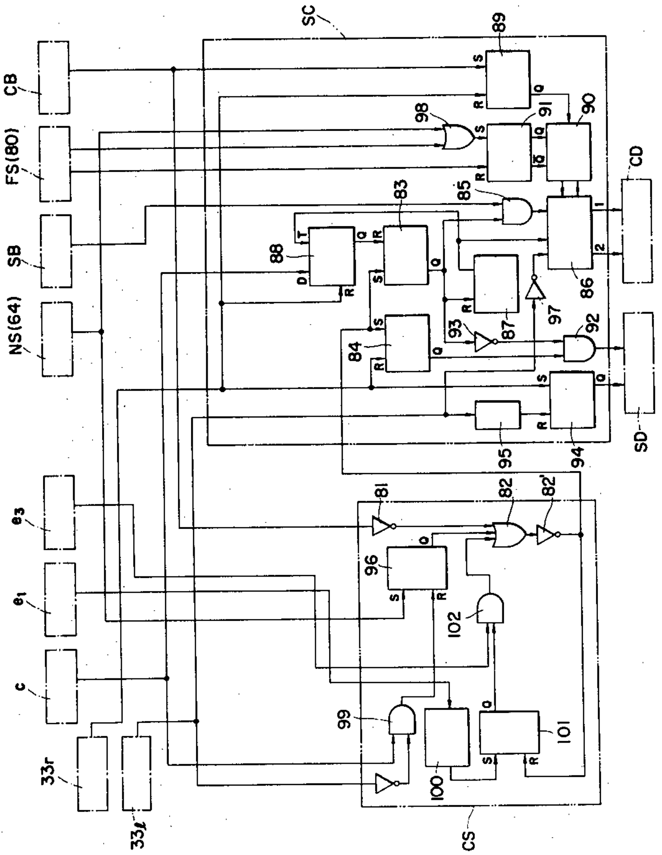


FIG. 13


CB
FS(80)
SB
NS(64)
SC
CD
SD
CS
33r
33ℓ
c
81
82
82'
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102

1592349 COMPLETE SPECIFICATION

20 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 11

FIG. 14

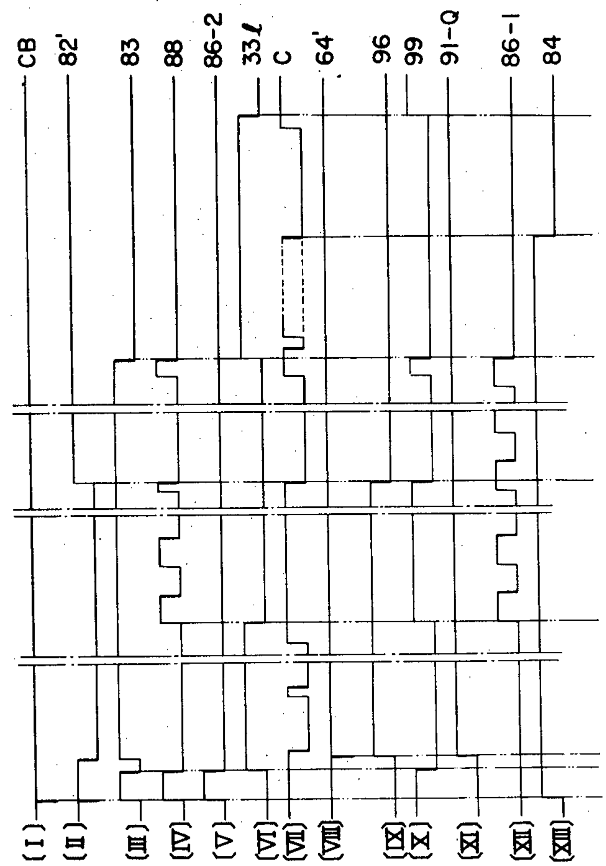


FIG. 15

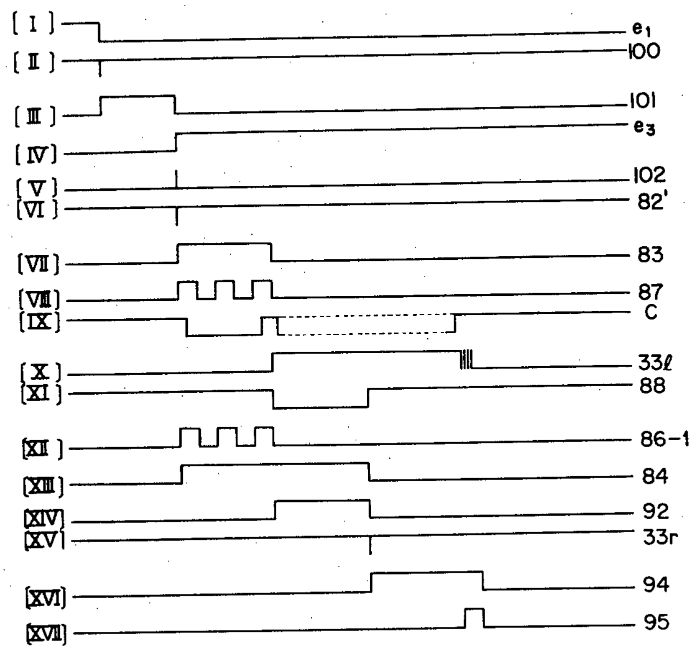

[I]
[II]
[III]
[IV]
[V]
[VI]
[VII]
[VIII]
[IX]
[X]
[XI]
[XII]
[XIII]
[XIV]
[XV]
[XVI]
[XVII]
e1
100
101
e3
102
82'
83
87
C
33ℓ
88
86-1
84
92
33r
94
95

FIG. 16

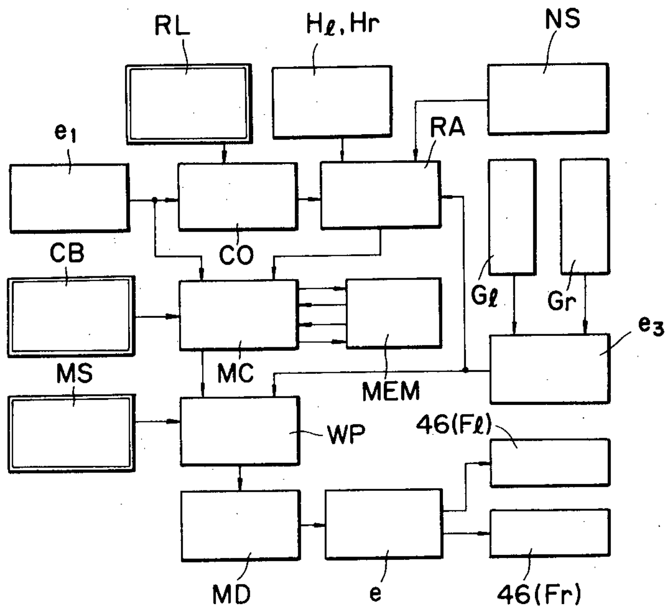


FIG. 17

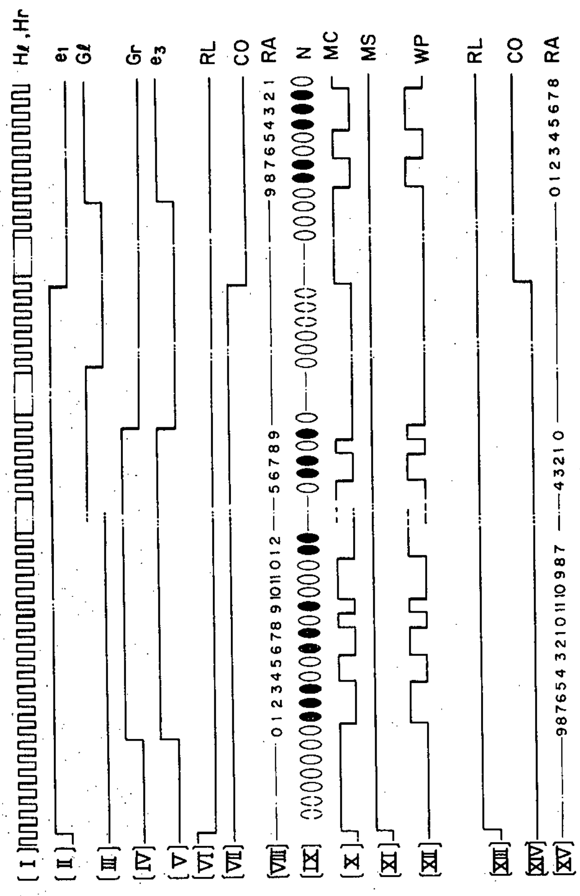
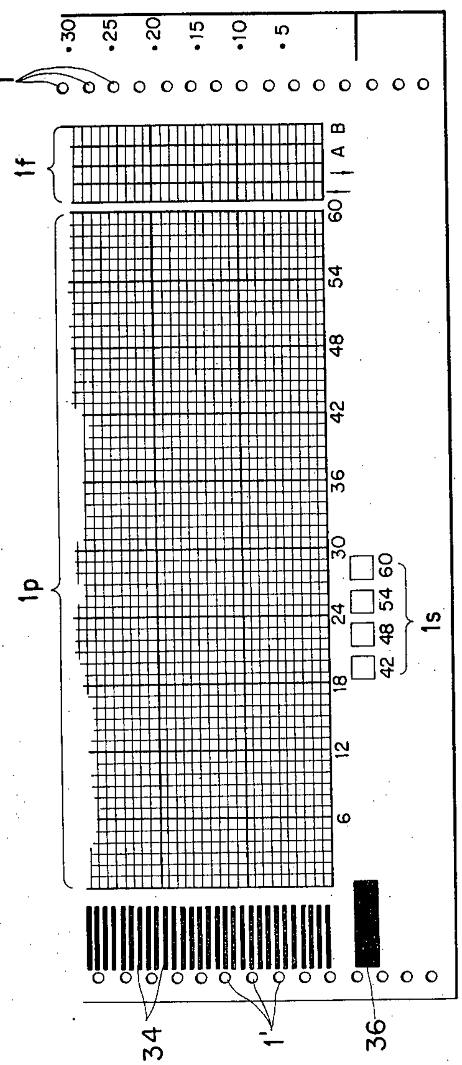

Hℓ, Hr
e1
Gℓ
Gr
e3
RL
CO
RA
N
MC
MS
WP
RL
CO
RA
[I]
[II]
[III]
[IV]
[V]
[VI]
[VII]
[VIII]
[IX]
[X]
[XI]
[XII]
[XIII]
[XIV]
[XV]

FIG. 18


1'
1f
1p
1s
34
36
.30
.25
.20
.15
.10
.5
A
B
6
12
18
24
30
36
42
48
54
60
42
48
54
60

1592349 COMPLETE SPECIFICATION

20 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 16

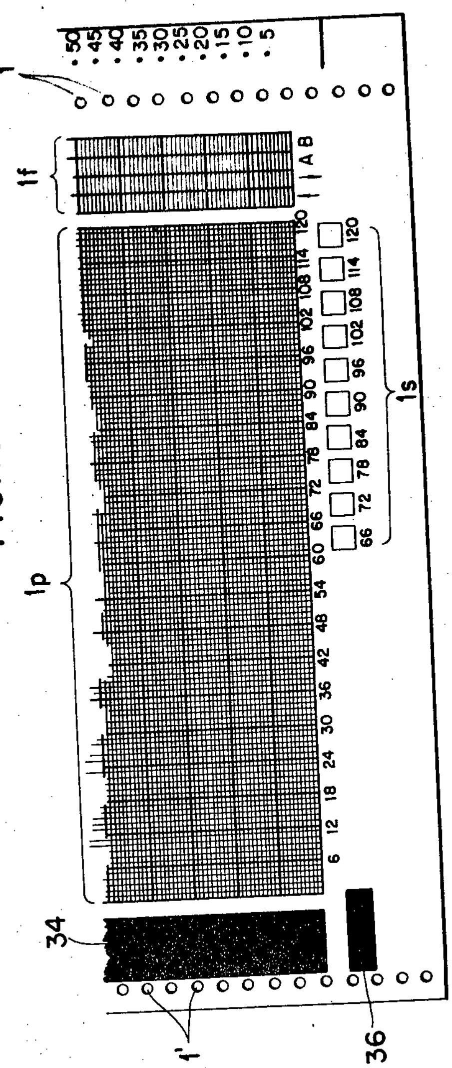


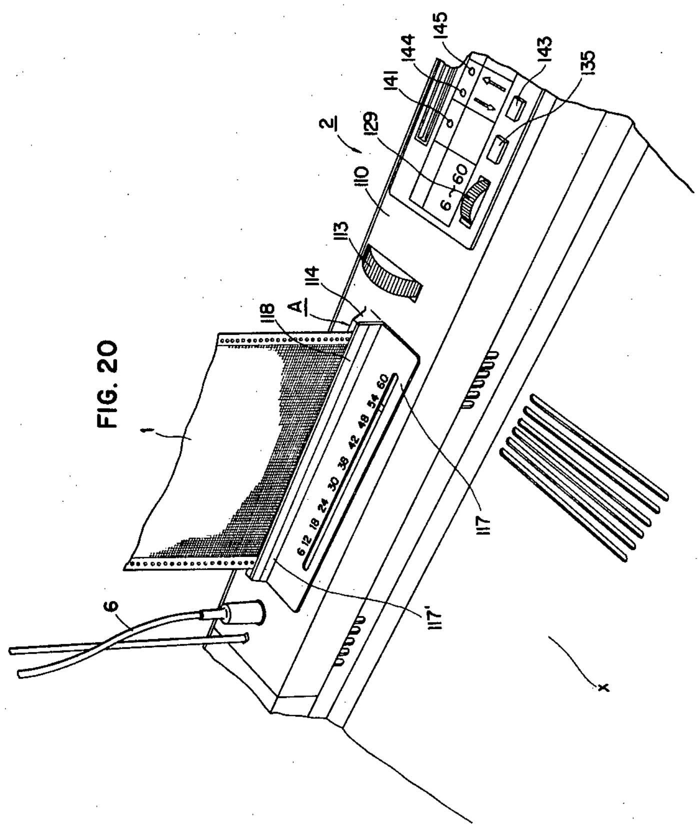
FIG.19

1592349 COMPLETE SPECIFICATION

20 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 17

FIG. 20



1592349 COMPLETE SPECIFICATION

20 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 18

FIG. 21

A

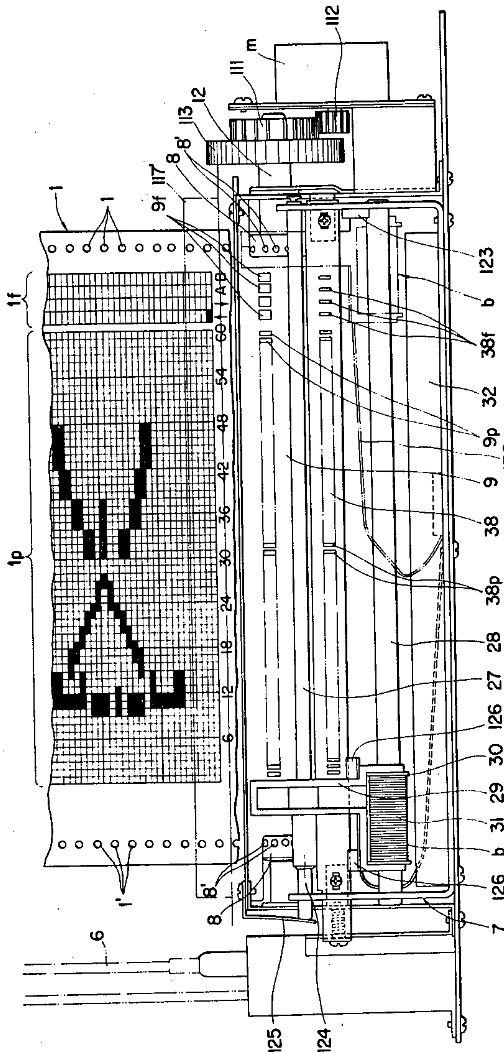


FIG. 23

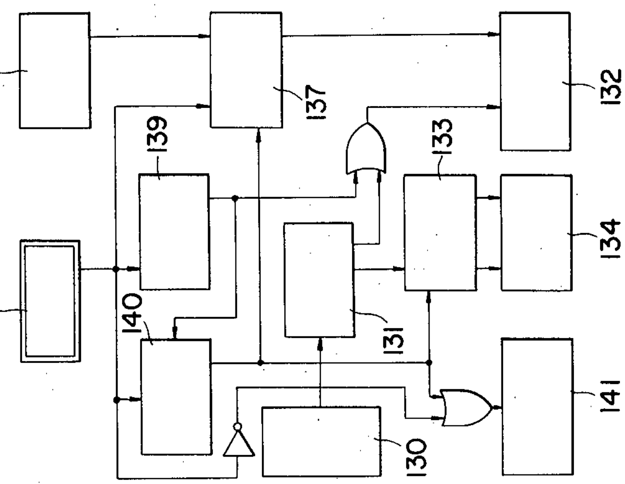

130
131
132
133
134
135
136
137
139
140
141

FIG. 22

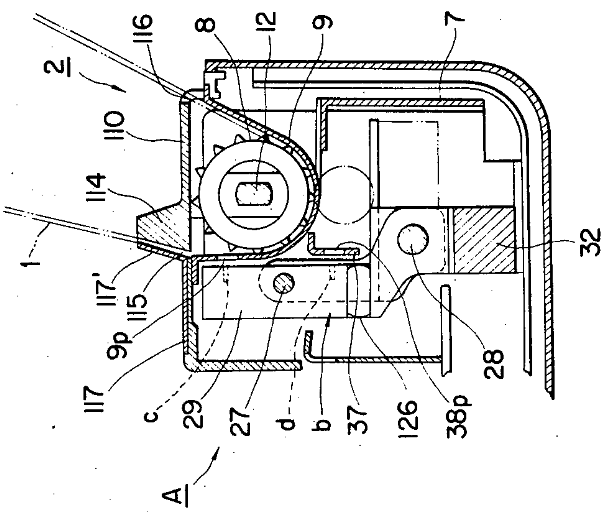

1
2
7
8
9
9p
12
27
28
29
32
37
38p
110
114
115
116
117
117'
126
b
c
d
A

FIG. 24